electronics TODAY INTERNATIONAL

JANUARY 1976, VOL. 6 No. 1

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Perth: Aubrey Barker, 38 Mounts Bay Rd. Tel 22-3184.

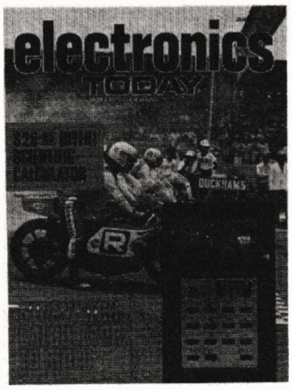
PUBLISHER: Max Press

OVERSEAS

London: Electronics Today International, 36 Ebury St, SW1 WOLW Tel 01-730 8282. New York: A.C.P. 444 Madison Ave, New York, 10022.

GENERAL:

Electronics Today International is published by Modern Magazines (Holdings) Ltd, 15 Boundary St, Rushcutters Bay, NSW 2011. It is printed (in 1975) by Wilke & Co, Browns Road, Clayton, Vic and distributed by Australian Consolidated Press. *Recommended price only. Copyright.



COVER: This month ETI shows how to build a digital stopwatch inside an existing calculator case — and still retain all calculator functions. Cost? Under $17 — including the calculator! Background pix — Indonesian Grand Prix — photo courtesy REVS Motorcycle News.

PROJECTS

NOISE GENERATOR 40
Unit generates white or pink noise for audio equipment testing.

CALCULATOR STOPWATCH 47
Build a stopwatch inside a calculator! Cost – under $17 all parts.

RF SIGNAL GENERATOR 55
Simple effective unit for servicing AM receivers

AUDIO MILLIVOLTMETER 73
Sensitive instrument for 'A' weighted audio noise and signal measurements.

FEATURES

SCIENTIFIC CALCULATOR OFFER 11
Unitrex 901SR calculator for $29.95 plus $2 post and packing!

LOW-COST 'SCOPES 14
What they do – and how to choose one – also market survey.

CA 3130 OPERATIONAL AMPLIFIER 28
Versatile new device has input impedance of 1.5 x 10^{12} ohms.

DESIGN YOUR OWN FM TUNER Pt. 3 62
How to design a high quality FM tuner – it's easier than you might think.

IDEAS FOR EXPERIMENTERS 70
Potpourri of circuits, ideas, hints and tips.

ELECTRONICS IT'S EASY! 79
Code converters and display systems.

AUDIO FACTS 91
Regular monthly audio feature – latest news on audio developments.

NEWS & INFORMATION

NEWS 5; NEXT MONTH'S ISSUE 10; ADVERTISING INDEX 94; SERVICE NOTES 94.

A MODERN MAGAZINES PUBLICATION

news digest

PRINCE PHILIP PRIZE FOR AUSTRALIAN DESIGN 1975

Standard Telephones and Cables Electronic Minimat EM 90 Private Automatic Branch Exchange (PABX) has been awarded a Certificate of Merit for winning the Operational Systems Category in the Prince Philip Prize for Australian Design 1975.

The PABX operating mechanism in the Electronic Minimat EM90 departs from the normal cross-bar automatic exchange equipment and substitutes an all solid state equipment. In addition, the system of control from the manual console incorporates a number of excellent features of an innovative nature.

Although utilising some technology based on the work of international affiliates, the whole design, conception and execution has been carried out in Australia by a large development team. Many standard electronic and telephone components have been incorporated, but the resulting system has many unique features in a design of reduced size and weight. These include push button dialling for the operator, busy extension display, extension number and status display, console metering, night service security, operator restriction of access, priority facility, automatic call-back, S.T.D. barring and most importantly, both-way exchange lines. The design of the console itself is functional and attractive. In use it is simple to operate.

As a system it provides the maximum of desirable facilities. As equipment, the use of complete solid-state circuitry ensures ease of servicing and substantially trouble free operation. The Judges were most impressed with the system.

AUTOMATIC FOCUSING OF CAMERAS

Honeywell's Photographic Products Division have announced an electronic development that will make automatic focusing of cameras commercially feasible for the first time.

The development, a small solid-state electronic device called the Honeywell Visitronic Auto/Focus, represents a "significant breakthrough in electronic optical technology and is expected to have considerable impact on the photographic industry," said Robert L. Pennock, Vice President and General Manager of the Division.

"Visitronic Auto/Focus can be designed into virtually any type of camera and as a result, the picture-taking process from focusing to exposure can be fully automatic," Pennock said.

Automatic exposure already is widely used in camera design, he pointed out, but automatic electronic focusing has been under intense investigation and experimentation for many years by scientists and engineers throughout the world.

The device which works on electronic and optical principles, was developed by Honeywell's Photographic Products Division with the assistance of the company's Minneapolis-based, Corporate Research Centre and Solid State Electronics Centre.

SARNOFF LEAVES RCA

Robert Sarnoff has announced his resignation as chairman and chief executive officer of RCA.

Sarnoff's resignation came as a total surprise to the industry. RCA decline to comment except to state that 'Mr Sarnoff intends to pursue other interests of a personal nature'.

Mr. Sarnoff recently married Anna Moffo of the Metropolitan Opera.

CONCORDE NOISE PROBLEM NOT SOLVABLE?

During Concorde's visit to Australia in 1972, this magazine asked the then Federal government for permission to publish their officially measured noise figures.

This permission was refused so we consequently commissioned our acoustical consultants to take measurements for us.

As expected we found that the aircraft's noise level was very much higher than its protagonists had claimed and in fact exceeded by a wide margin the noise level standards of most airports.

It now seems that Concorde's noise problems may be unsolvable. A recent editorial in Nature (October 30 1975) states that present noise standards at London Airport require Concorde to generate no more than 107 EPNdB. Modern subsonic planes meet these standards with at least 6 dB in hand. But Concorde exceeds the required level sometimes by as much as 10 dB.

Nature go on to say 'The story has some rather unpleasant implications for the relationship between government and science and technology.

news digest

Those who worked in noise were aware, years ago, that the Concorde problem was essentially insoluble, and that the chances of finding a palliative in a strictly limited time were negligible. And yet this message never got through to, or was ignored by, those who might, given a few years, have found political or administrative solutions which would have alleviated the present situation. "We couldn't write to the papers about it", one engineer told us, "quite apart from the risk of professional suicide, we knew that an immense public relations effort would be mounted to demonstrate how limited the horizons were bound to be of one man in one laboratory."

SOLAR CELL IS 20% EFFICIENT

A 20% efficient solar cell has been developed by Varian Associates.

According to the firm, its 8 mm diameter cell produces 10 watts of electricity directly from a focused sunlight beam. Varian makes the cell from a gallium arsenide material developed by IBM. Although the cells are not yet in commercial production, Varian says it plans eventually to build a system of cells that can generate 1 kW.

ASTRONOMERS DETECT INDIVIDUAL PHOTONS

A digital television system for astronomy, developed by University of Arizona astronomers, is sensitive enough to detect individual photons of light coming into a telescope and record them for immediate playback.

As a result it is possible to see objects 100 times fainter than previously possible. The system is based on a special television tube — a silicon intensified target tube — that records 64 000 points of light simultaneously. The information then is sent in digital form to a computer, which removes the image's noise. Photographs or a spectrogram can be produced.

ELECTRONIC WATCH HAS CONTINUOUS DISPLAY

A challenge to LED and LCD watches has been launched by America's Optel Corporation (Princeton N.J.). Optel have just released details of a prototype unit incorporating an 'electro-chromic' display claimed to be capable of showing a continuous readout without constant battery power.

The prototype unit is a three function device which shows hours and minutes continously and seconds on demand. The corporation say that there are still 'some problems' with the design but claim a two to five year life for the prototype readout which they say has a 200 millisecond response time.

Optel's prototype unit was shown at a recent meeting of the International Society for Hybrid Microelectronics.

In Switzerland, Brown Boveri SA has introduced a new field effect liquid crystal with permanent readout of hours, minutes and seconds.

NOVUS TO MAKE SCIENTIFIC CALCULATORS

National Semiconductor plan to add complex scientific calculators to its Novus range — starting in January 1976. The new calculators are intended to compete with basically similar units from Hewlett Packard and Texas Instruments.

PROGRAMMED TV FROM TOSHIBA

A TV channel preselector is shortly to be produced by Toshiba. The device enables the viewer to pre-programme his selections for the day.

The actuating device is a clocked complementary-MOS chip which automatically switches a varactor tuned colour TV set to the desired channel at the preset time.

The selector can be set for up to 16 programmes. It is battery powered to ensure that programmes are not missed due to power failure during the day.

SIGNETICS DROP CMOS

Our US correspondent advises us that Signetics have just telexed all their US sales staff and distributors advising them that the company will be discontinuing their CMOS logic series as from November 3.

Signetics' sales of CMOS products fell short of their projected target by a considerable margin. We understand that whilst the 1975 target was US$200 million, actual sales are not expected to exceed US$120 million.

SIMPLE PROJECTS BOOK

HOW TO BUILD PROJECTS. CRYSTAL RADIOS. ONE-TRANSISTOR RADIO. KILL THAT GHOST. TV MASTHEAD AMPLIFIER. FM ANTENNA. SIMPLE SPEAKER. SIMPLE AMP

SIMPLE PROJECTS

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UNIT. SIMPLE LOUDHAILER. BASIC POWER SUPPLY. FET DC VOLTMETER. LIGHT DIMMER. DRILL SPEED CONTROLLER. TWO SIREN CIRCUITS. HI-POWER STROBE. LIGHT OPERATED SWITCH. CAR ALARM. AUTO-AMP. FOUR-CHANNEL FOR $10. BUYING COMPONENTS. TRANSISTOR TESTER. COURTESY LIGHT EXTENDER. BETTER SOUND FOR $5. ETI UTILIBOARD. SIMPLE INTERCOMS. MONOPHONIC ORGAN.

More than thirty five of the most popular simple projects ever published in Electronics Today have now been published in a single 94 page book.

Called 'Simple Projects' the book is available now from all main newsagents for a recommended retail price of $2.00. It is also available directly from Electronics Today — see advertisement elsewhere in this issue.

PAL COLOUR CAMERA SYSTEM

A simple, inexpensive, PAL colour camera system has been released by Hagemeyer (Australasia) B.V., sole importers of JVC video and audio equipment in Australia.

The camera has been designed for field or studio use. An ergonomically designed hand grip converts the camera to a portable unit for use with JVC PAL colour portable recorder PV-4800E.

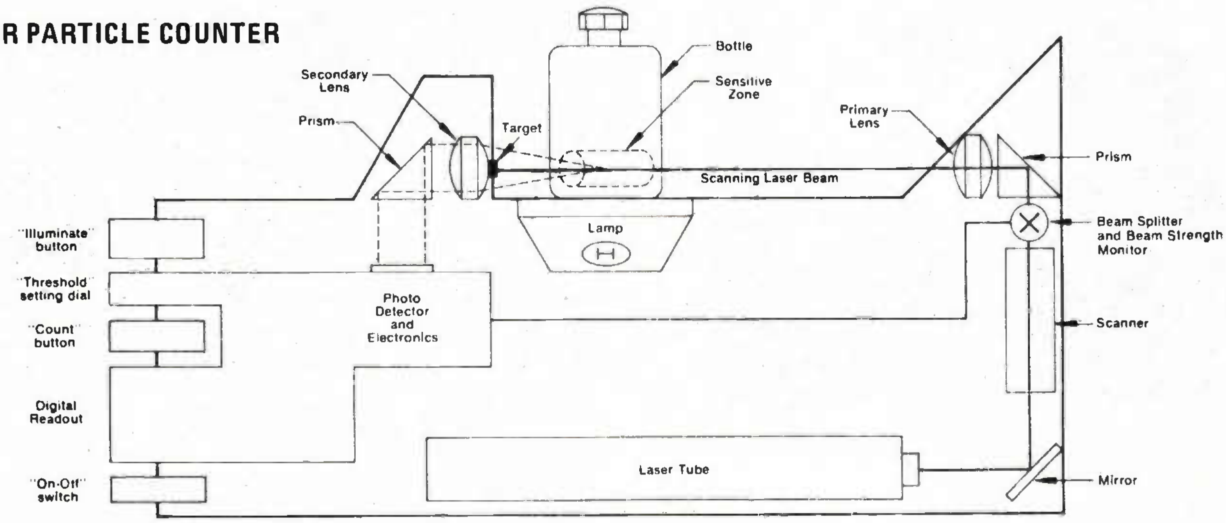
Fitted to a tripod and equipped with a mains adaptor, the camera system provides video and audio signals for use with PAL colour Video U-matic cassette recorder or ½" PAL colour recorders to the EIA-J standard.

For studio use JVC's remote controlled PAL colour U-matic video cassette recorder CR-6000E is remotely controlled in the record function from the stop/start switch on the camera.

Apart from the 4:1 zoom lens together with constantly variable aperture, the camera has only two switches. One for 240 Vac power and the other is a three position colour temperature control.

Error free operation together with low cost makes this colour camera system eminently suitable for users in the fields of education, industry and commerce.

LASER PARTICLE COUNTER



A new American instrument counts micron-sized suspended particles in fluids in 15 seconds. The instrument called the Prototron ILI 1000 is non-destructive and can test fluids in sealed glass or clear plastic containers.

The number of particles in one millimetre of fluid is determined by counting the pulses of light scattered by the solids in a focussed laser beam. It is claimed that the machine is sensitive to particles in the range 1-100 microns. Variable threshold level enables particles to be counted according to size within the specified range.

One advantage offered is the ability to test such products as intravenous liquids without breaking the seal on the bottle. Other applications include the testing of photographic liquids, hydraulic fluids and pharmaceuticals.

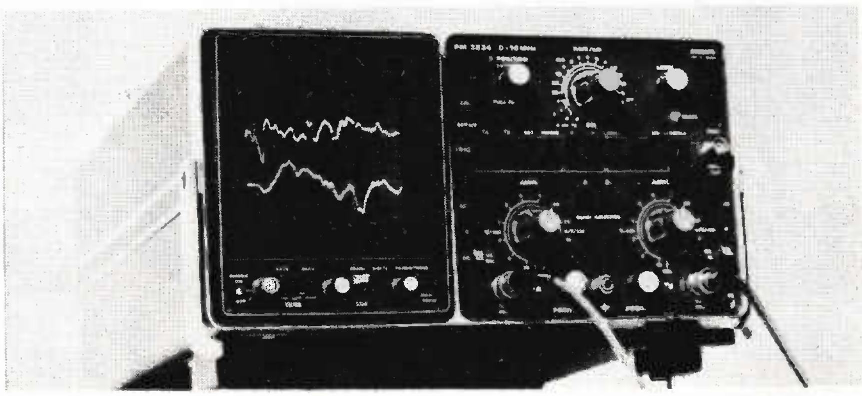
The Prototron instrument is available through Foss Electric (Aust.) Pty. Ltd, 251 Condamine St, Balgowlah, NSW.

TRUE DUAL BEAM PLUS STORAGE OSCILLOSCOPE

Philips Industries have recently introduced a new 10 MHz 2 mV storage oscilloscope that features true dual beam operation, a technique developed by Philips in order to eliminate the need for chopped or alternate mode displays. This technique ensures that the phase relationship of the signals is always correct and allows the complete waveform to be displayed.

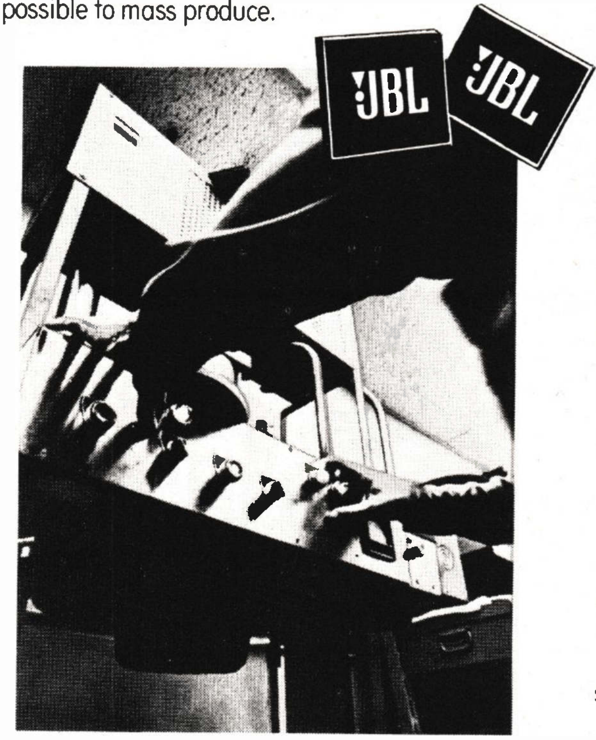
In this new oscilloscope, designated the PM 3234, this technique is combined with that of half tone storage and the result is a very versatile specification that is of particular value for obtaining true displays and records of single shot phenomena.

When the storage facility is not required the PM 3234 operates in the normal manner but with the added benefit of having continuous control



Hand made sound.

With JBL you know you're not just paying for the name. You're paying for a quality of sound that is impossible to mass produce.



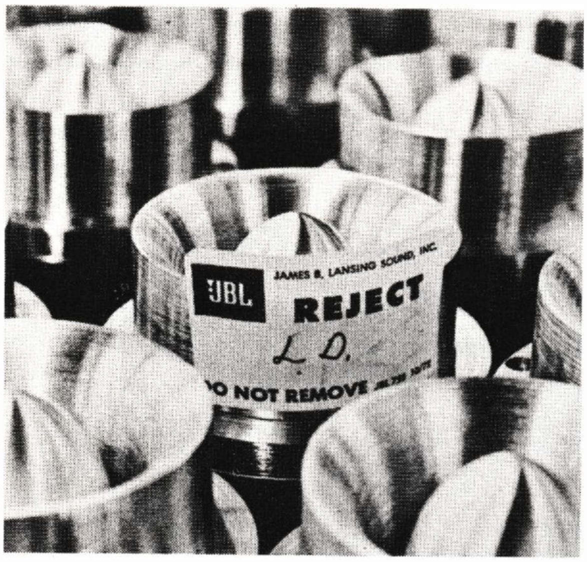
JBL's require equipment so specialised we had to design and build our own.

Cabinet tolerances are typically held to 1/64th of an inch.

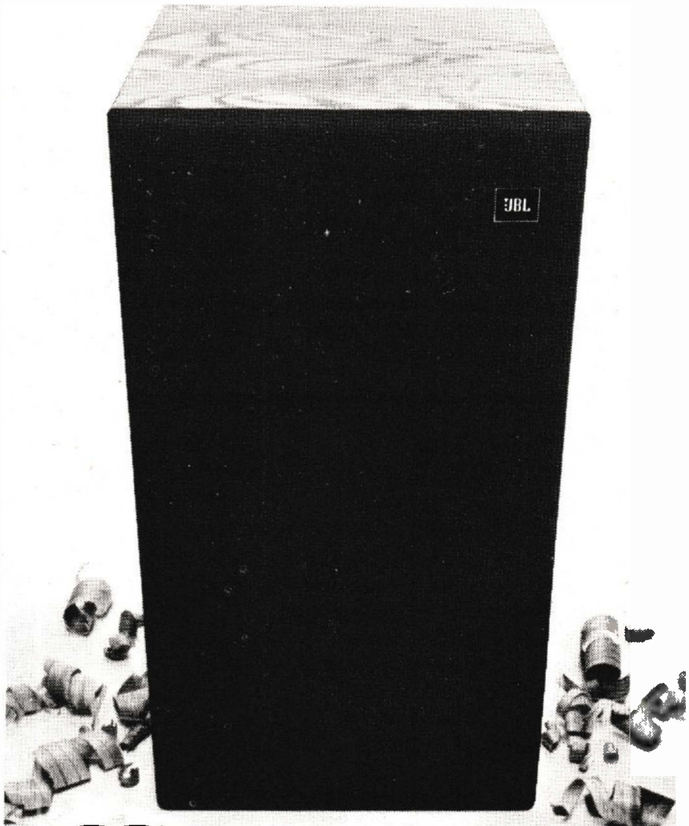
Until we developed them just recently, most JBL's were out of the normal person's reach. Now you can own a pair of JBL's for around $500.

They're still more expensive than ordinary speakers, but then they're JBL's aren't they.

If we cut out all the things we do by hand, and the checking double checking and rejecting, we could probably produce a speaker for about 25% less. But then it wouldn't really be a JBL. Our reputation is based on an unchanging commitment to quality. We make no compromises. Never have, never will. The same applies to all the JBL range. Like the JBL Decades.



Near enough is just not good enough.



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PO Box 6, Brookvale NSW 2100

of the persistence from 0.3 seconds to 1.5 minutes. This allows difficult-to-see signals like low frequency signals with flicker and high frequency, fast rise time pulses with low repetition rates to be displayed in the optimum manner.

PORTABLE PRECISION TEMPERATURE BRIDGE

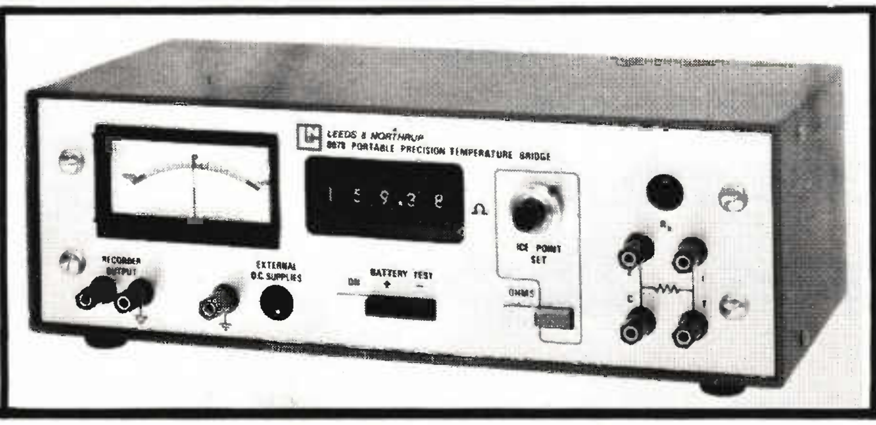
Leeds & Northrup Australia Pty. Limited have recently concluded an agreement with the CSIRO, which will permit Leeds & Northrup to develop, manufacture and market (under licence to CSIRO) a new, advanced design, versatile, precise ac resistance thermometer bridge.

The new, low-cost thermometer bridge was designed by Mr. Clive Pickup — a scientist at the National Measurement Laboratory, University Grounds, Chippendale, N.S.W. It was developed to overcome practical measuring problems encountered by scientists, research staff and industrial personnel who traditionally use liquid in glass thermometers, or thermocouples and thermistors plus an assortment of electrical or electronic equipment to make accurate temperature measurements.

The clever application of previously known — but not used — measuring principles, together with the incorporation of modern electronic technology, has produced a bridge design which is believed to be in advance of any known equivalent instrument on the world market. Mr. Pickup's original bread board design has been redeveloped by Leeds & Northrup engineers in Australia and, additionally, new thermometer Ro compensation circuitry has been added, which now makes the temperature bridge truly unique. The result is a simple to use, small, attractively designed portable instrument, which can measure and record temperature changes as small as 0.001°C, yet can equally well be used by unskilled industrial staff to measure temperatures to the lower levels of precision normally required for routine industrial purposes. The robust construction of the bridge makes it very suitable in such applications.

Additionally a comprehensive range of accessories has been developed in Australia to complement the bridge. Included are two general purpose hand held rugged type miniature resistance thermometer assemblies which have proven to be ideal for typical laboratory, plant and field applications in the temperature range -200 to +500°C.

The instrument, which will be known as the 8078 Portable Precision Temperature Bridge, will be built by Leeds & Northrup Australia Pty. Limited. Two prototype production units have already been built, which have passed rigorous evaluation testing at the National Measurement Laboratory. Production units are expected to be available in February 1976 and a comprehensive world-wide marketing programme is planned by Leeds & Northrup Australia Pty. Limited to ensure the success of the project.



VACUUM/PRESSURE MEASUREMENT SYSTEMS CATALOGUE

Datametrics have produced a new catalogue called "Vacuum/Pressure Measurement Systems" describing instruments for measuring pressure and vacuums.

The catalogue outlines operating principles of Barocel sensors and also describes and illustrates self-contained

instruments, modular instruments, popular accessories and options.

Datametrics transducers employ capacitance sensing techniques which give them high stability and wide dynamic range. Typical system resolution is claimed to be one part in a million with sensitivity down to one micro-torr. Pressure and vacuum ranges from one torr to 100 psi are available at John Morris Pty. Limited, P.O. Box 80, Chatswood . . . NSW 2067.

PHILIPS DIGITAL MULTIMETER

Philips compact, high quality, digital multimeter is highly competitive with standard analogue service instruments presently on the market. Designated the PM 2513, this new DMM offers a number of outstanding features.

The heart of the PM 2513 is an LSI circuit which performs part of the analogue circuit functions, the A/D conversion and the digital signal evaluation. The integrated circuit drives directly a very bright, 3½ digit, seven segment LED display with automatic decimal point. The display is recessed, so it is eminently readable, even under high ambient light conditions. It also features a polarity indication, plus an indication for range overloading and low battery loading.

Ac and dc voltages are measured in five ranges, from 0.1 to 600 V and 0.1 to 1000 V respectively.

Resolution is 100 μV in the 0.1 V range, and accuracy is ± 0.2% fsd ± 0.3% rdg for dc and ± 0.2% fsd ± 1% rdg for ac. Errors due to the instrument loading the circuit under

news digest

test are eliminated by the high input impedance of 10 M. Five ac and dc current ranges extend from 100 μA to 1 A fsd, with a resolution of 100 μA in the lowest range. Resistance is measured from 0.1Ω resolution to 1000 k fsd. The accuracy for both current and resistance measurements is 0.2% fsd ± 1.5% rdg. The overall accuracy is thus an order of magnitude higher than that of analogue instruments. Response time is also very low, with an average of one second for each measurement.

An unusual feature of the PM 2513 is built-in provision for temperature measurements, which can be made with an optional probe. A function selector button and a range setting are provided for this purpose. Surface temperature measurements can thus be made simply and economically in a range of −50°C to +200°C, with a resolution of 0.1°C and an accuracy of ± 1°C.

CANNIBALS AND MISSIONARIES

Last month we published a constructional project to represent in electrical form the following puzzle:

Three missionaries and three cannibals came to a river they wanted to cross. A little boat at the bank would carry only two people. All the missionaries could row, but only one of the cannibals could row — he wore a white shirt and had been to Oxford. If at any time, on either side of the river, the cannibals outnumber the missionaries then the cannibals will eat the missionaries, which, understandably, the missionaries didn't want. Problem: how did they cross safely?

For those who made the project and think it can't be solved — and for those still struggling with the problem on bits of paper — here's a solution:

M means any missionary. C means either of the non-rowing cannibals. C2 means the cannibal who can row.

1. C and C2 go over
2. C2 comes back
3. C and C2 go over
4. C2 comes back
5. M and M go over
6. M and C come back
7. M and C2 go over
8. M and C come back
9. M and M go over
10. C2 comes back
11. C and C2 go over
12. C2 comes back
13. C and C2 go over

---

next month

PROJECTS

* TOP QUALITY STEREO FM TUNER
Simple to construct unit has LED frequency indication, varicap tuning — preset plus manual — auto frequency control.

* MAGNAVOX 10-50 LOUDSPEAKER
The earlier Magnavox 8-30 speaker was a winner! Here's its even better successor.

RADIO AMATEURS

* SOLID STATE CONVERTERS
Converters for 28, 52, and 144 MHz bands.

* RF MARKER GENERATOR.
Accurate RF frequency marker

* DIGITAL TEMPERATURE METER
Full three digit display.

The feature articles listed above are included amongst those currently scheduled for our February issue. However, unforeseeable circumstances, such as highly topical news or developments may affect the final issue content.

electronics TODAY INTERNATIONAL

February Issue — on sale mid-January.

Special Readers' Offer

UNITREX 901SR

Scientific Calculator

$29·95*

* plus $2 postage and packing.

JUST TWELVE MONTHS ago we offered readers the opportunity to buy a pocket scientific calculator for $59.50. The response was extraordinary — over 1500 were sold within a week of the offer being published. At the time of the offer, competitive units were priced at $100 upwards so our special offer was a bargain indeed.

Now, we have an equally attractive offer. Electronics Today International have made arrangements for Unitrex to supply our readers with their excellent 901SR scientific calculator for the very low price of $29.95 plus two dollars postage and packing. The normal selling price of this unit at the date of publication was $39.95 plus $2 postage and packing.

The Unitrex 901SR is an eight-digit scientific calculator having an easily-readable, green, seven-segment display.

It has a full range of 26 scientific functions including natural and common logarithms and their reciprocals; square root; x to a power; trig functions and their inverse as well as pi and reciprocals.

The calculator has a very flexible 6-key memory together with operations in degrees, radians, or grads mode.

The 901SR does not have scientific notation, but when two eight digit numbers (for example) are multiplied, an answer is obtained with the decimal point positioned eight places to the left of its true position. An overflow sign is now displayed and the calculator locks out. Depressing the clear key, once, deletes the overflow — lockout and symbol and calculation may then continue.

The unit is powered by two AA-sized dry cells.

WARRANTY

The Unitrex 901SR calculators offered carry the same warranty as those sold at full price. That is — "the calculator is warranted (except for batteries) for a period of 12 months from original purchase date — under normal use and service against defective materials or workmanship. Defective parts will be repaired or replaced at our (Unitrex's) option when the calculator is returned prepaid to Unitrex of Australia Pty Ltd., 414 Collins St, Melbourne, Vic 3000. The warranty is void if the calculator has been damaged by accident or misuse. Removal or alteration of serial number or repair by unauthorised personnel also voids warranty."

"The warranty contains the entire obligation of Unitrex of Australia Pty Ltd and no other warranties, expressed, implied or statutory are given — this warranty does not exclude limit restrict or modify any condition or warranty implied by the Trade Practices Act 1974, or other State laws or Acts. . ."

NOTES

We regret that we cannot arrange to supply these special-offer units against a sales-tax exemption.

The units can only be obtained in the manner outlined below. Electronics Today International cannot supply directly nor can undertake to demonstrate or discuss details of the units offered.

All units will be thoroughly inspected by Unitrex before despatch. The package should be carefully inspected before accepting delivery. Acceptance should be refused if the package is damaged.

Whilst every possible effort will be made to fulfill readers' orders, this offer is subject to stocks being available. So if you want to be sure of receiving this special bargain-price unit send your cheque in soon!

Orders must be addressed exactly as per the coupon below. Please note — due to current postal delays, readers should expect a delay of between three to four weeks between posting an order and obtaining delivery.

Finally — in the improbable event of the unit not working — please please return it directly to Unitrex, 414 Collins St, Melbourne, Vic 3000. NOT repeat NOT to ourselves. This offer closes on January 31st 1976.

UNITREX CALCULATOR OFFER.

NAME ....

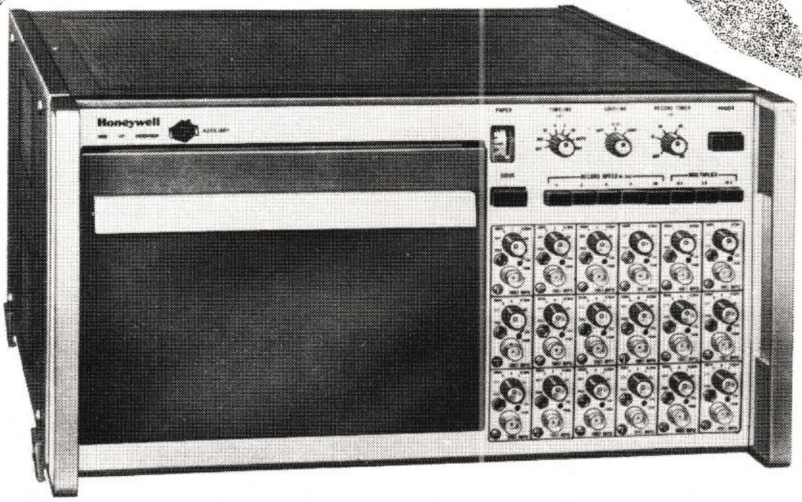
ADDRESS ....

. ...

Please forward ...... Unitrex Scientific Calculator/s.
My cheque/postal note for $31.95 (including postage and packing) is enclosed. (Make cheque/postal note payable to 'Unitrex Offer').

SEND TO UNITREX CALCULATOR OFFER.
c/– ELECTRONICS TODAY INTERNATIONAL
15, BOUNDARY ST,
RUSHCUTTERS BAY. NSW 2011.

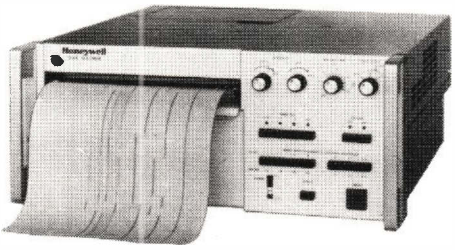
FROM **Honeywell**



FIBRE OPTIC
Visicorder
OSCILLOGRAPHS

1858 Series: New concept fibre-optic CRT recorder complete with self-contained signal conditioning . . . a compact 18-channel Graphic Data Acquisition System.

Since their introduction by Honeywell Visicorder oscillographs have set the standards for high speed graphic recording, Honeywell's Visicorder oscillographs record each channel's data by means of precisely controlled light beams. The art of light beam oscillography has been greatly enhanced by the use of UV-sensitive direct-print paper, which can be used easily in all Visicorder oscillographs. No stylus, ink, powder, chemicals or heaters are required. When exposed by UV light in the oscillograph, the latent image appears as the direct-print paper emerges into visible light. When extremely high writing speed and resolution are required, certain models can be used with wet or dry processed film or paper.



The Model 1508B Visicorder is a direct-writing Oscillographic Recorder designed to provide maximum usefulness, versatility, operator convenience, and exceptionally high accuracy and reliability.

FO RECORDER FEATURES

★ Inertialess recording—no moving elements, no styli

★ No trace overshoot

★ Sharp static traces without high frequency "wipe-out"

- 18-channel system in single 8¾ inch high package
- Front panel plug-in signal conditioning modules
- DC—5000 Hz response at up to 7.2 inch trace amplitude
- 100 μV-300 input sensitivity, to 300V common mode
- Direct writing, 8 inch record width, 200 ft. record length
- 0.1% accuracy 5 interval timing system with accentuated tenth line
- Time-interval marker
- Auto-linearised for increased data accuracy
- Numbered trace identification
- Wide-range, dc-servo drive system
- 0.1 to 120 ips record speeds
- 42 discrete record speeds with binary addition push-buttons
- Remote drive and speed control
- Internal record takeup
- Automatic record-length control
- 120/240V, 50-400 Hz power, switch selectable
- Lightweight, low power consumption
- Rack or table mounting
- Wide selection of signal-conditioning modules available
- Easy to use as an oscilloscope—just add signal input connections

For full information contact Australian Representatives: **JACOBY MITCHELL**

Specifications quoted are for general guidance only, are subject to verification and change without notice.

215 North Rocks Rd., North Rocks, N.S.W. 2151. Phone 630 7400.

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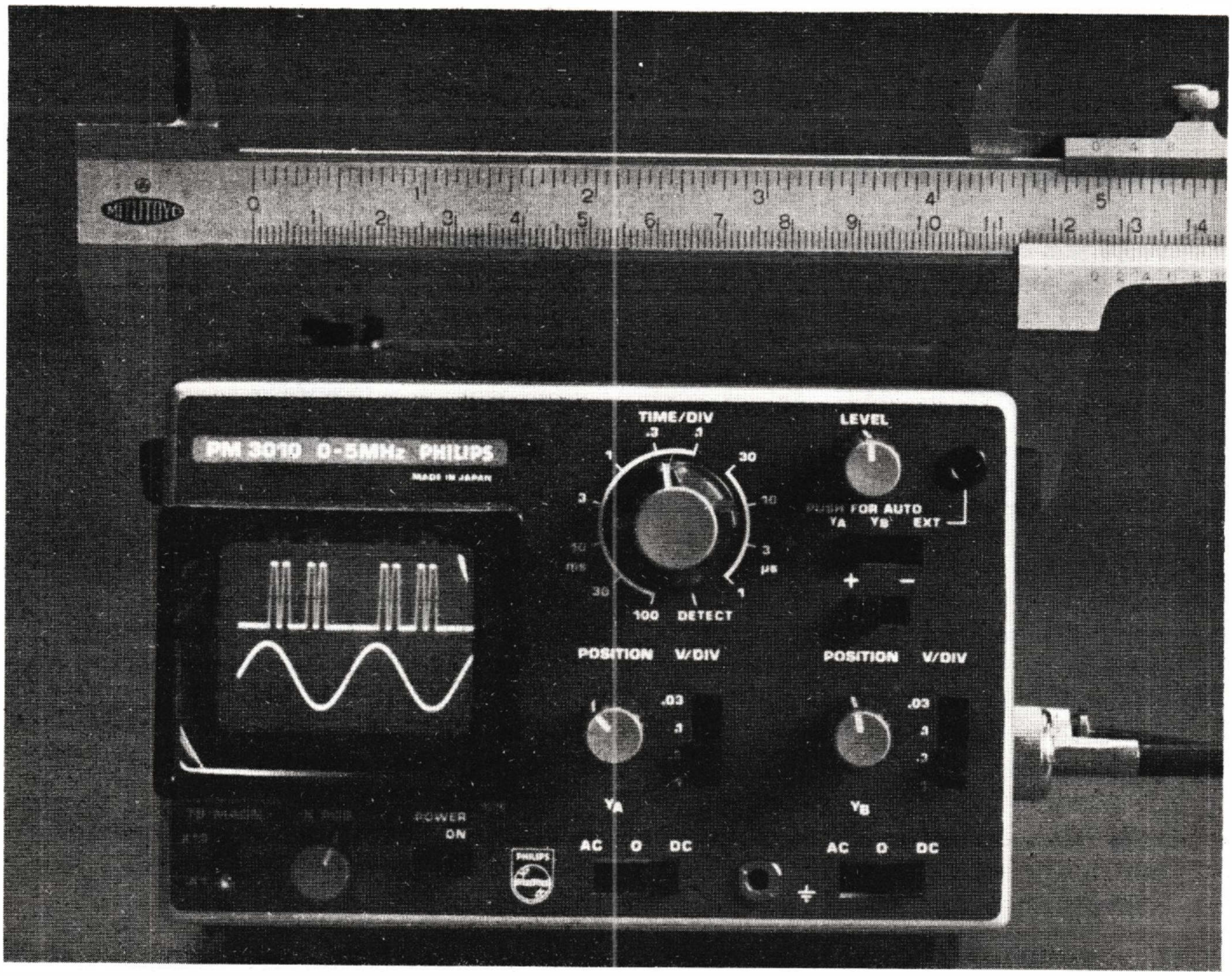


LOW COST 'SCOPES

What they do-and how to choose one

THE EXTENT to which an oscilloscope can be used depends largely on the instrument itself – and the most versatile 'scopes are usually the most expensive.

One can pay as little as about $100 for a small, general purpose, or service type 'scope and $2000 or more for a wide-band multi-purpose instrument with a storage c.r.t. facility. However, good secondhand instruments are available, mostly of the older valve type and these are nearly equal in performance, and accuracy to their modern transistorised counterparts, *providing* they are in good condition and one has the means of checking calibration etc.

As a general rule, the choice of a 'scope should be made according to the kind of work one wishes to do. As a guide, instruments costing between $100 and about $400 are usually perfectly adequate for audio, radio, TV and electronics applications of a general nature. A double beam (two separate traces) instrument is a great asset and allows input and output waveforms to be displayed simultaneously for comparison but, whatever type is used, it is important to know its limitations and the calibration accuracy. For example, a 'scope with a Y amplifier bandwidth of up to say, 2 MHz will not show the amplitude of a 5 MHz signal in true relationship to one at 1 MHz. One would not be able accurately to measure the duration of a voltage pulse in terms of microseconds with a fastest timebase of a few milliseconds; to display a 1 μs pulse opened out to cover one centimetre on a ten centimetre c.r.t. screen would require a timebase speed of 10 μs. Signal amplitudes can only be measured accurately if the attenuators for input signals and the Y (or X) amplifiers are in good order. Last but not least comes interpretation of the display itself and here really useful information can only be obtained from intelligent observation made in conjunction with accurate calibration and full knowledge of the performance parameters of the 'scope itself.

CALIBRATION

For the benefit of those unfamiliar with the oscilloscope, a few examples concerned with calibration may not be amiss. The oscillogram in Fig.1 shows a typical timebase waveform (B) beneath the negative-going trace flyback suppression pulse: Now the timebase waveform looks linear, which it is, and the flyback suppression pulse coincides exactly with the return of the timebase waveform from zero to maximum amplitude. A very linear timebase is important otherwise repetitive waveforms will appear as crowding together toward one side or the other of the display. An example of good linearity is shown in Fig.2 in which (A) is the timebase waveform and (B) an actual display of squarewaves of 1 kHz. The three complete cycles of square-waves are uniform in width and since 1 kHz is a time duration of 1 mS, the timebase is 3 mS. Note that the timebase is synchronised to the square-waves and good synchronisation is also important, particularly when examining coincident waveforms.

Most oscilloscopes have a calibrated graticule over the c.r.t., usually divided into centimetre squares as in Fig.3 against which is displayed a square-wave. If the vertical calibration is say 0.5 V per centimetre, then the amplitude of the square-wave is almost 2 V. The frequency of the square-wave is unknown and only a complete half-cycle is displayed but the horizontal calibration is say 0.1 ms/cm. The duration of the half-cycle is almost 5 x 0.1 ms = 0.5 ms which gives 1 ms for the full cycle, or a frequency of 1000 Hz.

Finally Fig. 4 shows five complete cycles of a square-wave at a frequency of 1000 Hz (A). What is the duration of the time base? Each complete cycle is 1 ms so the timebase speed is 5 ms, (just over in fact as another quarter-cycle appears at the extreme right). The waveform (B) below, shows marker pips, derived by differentiation of the square-wave. These are more convenient for calibration of a timebase of unknown duration. The square-wave is simply passed through a CR circuit (Fig. 5) and the positive or negative-going pulses can be rectified out.

Having devoted a little space to calibration and to some extent interpretation of displays, let us now look at some typical applications of the oscilloscope. These are relatively few and fairly basic for any attempt to cover *all* the possibilities would require endless editions of ETI.

MISLEADING DISPLAYS

False information can be given by an oscilloscope display because of unwanted signals from circuits under test, defects in the oscilloscope itself and so on. It is also important to make full use of the various timebase speeds when analysing displayed waveforms. A simple case is shown in Fig. 6 where (A) is a 1000 Hz sinewave but appears to be duplicated. Reducing the timebase speed reveals that this is due to modulation by another signal of lower frequency, in this case 50 Hz mains hum which could come from the circuit being tested, unscreened leads, or even the 'scope itself.

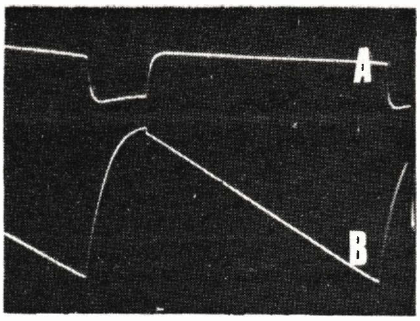


Fig.1. Typical time base waveform (B) with flyback suppression pulse (A) Note excellent linearity of time base waveform.

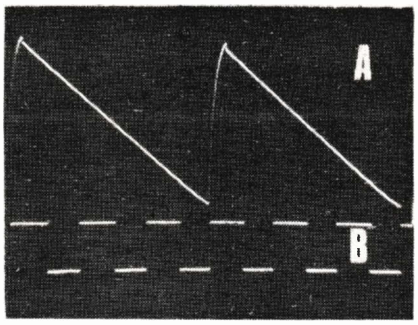


Fig.2. Time base waveform (A) against displayed square-waves (B) to show synchronisation. Text explains time relationship.

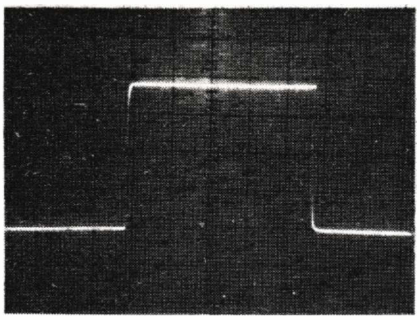


Fig.3. Graticule in centimetre squares provides voltage (Y deflection) against time scale (X deflection) calibration (see text for interpretation).

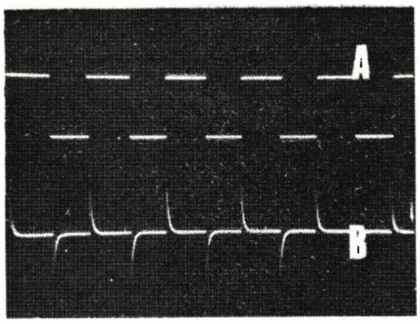


Fig.4. Display of square-waves (A) and marker pips obtained by differentiation. See also Fig.5 and text for further explanation.

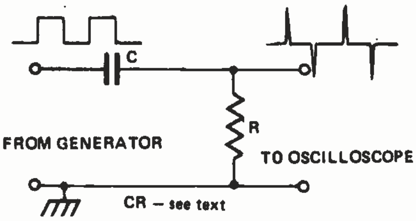


Fig.5. Simple RC network to obtain marker pips from a square-wave signal and which lend themselves for time scale calibration A diode may be connected across R to eliminate positive and/or negative going pulses as desired.

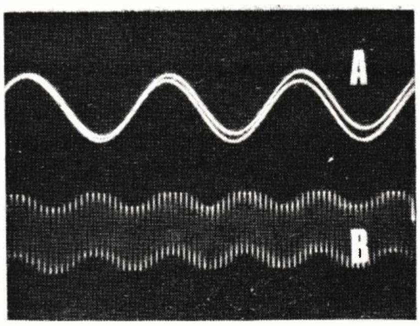
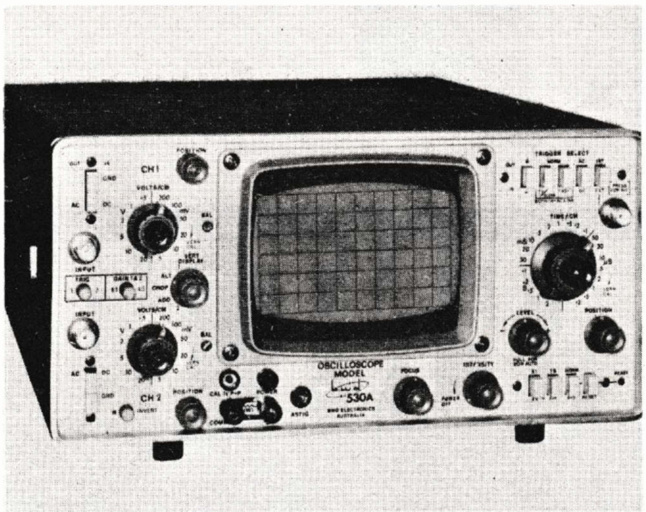


Fig.6. (A) Sine-wave deflected by (B) 50 Hz hum modulation.



BWD is the only Australian manufacturer of oscilloscopes. The 530A is a dual trace 20 MHz instrument featuring 20 nanosecond signal delay, comprehensive triggering and optional battery supply.

4 TOP QUALITY SYSTEMS TO CHOOSE FROM

Leak 600 Speakers
TEAC AS.100 Amplifier
Sansui 525/91ED *Rank Turntable

$749

Sony SS.7100 Speakers
Sansui 4400 Amplifiers
Apan Bfu. 121 Turntable

$559

Nikko 500 Amplifier
PHF 3 ways Speakers
Sansui 212 Turntable

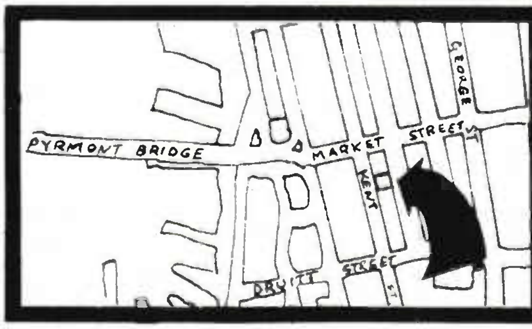
$449

Technics SU.3000 Amplifier
Kenwood 1022 Turntable
PHF 2 ways speakers

$379

KENT HI-FI

412 KENT STREET, SYDNEY Ph. 29-6973



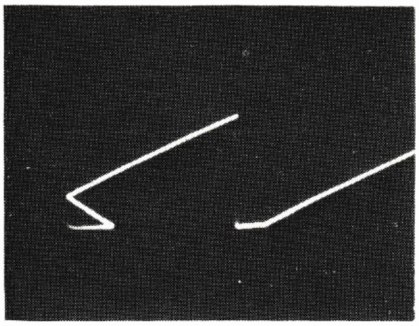


Fig.7. Distortion of displayed waveform due to crosstalk within 'scope circuitry itself.

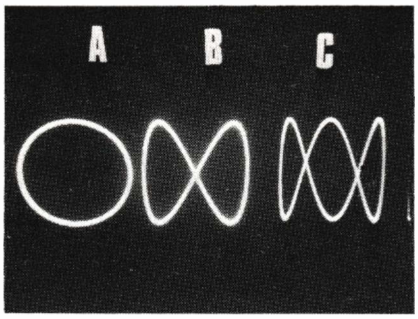


Fig.9. Typical Lissajous patterns of 1:1, 2:1 and 3:1. See text for interpretation.

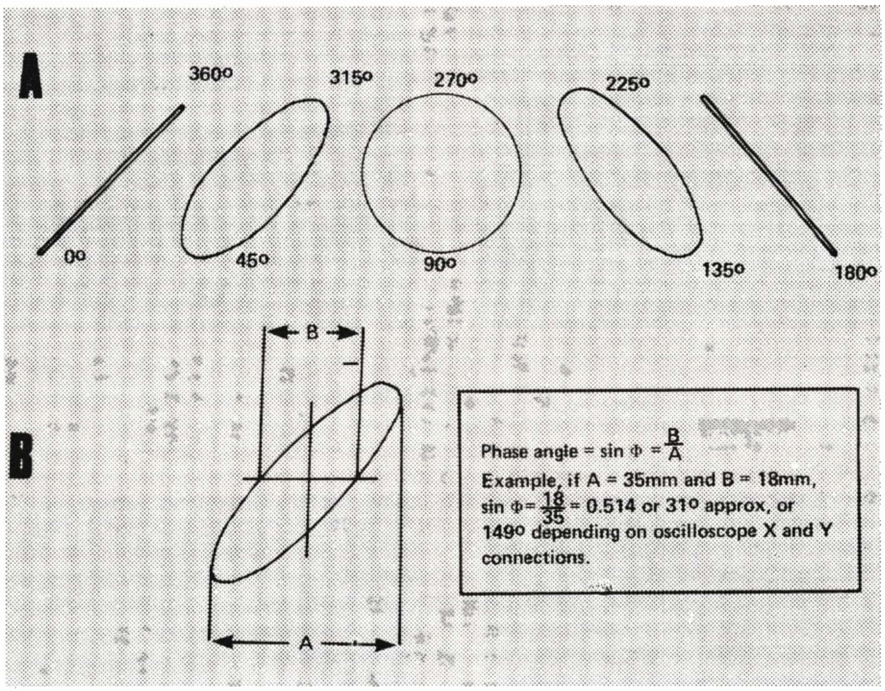


Fig.8. (A) Phase angles. See text for explanation. (B) Determination of phase angle from an oscilloscope.

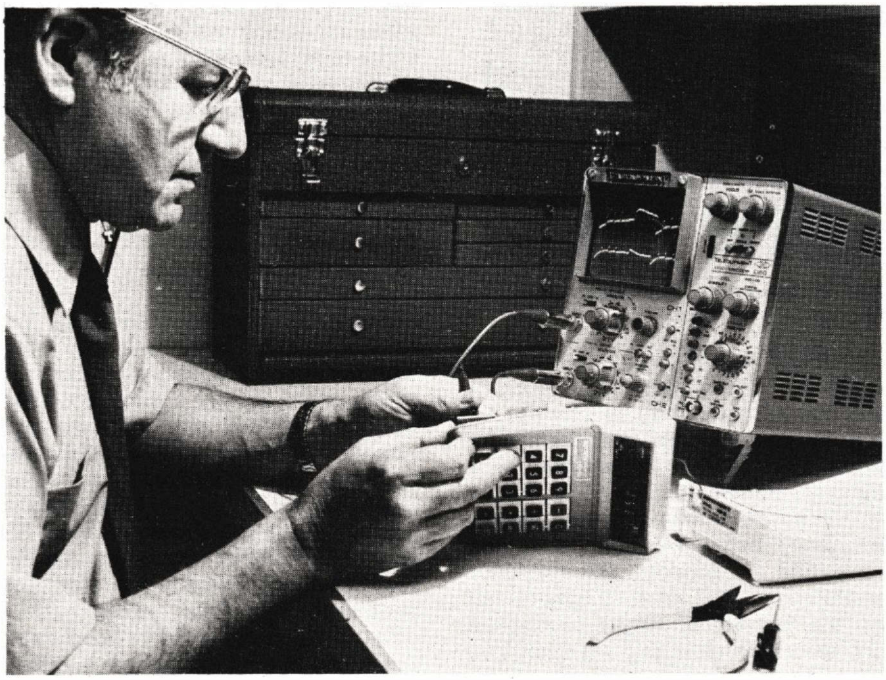
In Fig. 7 a ramp voltage waveform is shown but the first cycle is distorted, in this case by crosstalk in the 'scope, so it pays to investigate not only the equipment being tested but also the 'scope itself when things do not appear as they should.

PHASE SHIFT

The oscilloscope can be used to determine phase shift, of signals, through an amplifier for instance, by feeding the input signal to the Y plates and the output signal to the X plates. Some 'scopes have what is called an *XY facility* for this and matched amplifiers but accuracy will be limited by phase shift in the X and Y amplifiers themselves. When there is no phase shift (0°) or reversal to 180°, a diagonal line will appear in one direction or the other, as in Fig. 8A. An ellipse indicates phase shift at angles between 0° and 180°, or 180° and 360°, for example at 45°, 135°, 225° and so on, until the angle is either 90° or 270° at which a full circle is displayed, as in Fig. 8A. The phase angle can be ascertained as per Fig. 8B.

LISSAJOUS PATTERNS

Determination of an unknown frequency with the aid of a known frequency and an oscilloscope can be made by the Lissajous method (after the French physicist M. Lissajous). The known frequency is conncted to say, the Y plates and the unknown to the X plates. When the unknown exactly equals the known then a circle is formed as in Fig. 9A if the signals are of equal amplitude. If the frequency difference is 2 to 1 then two loops will be formed as Fig. 9 (B and C), and so on. When the loops are above each other (turn the page sideways) the frequency ratios are reversed e.g., 1/2 or 1/3 etc.



Dual beam operation is essential in the servicing of digital equipment. Here a Telequipment model D66 is being used to fault find an electronic calculator.

LOW COST 'SCOPES

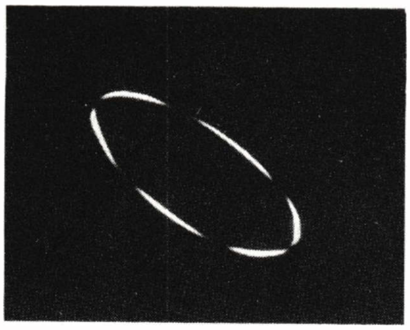


Fig. 10. Frequency comparison by Z modulation is explained in the text.

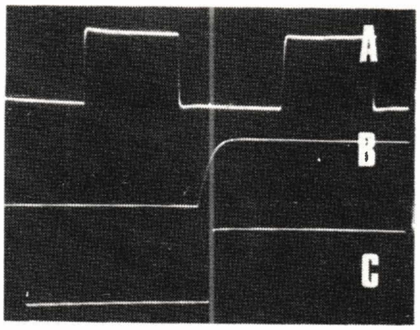


Fig. 11. (A) Appears to be a good square-wave with a fast leading edge. (B) reveals it is not so fast (several μsec) whereas (C) has a rise time of 1 μsec.

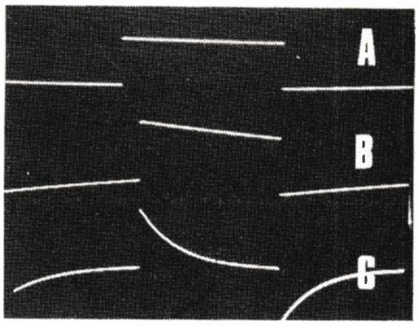


Fig. 12. Amplifier tests with square-wave (A) 1000 Hz square-wave input signal. (B) only slight slope at top indicates good response at low frequencies. (C) Curved and steep slope indicates severe loss of low frequency response.

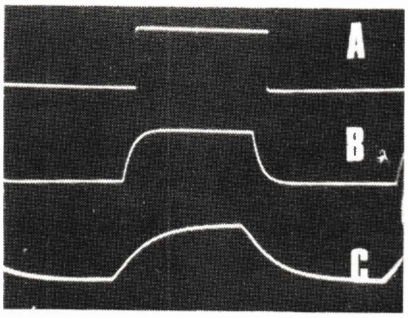


Fig. 13. Amplifier tests with square-waves. (A) 1000 Hz dquare-wave input signal. (B) indicates fairly good high frequency response falling away about 20 kHz. (C) indicates poor high frequency response falling away badly at probably less than 10 Hz.

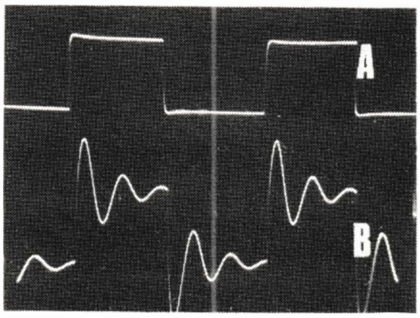


Fig. 14. Square-wave test for ringing. (A) input signal (B) Output from amplifier showing severe ringing due to inductive circuitry. Frequency of ring is about 5 kHz.

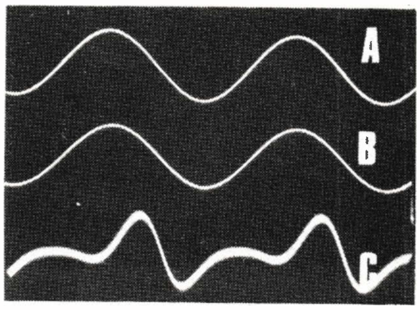


Fig. 15. Deceptive sine-waves (A) and (B) both look good but (A) has less than 0.02% distortion whereas (B) has more than 0.3% and its harmonic content is shown at (C) greatly amplified.

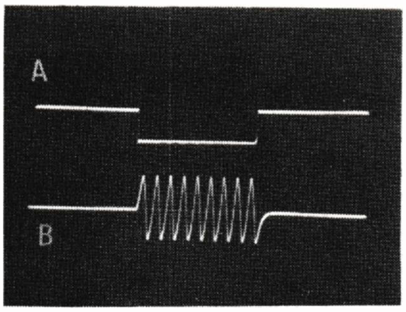


Fig. 16. Coincident pulse waveforms. See text for explanation.

A similar technique is *Z modulation* (brilliance modulation of the c.r.t.) and many 'scopes have this facility. In Fig. 10, an ellipse has been formed by phase shift (it may be a circle) of a signal of known frequency. Signals of an unknown, and in this case higher, frequency have been applied to the c.r.t. grid to produce the brilliance modulation. The ratio is determined by the number of bright or blacked out spaces which in Fig. 10 is six, i.e., a 6 to 1 ratio.

SOME AUDIO APPLICATIONS

Square-wave testing is popular with audio engineers as a ready means of estimating, among other things, the frequency response performance of amplifiers including tone controls, filters etc. A uniform square-wave with a rise-time over 10% to 90% of the leading edge of about 1μS is essential. This can be checked by using the 'scope calibration as already outlined. Don't accept what appears to be a nice looking square-wave as in Fig. 11 (A) because the leading edge *looks* fast. Opened out, it appears [as in Fig. 11 (B) and the rise-time is several micro-seconds, whereas (C) has a rise-time of better than 1μS. We cannot delve too far into the interpretation of square-wave displays as this could warrant a whole article in itself but instead give some general examples, with the aid of oscillograms, of how amplifier performance can be estimated just by looking at the display. These are shown in Figs. 12, 13 and 14. Further information on the subject will be found in the references given at the end of this article.

Figure 15 shows at (A) a good clean sine-wave, but supposing this is passed through an amplifier and appears as either (B) or (C). Both indicate what is called *clipping* and (B) is asymmetrical i.e., positive peak only clipped, whilst (C) shows symmetrical clipping with both positive and negative peaks clipped. This suggests either too much input signal and therefore overloading at the input stage, or malfunction of the amplifier due to wrong component values causing wrong operating voltages etc.

SOME GENERAL APPLICATIONS

The double beam (two trace oscilloscope is invaluable for simultaneous display of two events, each time related to the other, and Fig. 16 (A) shows a square pulse (negative going) which has been used to gate a tone burst generator (B). The trace is fast enough to display one pulse so that close examination of time relationship can be made i.e., the tone burst starts its first cycle (positive going) precisely with the leading edge of the gate pulse.

The 'scope has many uses in analysing waveforms of unknown component and Fig. 17 shows a display of the spoken word *SEE*. The timebase was triggered by the beginning of the sound so the whole

Continued on page 21

Play with a loaded deck.

CT-F9191

Packed with features from front to back, Pioneer's new CT-F9191 cassette deck stacks all the cards in your favor. A balanced combination of precision and convenience created by Pioneer to beat even the best reel-to-reel decks at their own game.

The CT-F9191 starts out by delivering top performance via access to the front. A newly designed tape carriage employs hexagonal reel shafts plus twin-link stays. The cassette is completely visible for checking tape movement and direction (a Pioneer exclusive). And since there's no rattle-prone ejection mechanism, changing tapes is a "snap."

In the CT-F9191, two motors provide the key to stable tape transport. An electronically controlled DC motor with built-in generator guarantees accurate record/play tape speed. A second motor for high speed fast-forward and rewind. As a result, wow and flutter is no more than 0.07% and speed deviation is precise within ±1.0%.

Next, a high-performance ferrite-solid head and a built-in Dolby* Type-B noise reduction system join to increase the S/N ratio to more than 62dB.

Operating the CT-F9191 is easy. Feather-touch user-oriented controls activate solenoid circuits thereby eliminating inconvenient mechanical linkages. After that, an advanced Memory Rewind device permits quick location and playback from any point on a prerecorded tape automatically. There is an automatic chrome-tape detector plus separate BIAS and EQ selection. And for making music tapes with wide dynamic range, an LED peak level indicator reacts instantly to warn of any distortion +5dB over the reference level.

Next in the series, the CT-F7171, 6161 and 2121. Created for those who want to play, but with a deck that's loaded slightly less. Of course, the stakes are lower as well.

Pioneer's new front-loading cassette decks. A full house of outstanding features. No matter how you play them, you'll wind up with a winning hand in every suit.

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178-184 Boundary Road, Braeside, Victoria 3195, Phone: 90-9011, Sydney 93-0246, Brisbane 52-8213, Adelaide 433379, Perth 76-7776

PIONEER®
leads the world in sound.

*Dolby is a trademark of Dolby Laboratories Inc.

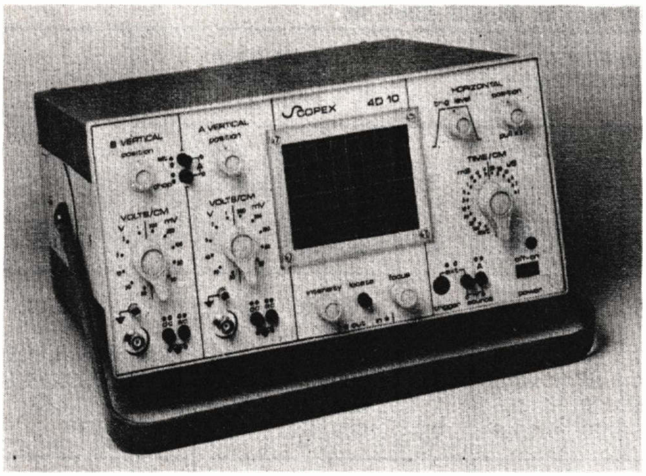
Roll over, chromium!

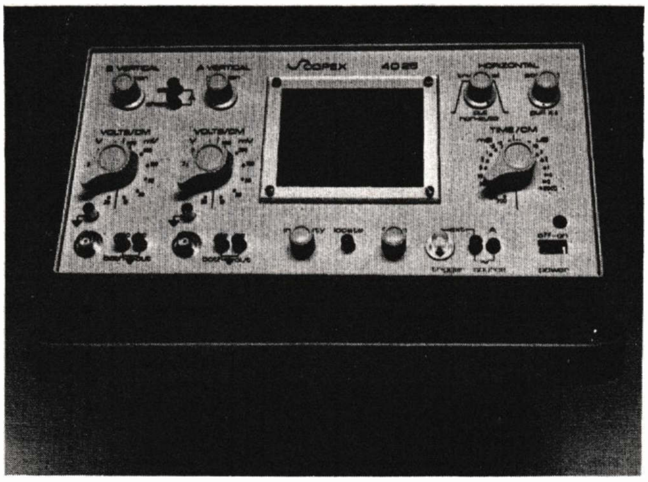
New particle: TDK has developed a new particle called Super Avilyn. It's cobalt and ferric-oxide in a single layer. It is **not** the same as so-called 'cobalt-doped' and 'cobalt-energized' tapes.
New performance: The superior high-end saturation of Super Avilyn's high-coercivity formulation (allowing it to take more high frequency energy during recording), combined with its compatibility with the CrO_2 equalization (1EC 70 microsecond time constant) results in a simultaneous suppression of high-end noise (for better S/N) and delivery of a flat response curve with better highs.
SA's performance exceeds even CrO_2, which suffered from reduced output in the middle and low frequencies (SA provides 1.5-2db more output than the best CrO_2 in those ranges, equal output at high frequency).
SA also outperforms the ferric-oxide tapes (regular and cobalt-energized) which are unable to take full advantage of the noise reduction benefits of the CrO_2 equalization because their high-end saturation characteristics are not compatible with this standard.

Ask for TDK SA Cassettes.

Australian Distributor: Convoy International Pty. Ltd.
4 Dowling Street, Woolloomooloo 2011. 358 2088.

PF 648





The Scopex 4D-25 features simple triggering, 25 MHz bandwidth and signal delay. The 4D-10 is virtually identical except that bandwith is 10 MHz and delay is not provided.

waveform of the word is displayed. The S sound is clearly definable followed by the *EE* waveform. A faster time base would show even more detail of frequency components or formats as they are called.

The trackability of pickup cartridges has become an important performances factor in the world of hi-fi and special laboratory test records are used, with the aid of an oscilloscope, to obtain instant indication of performance. An example is shown in Fig. 18 in which (A) shows a typical test signal and how it should appear on the 'scope if the trackability is good. The lower trace (B) shows poor trackability by the distortion in the pulse envelope and individual sine-waves.

It would be possible to go on almost *ad infinitum* giving examples of oscilloscope displays and their interpretation and of course literally hundreds of ways in which a 'scope can be used.

FREQUENCY SWEEP TECHNIQUES

The Oscilloscope at Work by A.Haas and R.W. Hallows. Iliffe and Sons. Last published 1959 but should be available from technical libraries. A very comprehensive work.

Servicing with the Oscilloscope by Gordon J. King. Newnes-Butterworth. New edition to be published. Excellent examples covering radio, audio and TV.

Radio and Electronics Laboratory Handbook by M.G. Scroggie. Iliffe Books. Latest edition published 1971. Informative on the use of the oscilloscope and other laboratory instruments.

The book mentioned above by Gordon J. King deals with television very thoroughly and thanks are due to him for the excellent frequency sweep oscillograms of FM tuner responses (26, 27 and 28).

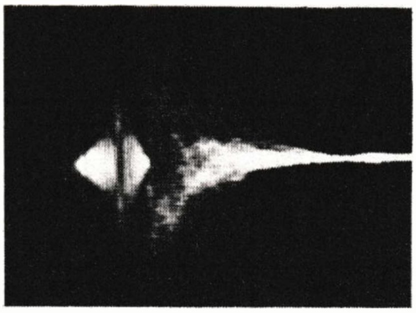


Fig.17. Spoken voice waveform of the word 'SEE'.

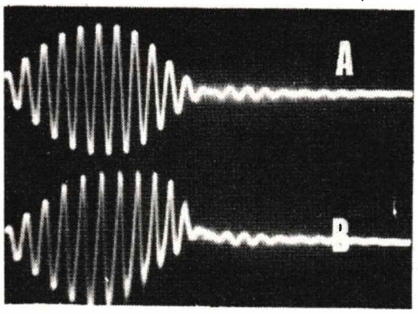
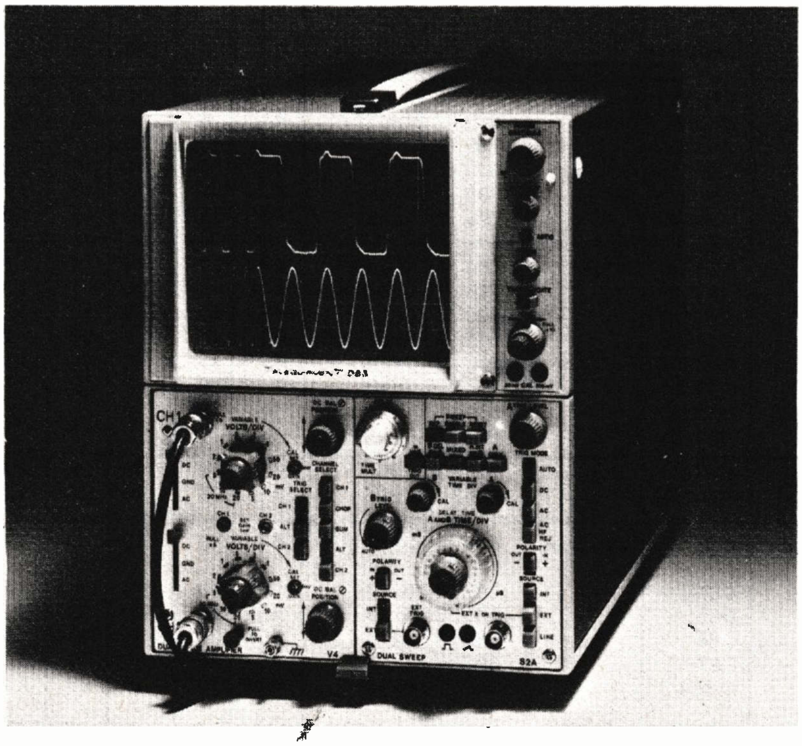


Fig.18. Pickup cartridge trackability testing. (A) Good trackability. (B) Poor trackability. See text for exaplantion.



Although not included in the survey chart, plug-in instruments such as this are available for around $1100 (including plug-ins). This instrument, the Telequipment D83, is shown fitted with a delayed-sweep time base and 50 MHz dual-trace plug-ins.

OSCILLOSCOPE SURVEY

MANUFACTURER	MODEL	DISTRIBUTOR	PRICE NOTE 5	No. OF BEAMS	SCREENSIZE (cm) NOTE 1	GRATICULE	GRATICULE LIGHT	BANDWIDTH MHz	VERTICAL SENSITIVITY			TIME BASE RANGE NOTE 2					TRIGGER MODES NOTE 3
									HIGH mV	LOW V	RANGE SEQUENCE	FAST µs	SLOW ms	VARIABLE REDUCTION	RANGE SEQUENCE	EXPAND TIMES	
Advance	OS140	Jacoby Mitchell	344	1	8x10 (8)	●		10	5	20	1,2,5	1	100	10	1,10	1,2,5	1-5,7,8,13
	OS240		384	2	8x10 (8)	●		10	5	20	1,2,5	1	100	10	1,10	1,2,5	1-5,7,8,11,13
	OS250		500	2	8x10	●		10	5	20	1,2,5	1	500	2.5	1,2,5	10	1-5,7,8,11,13
	OS250TV		556	2	8x10	●		10	5	20	1,2,5	1	500	2.5	1,2,5	10	1-7,11,13
	OS1000A		816	2	8x10	●	●	20	5	20	1,2,5	0.5	1000	2.5	1,2,5	10	1-13
Kikusui	556B	Jacoby Mitchell	261	1	8x10	●		1.5	20	20	1,10	4 ranges 10 Hz–100 kHz					1,2,9
	537		205	1	7.5	●		5	10	20	1,10	4 ranges 10 Hz–100 kHz					1,2,3,4
	558		310	1	8x10	●		7	10	10	1,10	4 ranges 10 Hz–100 kHz					1-4
BWD Note 7	504	BWD	195	1	8x10	●		6	10	50	1,2,5	0.5	100	12	1,10		auto trigger
	506		385	1	8x10	●		15	5	20	1,2,5	0.2	2000	5	1,2,5	1,5	1-6,12,13
	509B		281	1	8x10	●		10	10	50	1,2,5	1	100	12	1,10	1,5	1-4,9,12,13
	511		479	1	8x10	●		10	10	50	1,2,5	0.2	2000	5	1,2,5	1,5	1-4,7,8,9,12-14
	530A		685	2	6x10	●		20	1	20	1,2,5	0.2	2000	5	1,2,5	1,5	1-5,7-14
	539C		399	2	8x10	●		20	10	50	1,2,5	0.5	500	5	1,2,5	1,5	1-9,11-13
Dumont Note 8	5111	Warburton O'Donnell	POA	1	8x10	●		10	10	5	1,2,5	0.5	200	●	1,2,5	5	1-5,7,10,12,13
Hewlett Packard	1220A	Hewlett Packard	870	2	8x10	●		15	2	10	1,2,5	0.1	500	10X	1,2,5		1-11,13
	1221A		746	1	8x10	●		15	2	10	1,2,5	0.1	500	10X	1,2,5		1-10,13
	1222A		1038	2	8x10	●		15	2	10	1,2,5	0.1	500	10X	1,2,5		1-11,13
Leader Note 8	LB0505	Warburton O'Donnell	POA	2	8x10	●	●	10	10	5	1,2,5	1	200		1,2,5	10	1-6,10-13
	LB0301		"	1	8x10 (6)	●		5	10	5	1,2,5	1	200		1,2,5	5	1-6,12
	LB0512		"	1	8x10	●		8	10		1,10	100 kHz to 10 Hz		●	1,10		1,2
	LB0510		"	1	8x10	●		4	20	2	1,10	100 kHz to 10 Hz		●	1,10		1-4,9
	LB0310A		"	1	8x10 (6)	●		4	20	2	1,10	100 kHz to 10 Hz		●	1,10		
National	VP5601A	Scientific Devices	610	1					10	30		0.3	100		1,3		1-4,12,13
	VP5601T		660	1	4x6 (4.5)	●		5	10	30	1,3	0.3	10	10X	1,3		1-6,12,13
	VP5602A		739	2					30	1		1	100	10X	1,3		1-4,12,13
	VP5107A		316	1	8x10	●		7	20	10	1,2,5	1	100	5X	1,3		1-4,12,13
	VP5107T		325	1	8x10	●		7	20	10	1,2,5	1	100	5X	1,3		1-6,12,13
	VP5105A		295	1	8x10	●		5	20	10	1,2,5	1	100	5X	1,3		1-4,12,13
Philips	PM3000	Philips	654	1	4x6 (4.5)	●		5	10	5	1,2,5	0.3	100		1,2,5		1-4,10,12,13
	PM3010		725	2	4x6 (4.5)	●		5	30	1	1,3,10	1	100		1,2,5	10	1-4,10,11,12,13
	PM3110		699	2	8x10	●		10	50	50	1,2,5	0.5	50	2.5X	1,2,5	5	1-6,9,11
	PM3200		516	1	8x10 (7.5)	●		15	2	50	1,2,5	0.1	500		1,2,5		1-4,7-10,13
	PM3232		1138	2	8x10	●	●	10	2	10	1,2,5	0.2	500	●	1,2,5	5	1-9,11-13
	PM3233		1164	2	8x10	●	●	10	2	10	1,2,5	0.2	500	●	1,2,5	5	1-9,11-13
	PM3225		581	1				15	2	new releases — no other details available at time of printing							
	PM3226		811	2				15	2								
Scopex	4D-10	Arlunya	349	2	6x8	●		10	10	50	1,2,5	1	100		1,2,5	5	1,2,9,12,13
	4D-25		669	2	6x8	●		25	10	50	1,2,5	0.2	200		1,2,5	5	1,2,9,12,13
Telequipment Note 7	D32	Tektronix	699	2	8x10 (7)	●		10	10	5	1,2,5	0.5	500	5X	1,2,5		1-7,10-13
	D61		349	2	8x10	●		10	10	5	1,2,5	0.5	500	5X	1,2,5		1-7,10-13
	D65		688	2	8x10	●	●	15	10	50	1,2,5	0.1	2000	2.5	1,2,5	5	1-8,11,13,14
	D66		749	2	8x10	●	●	25	10	50	1,2,5	0.1	2000	2.5	1,2,5	5	1-8,11,13,14
	D67		899	2	8x10	●	●	25	10	50	1,2,5	0.2	2000	2.5	1,2,5	5	1-8,10-14
	DM64		949	2	8x10	●	●	10	10	50	1,2,5	0.1	2000	2.5	1,2,5	5	1-8,11-14
Trio	CO1303A	Parameters	167	1	6x6	●		1.5	20	2	1,10	100 kHz–10 Hz			1,10		1
	CS1351		431	1	8x10 (7.5)	●		10	10	20	1,2,5	0.5	500	●	1,2,5	5	1-6,13
	CS1557		295	1	8x10	●		10	10	20	1,2,5	0.5	500	●	1,2,5	5	1-6,13
	CS1560		399	2	8x10	●		15	10	20	1,2,5	0.5	500	●	1,2,5	5	1-6,11-13

DUAL BEAM MODES NOTE 4	MODES DISPLAY NOTE 6	INPUT SOCKET	Z MOD	DELAY	CALIBRATOR	DIMENSIONS (mm)	REMARKS
	1	BNC	●		●	132x270x317	
3	1,2,5	BNC	●		●	132x270x317	
3	1,2,5	BNC	●		●	180x290x420	
3	1,2,5	BNC	●		●	180x290x420	internal sync separator for TV
3	1-5	BNC	●	50 ns fixed	●	180x290x420	internal sync separator for TV
	1	Banana			●	167x275x440	
	1	N			●	200x155x155	
	1	N			●	175x260x460	
		Banana				182x198x405	
	1	BNC	●		●	235x190x419	
	1	Banana	●		●	240x190x420	
	1,6	BNC	●		●	230x180x410	rechargeable battery version available at $1040
1,2	1-4	BNC	●	20 ns	●	165x320x430	optional battery supply available
1,2	1,2	BNC	●		●	240x190x430	
	1	BNC			●	228x164x420	
3	1,2,5	BNC				181x312x412	fitted with beam finder
	1	BNC				181x312x412	fitted with beam finder
3	1-5	BNC		●		181x310x412	fitted with beam finder X5 vertical expansion
1,2	1-5	BNC	●			185x250x380	
	1	N			●	120x200x300	
	1	N				270x175x422	
	1	BNC			●	250x180x415	
	1	Banana				180x125x300	
	1	BNC					built in battery supply
	1	BNC				125x 80x196)	optional ac adaptor/charger
3	1,2	BNC					available
	1	BNC				220x150x390	
	1	BNC			●	220x150x390	
	1	BNC				220x150x390	
	1					80x125x196	supplied with ac adaptor charger.
3	1,2					80x125x196)	Rechargeable battery optional extra
3	1,2	BNC				195x305x455	X10 vertical sensitivity switch ac only
	1	BNC				175x210x330	can be operated with external 24 Vdc supply
4	1,2,5	BNC			●	185x326x503	
4	1,2,5	BNC	●	150 ns	●	185x326x503	
1,2	1,2	BNC				153x312x350	fitted with beam finder
1,2	1,2	BNC				153x312x435)	
3	1,2				●	105x130x288	built in rechargeable batteries and charger
3	1,2,5	BNC			●	160x280x420	
1,2	1-5	BNC	●	200 ns	●	240x210x370	
1,2	1-5	BNC	●	200 ns	●	240x210x370	switched X10 vertical
1,2	1-4	BNC		200 ns	●	240x210x440	variable delayed sweep facilities
1,2	1-5	BNC	●		●	240x210x370	X10 vertical gives 1 mV sens. storage scope up to 1 hr view time
	1	Banana				180x130x350	
	1	N			●	200x135x300	
	1	N			●	225x195x400	
3	1-5	BNC			●	250x200x370	

NOTES

1. SCREEN SIZE
If graticule dimensions are not in cms figure in brackets indicates size in mm.

2. TIMEBASE RANGE
Quoted speeds are calibrated per division. Timebase variable reduction ratio is quoted in VARIABLE REDUCTION column. Where figure is followed by 'X' it is an expansion ratio. Fixed accurate switched expansion ratios are indicated in EXPAND column.

3. TRIGGER MODES
1. Internal or Y1
2. External
3. +
4. –
5. TV frame
6. TV Horizontal
7. AC
8. AC fast (HP filter)
9. Line
10. Free run
11. Y2
12. Auto
13. Level control
14. Single sweep

4. DUAL BEAM MODES
1. Chopped
2. Alternate
3. Auto select (1 & 2)
4. True dual beam CRT

5. PRICES
Prices are quoted at time of printing and may vary without notice.
They are inclusive of duty but exclude 15% sales tax.
Accessories such as probes etc are usually optional extras.

6. DISPLAY MODES
1. Y1
2. Y2
3. Y1 + Y2
4. Y1 – Y2
5. XY (Y2 = X)
6. differential input

7. EXCLUSIONS
Some companies have main frame/plug scopes which fall within ≈$1000 range. Due to specification complexity these have not been included in survey. Details available from company concerned.
Products surveyed are typical of those available in Australia. Not all companies are necessarily included.

8. PRICE ON APPLICATION
Prices well under $1000 but not released at time of survey.

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555 TIMERS	5 for $3.00
IC SOCKETS 8, 14 or 16 PIN	5 for $2.00

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4001	.35	4027	1.25
4002	.35	4028	2.50
4006	2.75	4029	2.75
4007	.40	4030	1.00
4009	1.00	4035	2.90
4010	1.00	4040	3.00
4011	.35	4044	2.45
4012	.35	4046	4.80
4013	1.25	4049	1.00
4014	2.75	4050	1.00
4015	2.50	4060	3.00
4016	1.00	4071	.45
4017	2.65	4081	.45
4018	2.80	4416	1.00
4019	1.00	4426	3.50
4020	2.95	4449	.45
4021	2.60	4511	2.65
4022	2.25	4518	2.60
4023	.45	4520	2.60
4024	2.75	14553	7.60

CMOS 74c SERIES

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74C04	.35	74C192	2.90
74C10	.35	74C193	2.90
74C14	1.60	74C221	2.35
74C48	3.30	74C89	14.00
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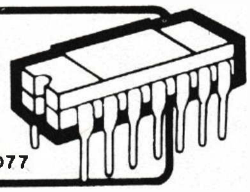

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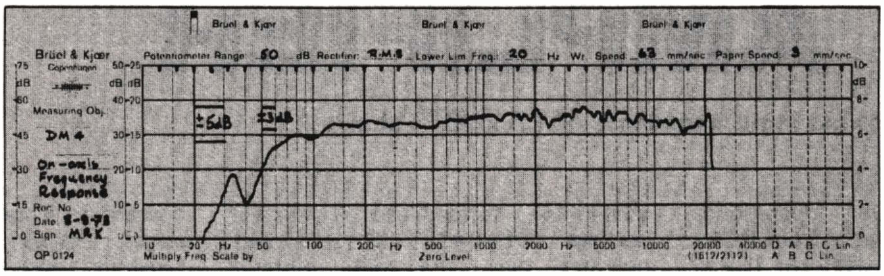

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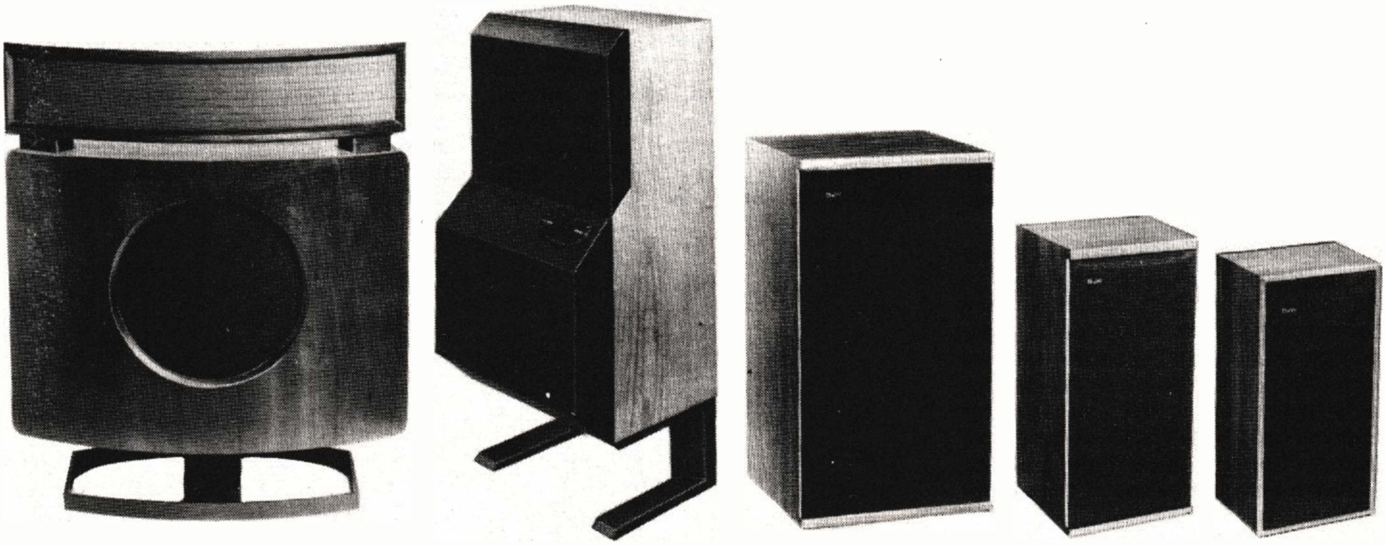

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THE CA3130 OPERATIONAL AMPLIFIER

Versatile new device has input impedance of 1.5×10^{12} ohms.

A NEW COSMOS operational amplifier is now available from RCA. It has several unusual features. It is a device which combines the advantages of both CMOS and bipolar transistors on a single monolithic chip.

The device, the RCA type CA3130, uses gate protected, p-channel MOS/FET (PMOS) transistors in the input circuit to obtain very high input impedance, very low input current, and exceptional speed performance.

The use of PMOS field-effect transistors in the input stage results in common-mode input-voltage capability down to 0.5 volt below the negative-supply terminal, an important attribute in single-supply applications.

The output circuit consists of a complementary-symmetry MOS (COS/MOS) transistor pair, capable of swinging the output voltage to within millivolts of either supply voltage terminal (at very high values of load impedance).

The CA3130 Series circuits operate at supply voltages ranging from 5 to 16 volts, or ±2.5 to ±8 volts when using split supplies. They can be phase compensated with a single external capacitor, and have terminals for adjustment of offset voltage for applications requiring offset-null capability. Terminal provisions are also made to permit strobing of the output stage.

The CA3130 Series is supplied in either the standard 8-lead TO-5-style package (T suffix) or in the 8-lead dual-in-line formed-lead TO-5-style package "DIL-CAN" (S suffix) and operates over the full military-temperature range of −55°C to +125°C. The CA3130B is intended for applications requiring premium-grade specifications and with limits established for: input current, temperature coefficient of input-offset voltage, and gain over the range of −55°C to +125°C. The CA 3130A offers superior input characteristics over those of the CA3130.

CIRCUIT DESCRIPTION

Fig. 3 is a block diagram of the CA3130 Series COS/MOS Operational Amplifiers. The input terminals may be operated down to 0.5 V below the negative supply rail, and the output can be swung very close to either supply rail in many applications. Consequently, the CA3130 Series circuits are ideal for single supply operation. Three Class A amplifier stages, having the individual gain capability and current consumption shown in Fig. 3, provide the total gain of the CA3130. A biasing circuit provides two potentials for common use in the first and second stages. Term. 8 can be used both for phase compensation and to strobe the output stage into quiescence. When Term. 8 is tied to the negative supply rail (Term. 4) by mechanical or electrical means, the output potential at Term. 6 essentially rises to the positive supply rail potential at Term. 7. This condition of essentially zero current drain in the output stage under the strobed "OFF" condition can only be achieved when the ohmic load resistance presented to the amplifier is very high (e.g. when the amplifier output is used to drive COS/MOS digital circuits in comparator applications).

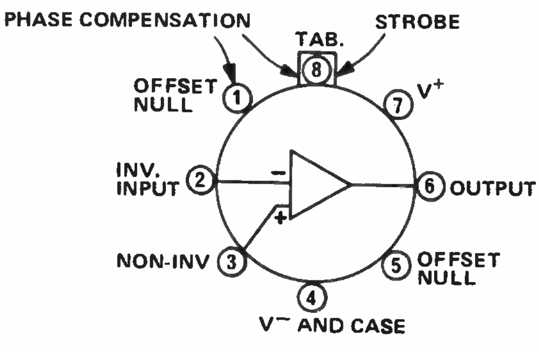


Fig. 1. Functional diagram of the CA3130.

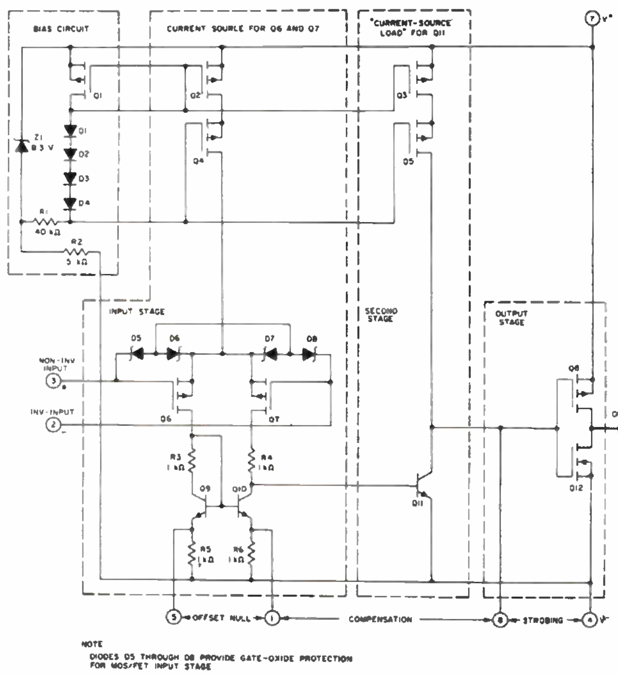


Fig. 2. Schematic diagram of the CA3130.

TABLE 1

MAXIMUM RATINGS, *Absolute-Maximum Values*

DC Supply Voltage (between V^+ and V^- terminals) . . 16 V
Differential-mode input voltage . . ±8 V
Common-mode DC input voltage . . . . V^+ to (V^- −0.5 V)
Input-terminal current . . . . 1 mA
Device Dissipation:
without heat sink-
up to 55°C . . . . 630 mW
above 55°C . . Derate linearly 6.67 mW/°C
With heat sink –
at 125°C . . . . 418 mW
below 125°C . Inc. lin. at 16.7 mW/°C
Temperature range operating . . . . . . −55 to +125°C
Output short-circuit duration* . . . . Infinite

* Short circuit may be applied to ground or to either supply.

CHARACTERISTIC	SYMBOL	TEST CONDITIONS V^+=15 V V^-=0 V T_A=25°C (Unless Specified Otherwise)	CA3130 Min.	CA3130 Typ.	CA3130 Max.	UNITS
Input Offset Voltage	$\lvert V_{IO}\rvert$	$V^{\pm}$=±7.5 V	–	8	15	mV
Input Offset Current	$\lvert I_{IO}\rvert$	$V^{\pm}$=±7.5 V	–	0.5	30	pA
Input Current	I_I	$V^{\pm}$=±7.5 V	–	5	50	pA
Large-Signal Voltage Gain	A_{OL}	V_O=10 $V_{p\text{-}p}$	50 k	320 k	–	V/V
		R_L=2 kΩ	94	110	–	dB
Common-Mode Rejection Ratio	CMRR		70	90	–	dB
Common-Mode Input-Voltage Range	V_{ICR}		0	−0.5 to 12	10	V
Power-Supply Rejection Ratio	$\Delta V_{IO}/\Delta V^+$	$V^{\pm}$=±7.5 V	–	32	320	µV/V
	$\Delta V_{IO}/\Delta V^-$		–	32	320	
Maximum Output Voltage	V_{OM}^+	R_L = 2 kΩ	12	13.3	–	V
	V_{OM}^-		–	0.002	0.01	
	$\lvert V_{OM}^+\rvert$	R_L = ∞	14.99	15	–	
	$\lvert V_{OM}^-\rvert$		–	0	0.01	
Maximum Output Current: Source	I_{OM}^+	V_O=0 V	12	22	45	mA
Sink	I_{OM}^-	V_O=15 V	12	20	45	
Supply Current	I^+	V_O=7.5 V R_L=∞	–	10	15	mA
		V_O=0 V R_L=∞	–	2	3	
Input Current	I_I		–	Fig. 11	–	nA
Input Offset Voltage Temperature Drift	$\Delta V_{IO}/\Delta T$	T_A= −55 to 125°C $V^{\pm}$= ±7.5 V▲ V_O=10 $V_{p\text{-}p}$* R_L=2 kΩ*	–	10	–	µV/°C
Large-Signal Voltage Gain	A_{OL}		–	320 k	–	V/V
			–	110	–	dB

* Applies only to A_{OL}.
▲ Applies only to I_I and $\Delta V_{IO}/\Delta T$.

HANDLING

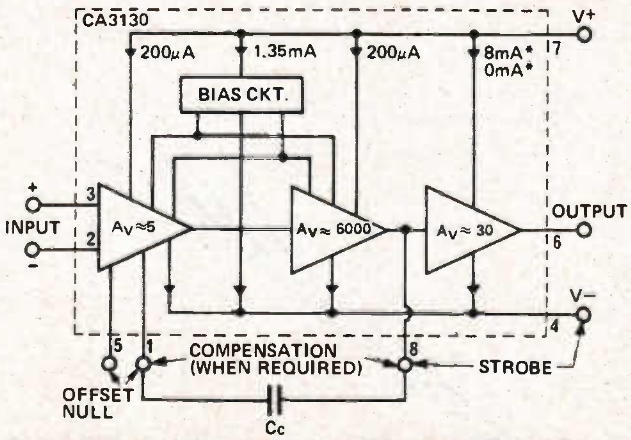
The CA3130 uses MOS field-effect transistors in the input circuit. Because MOS/FET's have extremely high input resistances, they are susceptible to damage when exposed to extremely high static electrical charges. To minimize the possibilities of damaging the input stage transistors, Q6 and Q7, the CA3130 utilizes a protective diode network in the input stage.

TABLE 2

CHARACTERISTIC	SYMBOL	TEST CONDITIONS V^+=+7.5 V V^-=−7.5 V T_A=25°C	CA3130	UNITS
Input Offset Voltage Adjustment Range		10 kΩ across Terms. 4 and 5 or 4 and 1	±22	mV
Input Resistance	R_I		1.5	TΩ
Input Capacitance	C_I	f = 1 MHz	4.3	pF
Equivalent Input Noise	e_n	BW=0.2 MHz R_S=1 MΩ*	23	µV
Unity Gain Crossover Frequency	f_T	C_C = 0	15	MHz
		C_C = 47 pF	4	
Slew Rate: Open Loop	SR	C_C = 0	30	V/µs
Closed Loop		C_C = 56 pF	10	
Transient Response: Rise Time	t_r	C_C = 56 pF C_L = 25 pF R_L = 2 kΩ (Voltage follower)	0.09	µs
Overshoot			10	%
Setting Time (4 Vp-p Input to <0.1%)			1.2	µs

* Although a 1-MΩ source is used for this test, the equivalent input noise remains constant for sources of R_S up to 10 MΩ.

CHARACTERISTIC	SYMBOL	TEST CONDITIONS V^+ = 5 V V^- = 0 V T_A = 25°C	CA3130	UNITS
Input Offset Voltage	V_{IO}		8	mV
Input Offset Current	I_{IO}		0.1	pA
Input Current	I_I		2	pA
Common-Mode Rejection Ratio	CMRR		80	dB
Large Signal	A_{OL}	V_O = 4 Vp-p	100 k	V/V
Voltage Gain		R_L = 5 kΩ	100	dB
Common-Mode Input Voltage Range	V_{ICR}		0 to 2.8	V
Supply Current	I^+	V_O = 5 V, R_L = ∞	300	µA
		V_O=2.5 V, R_L = ∞	500	
Power Supply Rejection Ratio	$\Delta V_{IO}/\Delta V^+$		200	µV/V



TOTAL SUPPLY VOLTAGE (FOR INDICATED VOLTAGE GAINS) = 15V
* WITH INPUT TERMINALS BIASED SO THAT TERM 6 POTENTIAL IS +7.5V ABOVE TERM 4
* WITH OUTPUT TERMINAL DRIVEN TO EITHER SUPPLY RAIL

Fig. 3. Block diagram of the CA3130 illustrates how the device is organized.

THE CA3130 OPERATIONAL AMPLIFIER

Nevertheless, it is good practice that the following precautions be observed during handling, testing and actual operation of the CA3130 devices to minimize exposure to damage-inducing hazards:

1. Soldering-iron tips, metal parts of fixtures, tools, and handling facilities should be grounded.
2. Devices should not be inserted into or removed from circuits with the power ON because transient voltages may cause damage.
3. Signals should not be applied to the input (Terms. 2 and 3) when the device power supply is OFF. Input-terminal currents should not exceed 1 mA.
4. After CA3130 devices have been mounted on circuit boards, proper handling precautions should still be observed if the input terminals are unterminated. It is good practice during board-processing operations to return Terms. 2 and 3 to Term. 4 by jumping the appropriate conductors.

OFFSET NULLING

Offset-voltage nulling is usually accomplished with a 100,000-ohm potentiometer connected across Terms. 1 and 5 and with the potentiometer slider arm connected to Term. 4. A fine offset-null adjustment usually can be effected with the slider arm positioned in the mid-point of the potentiometer's total range.

INPUT-CURRENT VARIATION WITH TEMPERATURE

The input current of the CA3130 Series circuits is typically 5pA at 25°C. The major portion of this input current is due to leakage current through the gate-protective diodes in the input circuit. As with any semiconductor-junction device, including op amps with a junction-FET input stage, the leakage current approximately doubles for every 10°C increase in temperature. Fig. 7 provides data on the typical variation of input bias current as a function of temperature in the CA3130.

In applications requiring the lowest practical input current and incremental increases in current because of "warm-up" effects, it is suggested that an appropriate heat sink be used with the CA3130. In addition, when "sinking" or "sourcing" significant output current the chip temperature increases, causing an increase in the input current. In such cases, heat-sinking can also very markedly reduce and stabilize input current variations.

INPUT-OFFSET-VOLTAGE (V_{IO})

It is well known that the

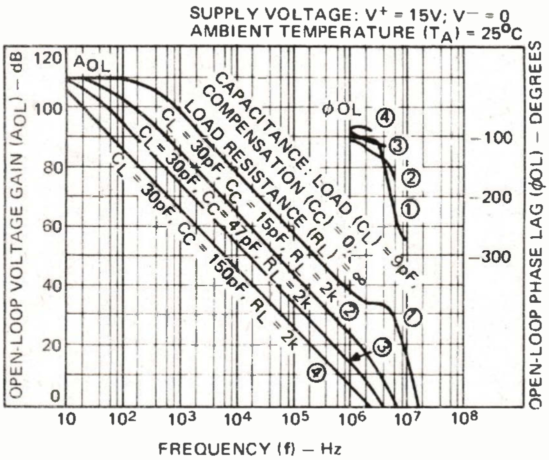


Fig. 4. Open loop voltage gain and phase shift versus frequency for various values of C_L, C_C and R_L.

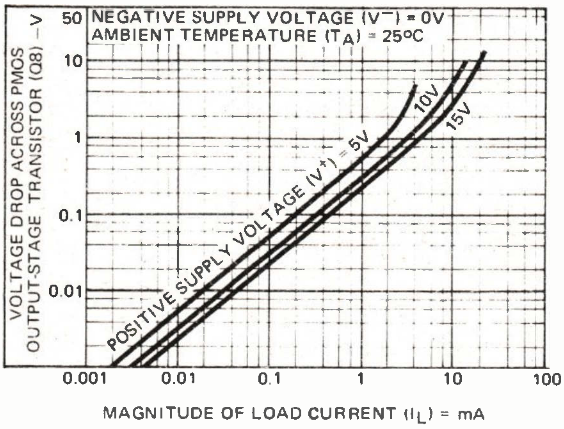


Fig. 5. Voltage across the PMOS output transistor, Q8, versus load current.

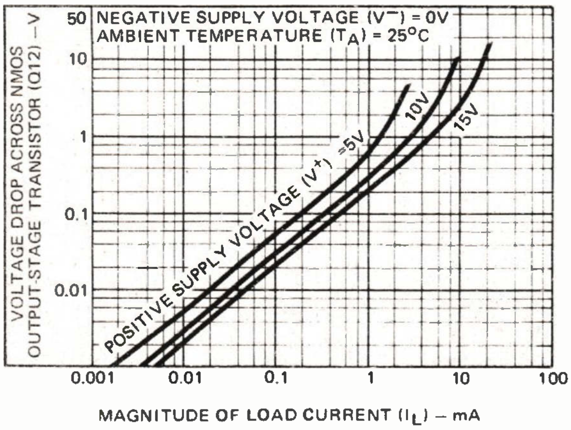


Fig. 6. Voltage across NMOS output transistor, Q12, versus load current.

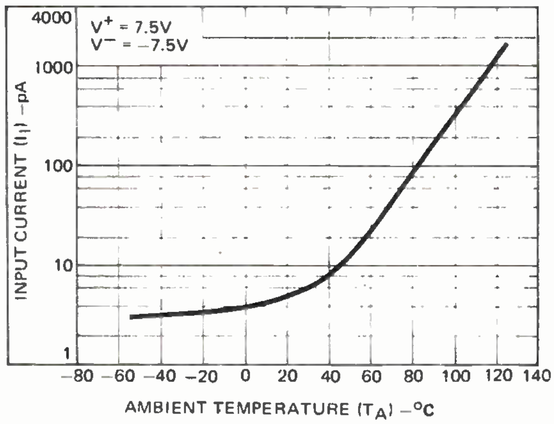


Fig. 7. Input current variation with ambient temperature change.

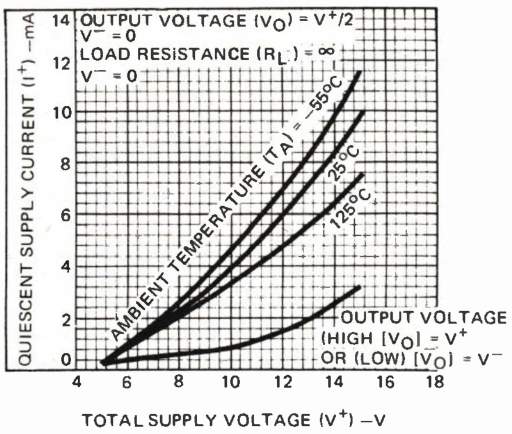


Fig. 8. Quiescent supply current versus supply voltage at several temperatures.

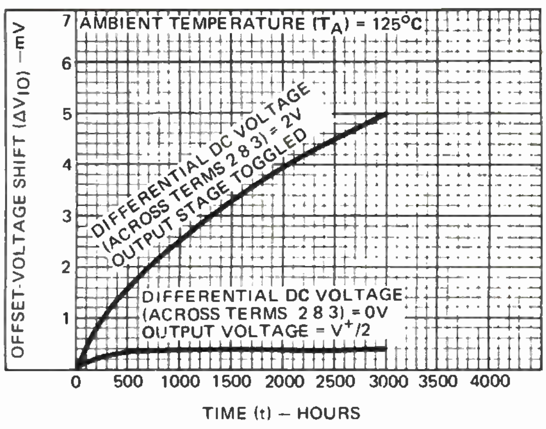


Fig. 9. Typical incremental shift in offset voltage versus operating life.

characteristics of a MOS/FET device can change slightly when a dc gate-source bias potential is applied to the device for extended time periods. The magnitude of the change is increased at high temperatures. Users of the CA3130 should be alert to the possible impacts of this effect if the application of the device involves extended operation at high temperatures with a significant differential dc bias voltage applied across Terms. 2 and 3. Fig. 9 shows typical data pertinent to shifts in offset voltage encountered with CA3130 devices during life testing. The two-volt dc differential voltage example represents conditions when the amplifier output stage is "toggled", e.g., as in comparator applications.

WIDEBAND NOISE

For low-noise performance the CA3130 is most advantageous in applications wherein the source resistance of the input signal is 1 megohm or more. In this case, the total input-referred noise voltage is typically only 23 µV when a test-circuit amplifier is operated at a total supply voltage of 15 volts. This value of total input-referred noise remains essentially constant, even though the value of source resistance is raised by an order of magnitude. This characteristic is due to the fact that reactance of the input capacitance becomes a significant factor in shunting the source resistance. It should be noted, however, that for values of source resistance very much greater than 1 megohm, the total noise voltage generated can be dominated by the thermal noise contributions of both the feedback and source resistors.

VOLTAGE FOLLOWERS

Operational amplifiers with very high input resistances, like the CA3130, are particularly suited to service as voltage followers. Fig. 10a shows the circuit of a classical voltage follower, using the CA3130 in a split-supply configuration.

A voltage follower, operated from a single supply, is shown in Fig. 10b. This follower circuit is linear over a wide dynamic range.

The follower does not lose its input-to-output phase-sense, even though the input is swung 7.5 volts below ground potential. This unique characteristic is an important attribute in both operational amplifier and comparator applications. The COS/MOS output stage also permits the output signal to swing down to the negative supply-rail potential (i.e. ground in the case shown). The digital-to-analog converter (DAC) circuit, described in the following section, illustrates the practical use of the CA3130 in a single-supply voltage-follower application.

9-BIT COS/MOS DAC

The circuit of a 9-bit Digital to Analog Converter (DAC) is shown in Fig. 11. This system combines the concepts of multiple-switch COS/MOS IC's, a low-cost ladder network of discrete metal-oxide film resistors, a CA3130 op-amp connected as a follower, and an inexpensive monolithic regulator in a simple single power-supply arrangement. An additional feature of the DAC is that it is readily interfaced with COS/MOS input logic, e.g. 10-volt logic levels are used in the circuit of Fig. 11.

The circuit uses an R/2R voltage-ladder network, with the output potential obtained directly by terminating the ladder arms at either the positive or the negative power-supply terminal. Each CD4007A contains three "inverters", each "inverter" functioning as a single-pole double-throw switch to terminate an arm of the R/2R network at either the positive or negative power-supply terminal. The resistor ladder is an assemply of one per cent tollerance metal-oxide film resistors. The five arms requiring the highest accuracy are assembled with series and parallel combinations of 806,000-ohm

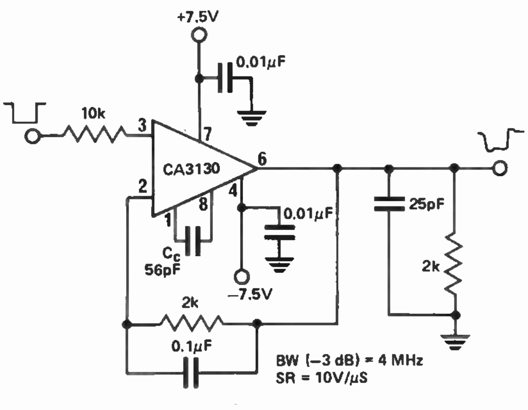


Fig. 10. Voltage follower circuit with split supply of plus and minus 7.5 volts. This circuit allows low impedance loads to be driven from a high impedance source.

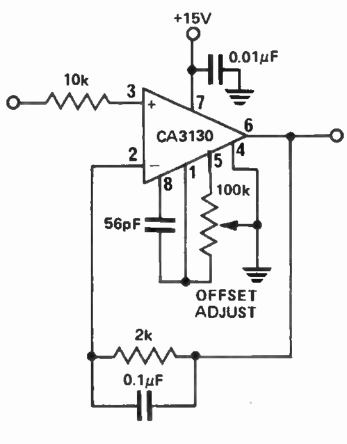
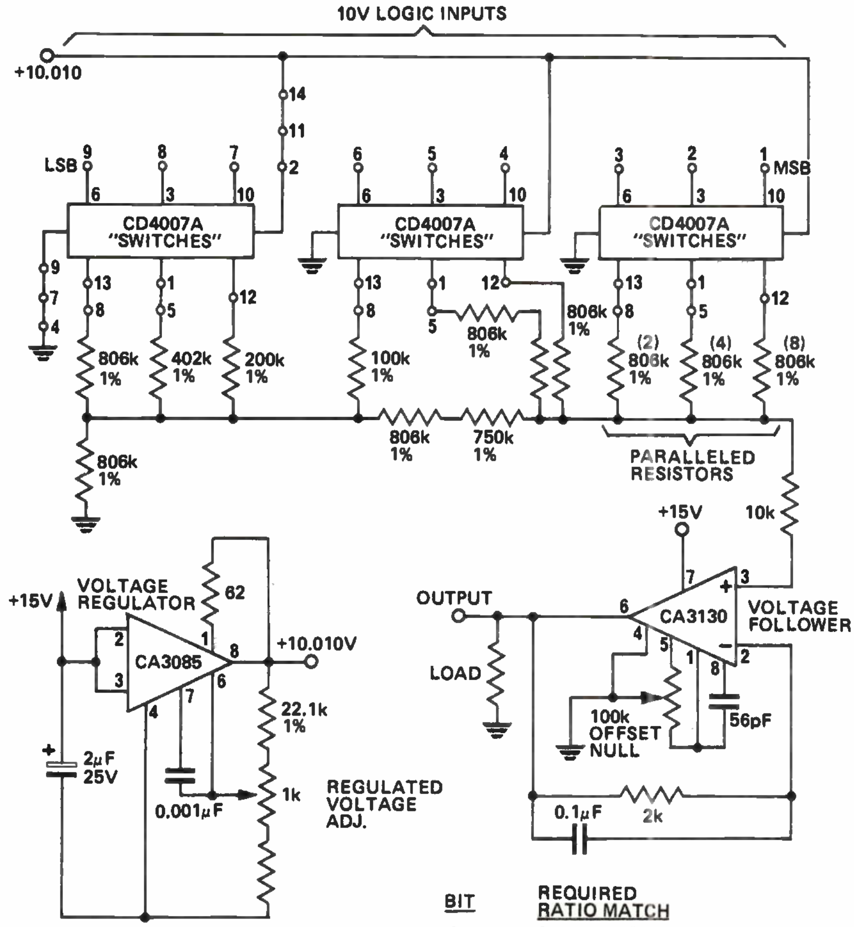


Fig. 10b. Voltage follower operating on single supply rail.

THE CA3130 OPERATIONAL AMPLIFIER



BIT	REQUIRED RATIO MATCH
1	STANDARD
2	±0.1%
3	±0.2%
4	±0.4%
5	±0.8%
6-9	±1% ABS

ALL RESISTORS IN OHMS.

Fig.11. Nine-bit digital-to-analogue converter uses CMOS digital switches and the CA3130.

resistors from the same manufacturing lot.

A single 15-volt supply provides a positive bus for the CA3130 follower amplifier and feeds the CA3085 voltage regulator. A "scale-adjust" function is provided by the regulator output control, set to a nominal 10-volt level in this system. The line-voltage regulation (approximately 0.2%) permits a 9-bit accuracy to be maintained with variations of several volts in the supply. The flexibility afforded by the COS/MOS building blocks simplifies the design of DAC systems tailored to particular needs.

SINGLE-SUPPLY, ABSOLUTE-VALUE, IDEAL FULL-WAVE RECTIFIER

An absolute-value circuit, using the CA3130 is shown in Fig. 12 . During positive excursions, the input signal is fed through the feedback network directly to the output. Simultaneously, the positive excursion of the input signal also drives the output terminal (No.6) of the inverting amplifier negative such that the 1N914 diode effectively disconnects the amplifier from the signal path. During a negative-going excursion of the input signal, the CA3130 functions as a normal inverting amplifier with a gain equal to −R2/R1. When the equality of the two equations shown in Fig. 12. is satisfied, the full-wave output is symmetrical.

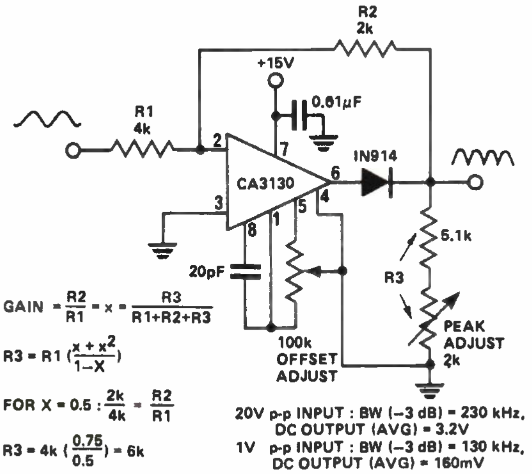
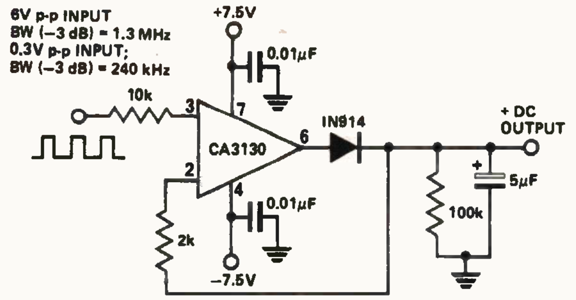


Fig. 12. An absolute value full-wave detector provides the average of the input waveform. This is useful for converting dc meters, eg digital voltmeters to read the average of the ac input signal.

PEAK DETECTORS

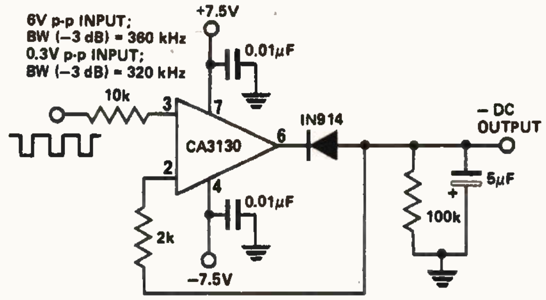
Peak-detector circuits are easily implemented with the CA3130, as illustrated in Figs. 13 and 14 for both the peak-positive and the peak-negative circuit. It should be noted that with large-signal inputs, the bandwidth of the peak-negative circuit is much less than that of the peak-positive circuit. The second stage of the CA3130 limits the bandwidth in this case.

Negative-going output-signal excursion requires a positive going signal excursion at the collector of transistor Q11, which is loaded by the intrinsic capacitance of the associated circuitry in this mode. On the other hand, during a negative-going signal excursion at the collector of Q11, the transistor functions in an active "pull-down" mode so that the intrinsic capacitance can be discharged more expeditiously.



(a) PEAK POSITIVE DETECTOR CIRCUIT

Fig. 13. Peak positive detector circuit. Detectors such as this are ideal for building accurete ac voltmeters.



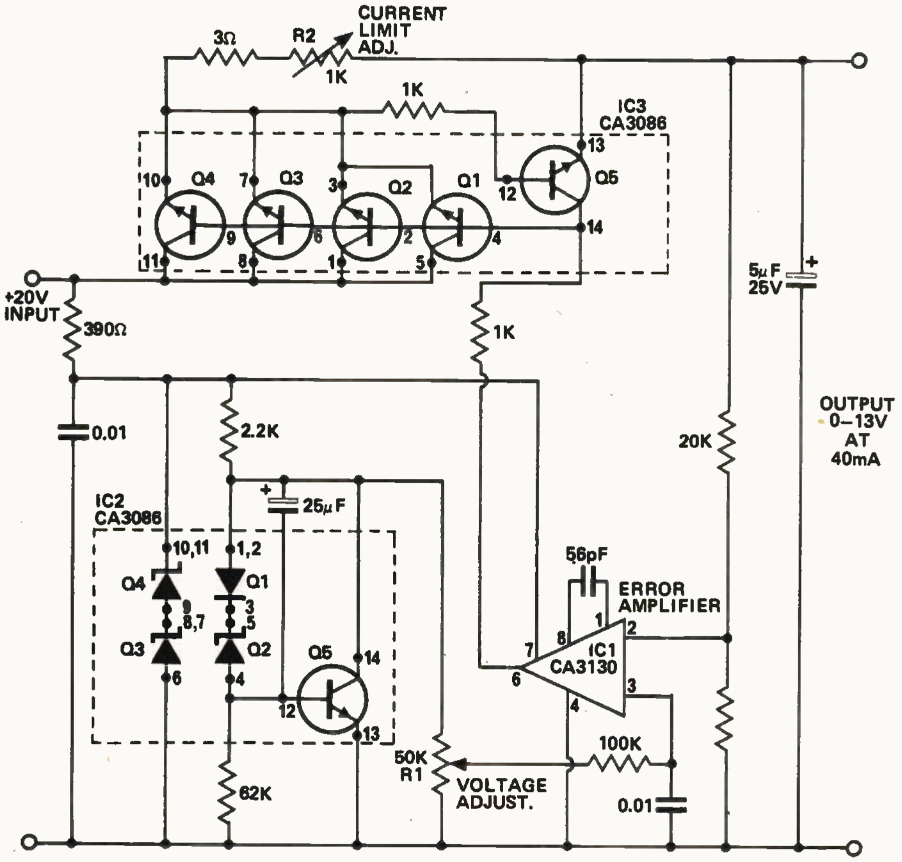
(b) PEAK NEGATIVE DETECTOR CIRCUIT

Fig. 14. The peak negative detector, although only requiring a reversal of the detector diode gives different bandwidth characteristics.

ERROR-AMPLIFIER IN REGULATED POWER SUPPLIES

The CA3130 is an ideal choice for error-amplifier service in regulated power supplies since it can function as an error-amplifier when the regulated output voltage is required to approach zero. Fig. 15 shows the schematic diagram of a 40 mA power supply capable of providing regulated output voltage by continuous adjustment over the range from 0 to 13 volts. Q3 and Q4 in IC2 (a CA3086 transistor-array IC) function as zeners to provide supply-voltage for the CA3130 comparator (ICI), Q1, Q2, and Q5 in IC2 are configured as a low impedance, temperature-compensated source of adjustable reference voltage for the error amplifier. Transistors Q1, Q2, Q3, and Q4 in IC3 (another CA3086 transistor-array IC) are connected in parallel as the series-pass element. Transistor Q5 in IC3 functions as a current-limiting device by diverting base drive from the series-pass transistors, in accordance with the adjustment of resistor R2.

Fig. 16 contains the schematic diagram of a regulated power-supply capable of providing regulated output voltage by continuous adjustment over the range from 0.1 to 50 volts and currents up to 1 ampere. The error amplifier (ICI) and circuitry associated with IC2 function as previously described although the output of ICI is boosted by a discrete transistor (Q4) to provide adequate base drive for the Darlington-connected series-pass transistors Q1, Q2. Transistor Q3 functions in the previously described current-limiting circuit.



REGULATION (NO LOAD TO FULL LOAD): < 0.01%
INPUT REGULATION: 0.02%/V
HUM AND NOISE OUTPUT: < 25μV UP TO 100 kHz

Fig. 15. This voltage regulator circuit provides 0 to 13 volts at up to 40 mA with good regulation and low hum and noise.

MULTIVIBRATORS

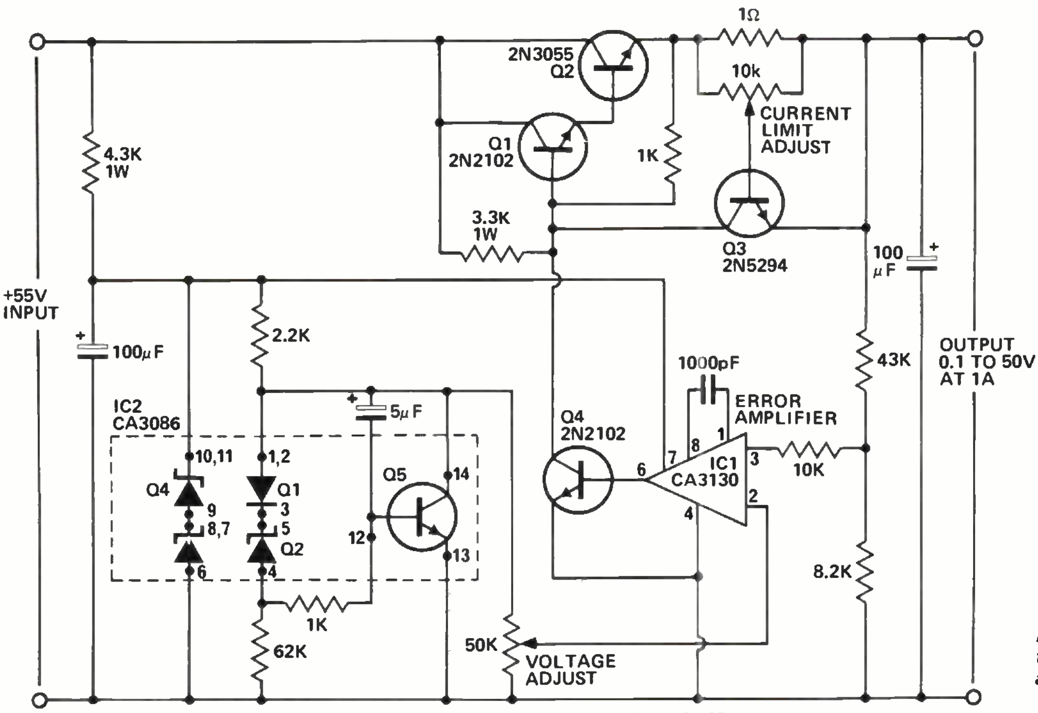
The exceptionally high input resistance presented by the CA3130 is an attractive feature for multivibrator circuit design because it permits the use of timing circuits with high R/C ratios. The circuit diagram of a pulse generator (astable multivibrator), with provisions for independent control of the "on" and "off" periods, is shown in Fig. 17. Resistors R1 and R2 are used to bias the CA3130 to the mid-point of the supply-voltage and R3 is the feedback resistor.

FUNCTION GENERATOR

Fig. 18 shows a function generator using the CA3130 in the integrator and threshold detector functions. This circuit generates a triangular or square-wave output that can be swept over a 1,000,000:1 range (0.1 Hz to 100 kHz) by means of a single control, R1. A voltage-control input is also available for remote sweep-control.

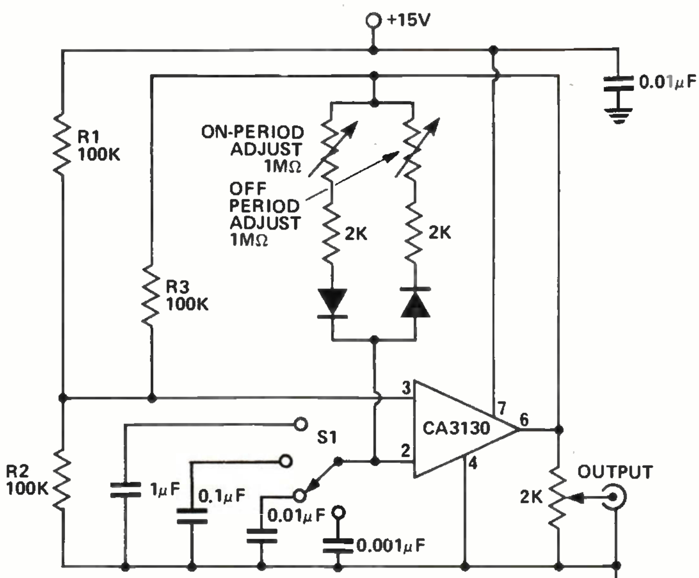
The heart of the frequency-determining system is an operational-transconductance-amplifier ICI, operated as a voltage-controlled current-source. The output, I_O is a current applied directly to the integrating capacitor, C1, in the feedback loop of the integrator IC2, using a CA3130, to provide the triangular-wave output. Potentiometer R2 is used to adjust the circuit for slope symmetry of positive-going and negative-going signal excursions.

THE CA3130 OPERATIONAL AMPLIFIER



REGULATION (NO LOAD TO FULL LOAD): < 0.005%
INPUT REGULATION: < 0.01%/V
HUM AND NOISE OUTPUT: < 250μ V RMS UP TO 100 kHz.

Fig. 16. This regulator provides 0.1 to 50 volts at currents up to 1 amp and has variable current limit.



FREQUENCY RANGE:

POSITION OF S1	PULSE PERIOD
0.001μF	4μS TO 1mS
0.01μF	40μS TO 10mS
0.1μF	0.4mS TO 100mS
1μF	4mS TO 1S.

Fig. 17. This pulse generator is basically an astable multivibrator with provision for independant control of ON and OFF periods.

Another CA3130, IC3, is used as a controlled switch to set the excursion limits of the triangular output from the integrator circuit. Capacitor C2 is a "peaking adjustment" to optimize the high-frequency square-wave performance of the circuit.

Potentiometer R3 is adjustable to perfect the "amplitude symmetry" of the square-wave output signals. Output from the threshold detector is fed back via resistor R4 to the input of IC1 so as to toggle the current source from plus to minus in generating the linear triangular wave.

OPERATION WITH OUTPUT-STAGE POWER-BOOSTER

The current-sourcing and sinking capability of the CA3130 output stage is easily supplemented to provide power-boost capability. In the circuit of Fig. 19, three COS/MOS transistor-pairs in a single CA3600E IC array are shown parallel connected with the output stage in the CA3130. In the Class A mode of CA3600E shown, a typical device consumes 20 mA of supply current at 15V operation. This arrangement boosts the current-handling capability of the CA3130 output stage by about 2.5.

The amplifier circuit in Fig. 24 employs feedback to establish a closed-loop gain of 48 dB. The typical large-signal bandwidth (−3 dB) is 50 kHz.

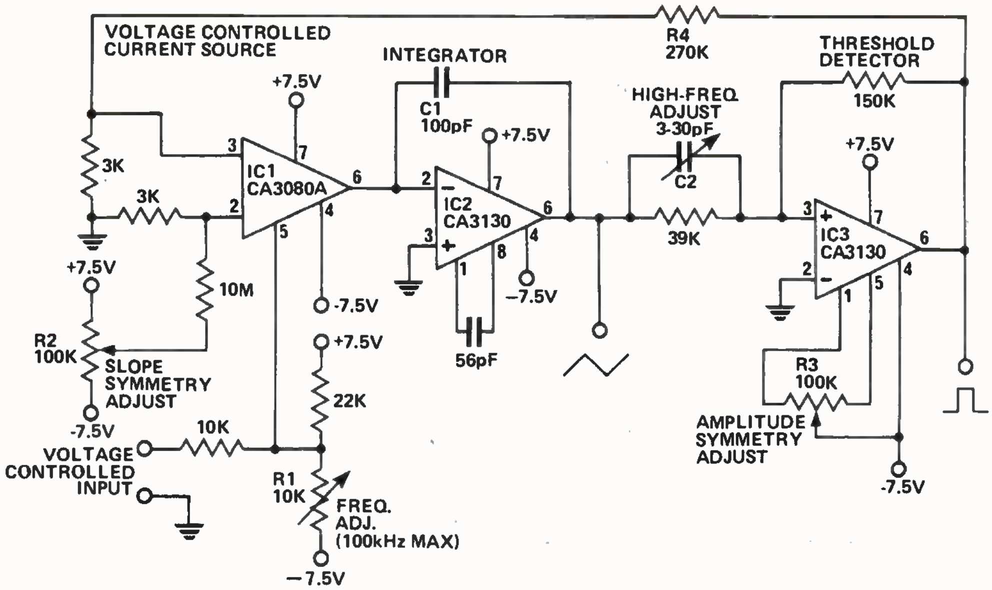


Fig. 18. This function generator provides a frequency variation of 1 000 000/1 with a single control.

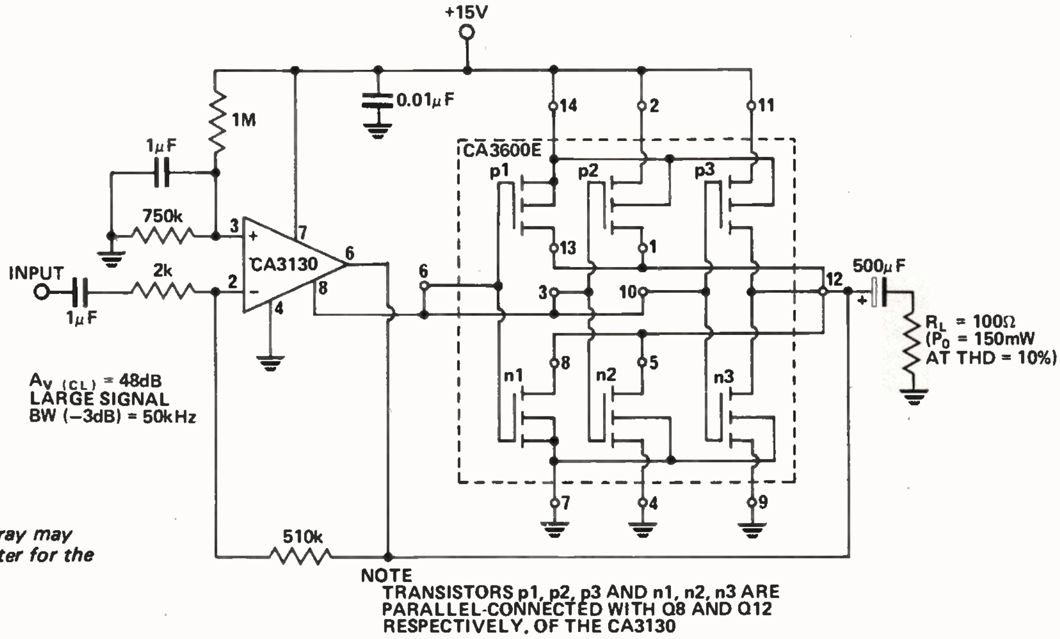


Fig. 19. A CMOS transistor array may be connected as a power booster for the output stage of a CA3130.

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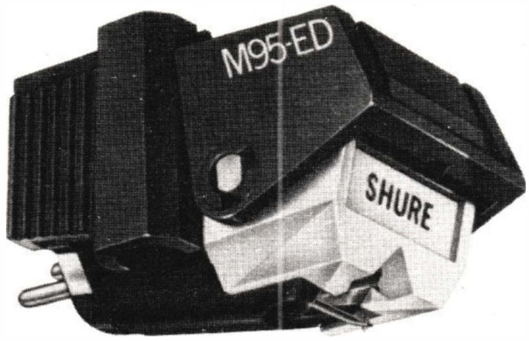

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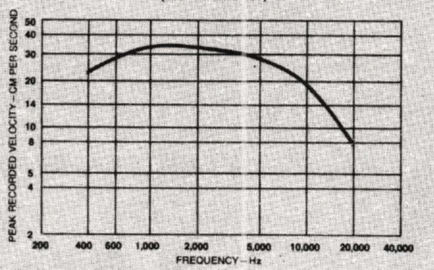
M95ED SPECIFICATIONS

Trackability at 1 gram tracking force using a Shure/SME Arm:
24 CM/SEC at 400 Hz
33 CM/SEC at 1,000 Hz
28 CM/SEC at 5,000 Hz
19 CM/SEC at 10,000 Hz

Tracking Force: ¾ to 1½ grams
Frequency Response: 20 to 20,000 Hz

TRACKABILITY CHART
(at 1 Gram)



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47,000 ohms resistance in parallel with 400 to 500 picofarads total capacitance per channel. (Load resistance can be as high as 100,000 ohms and total capacitance can be as low as 100 Picofarads with only minor audible change.) Total capacitance includes the capacitances of the tone arm wiring, phono cables, and the amplifier input circuit.

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Channel Separation: Minimum 25 dB at 1,000 Hz

Channel Balance: Output from each channel within 2 dB

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The CA3130 is the ideal choice when you're looking for a good measure of all these characteristics in one device. That's what makes the CA3130 so great. Its versatility comes from the unique combination of MOS/FET, bipolar and COS/MOS on the same chip.

Beyond the table, here's more typical data about the CA3130:

Input Impedance: 1.5 TΩ ($1.5 \times 10^{12}\,\Omega$).
Input Current: 5 pA.
Input Offset Current: 0.5 pA.
Input Offset Voltage: 0.8 mV (CA3130B).
Settling Time: 1.2 μsec.
An output voltage swing to within 10 mV of either supply rail.
Strobing terminals.
Package: 10 lead T05.

	CA3080E	CA3100T	CA3094E	CA3078T	CA3130
Gateable plus programmable gain control	>60 dB				Gateable
Unity gain crossover frequency, MHz		40			15
Slew Rate, V/μsec		25			10
Output, mA (peak)			300		22
Power consumption, mW				.0015	2.5
Single supply voltage required, V				1.5	5.0

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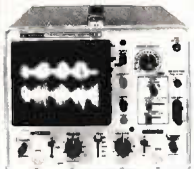
TRIO SCOPES (see special reviews this issue)

TRIO



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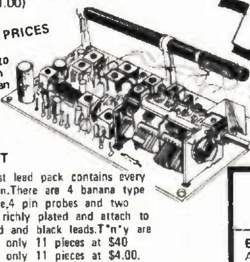

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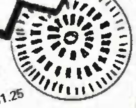

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(All rated at 4 ohms except 8x4 which is 4 or 8Ω)

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BASF	Singles	5	10	20
C60LHSM	2.50	2.00	1.85	1.55
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C90SMCrO2	3.50	3.00	2.75	2.50
And now HITACHI Cassettes				
C60LN	1.69	1.49	1.39	1.29
C90LN	2.25	1.99	1.84	1.69
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C90UD	2.99	2.69	2.49	2.29
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don't forget P&P
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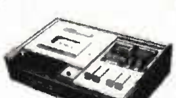

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Posh case for Kit $3.00 extra

Gore Hill open till 8pm Thurs' for Jan SALE!!

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Heavy duty chrome plate finish. 13" Underhang mounts in 1" hole. Extends 42" Gives maximum performance. Complete with lead and aerial plug. $4.75

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Mounts in 1" hole 3 sections extending to approx 45" Complete with lead and aerial plug. $3.75

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Be a snob and have a centre roof aerial. Spring back gives flexibility. Comes with lead and plug. $8.95

The SA5100 Electric Aerial
Flick the supplied switch and the aerial will glide up or down. Don't worry about when to stop, the slipping clutch will tell you and save any damage. Operates on 12V reg. or positive. Underhangs 12" mounts in 1" hole. $21.00

Rear Aerial Head
Want to mount your aerial on the rear of your car — do it properly and use a COMPENSATED AERIAL EXTENSION.
1 Metre length $2.50
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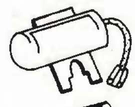
CAR RADIO NOISE SUPPRESSORS



C1 Cappy for coil, Generator, Alternator etc. 0.5µf 100V. Price .50¢

R1 Resistor for inserting in HT leads helps reduce impulse noise. 10Kohm Price .50¢

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Fantastic little plug in printed circuit board measures 100mm x 60mm and takes dual in line IC's or transistors over 400 holes and copper lands, 24 way .1" "plug" etched on board. Will take up to 14, 14pin or 16pin IC's or up to 20 "mini-dip" IC's. Ideal for hobbyists and professional engineers alike. ONLY 75c each or 10 for $5.00
24 way gold plated socket $2.00

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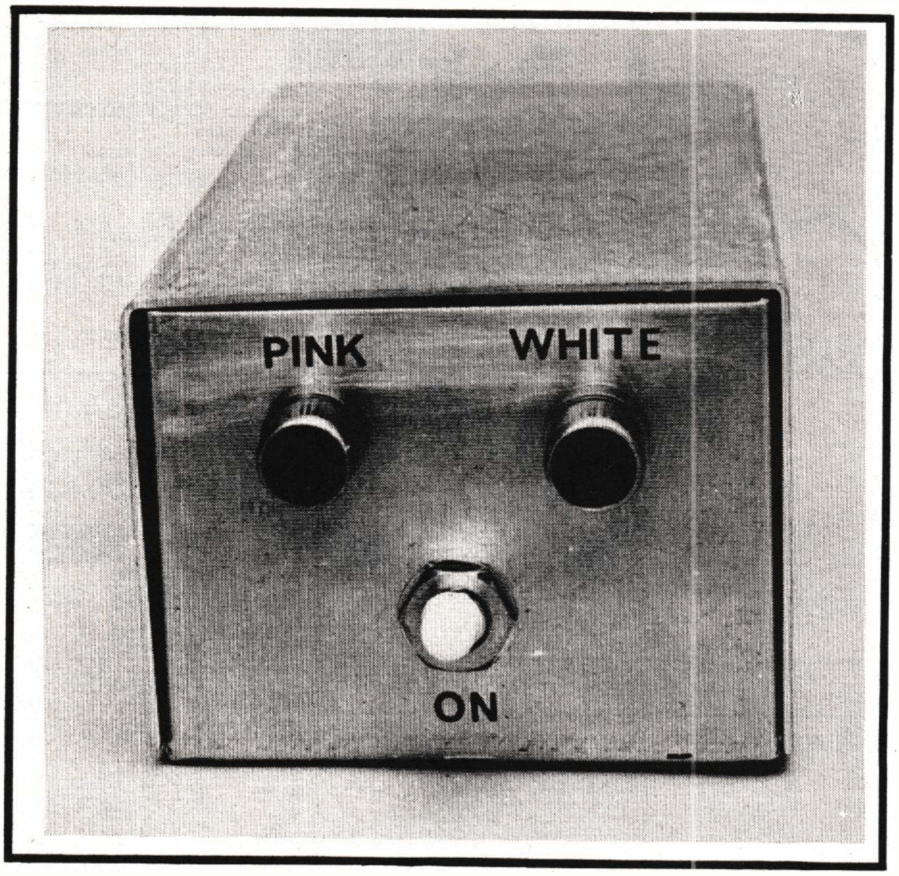
eti PROJECT 441

AUDIO NOISE GENERATOR



Simple circuit generates both white and pink noise.

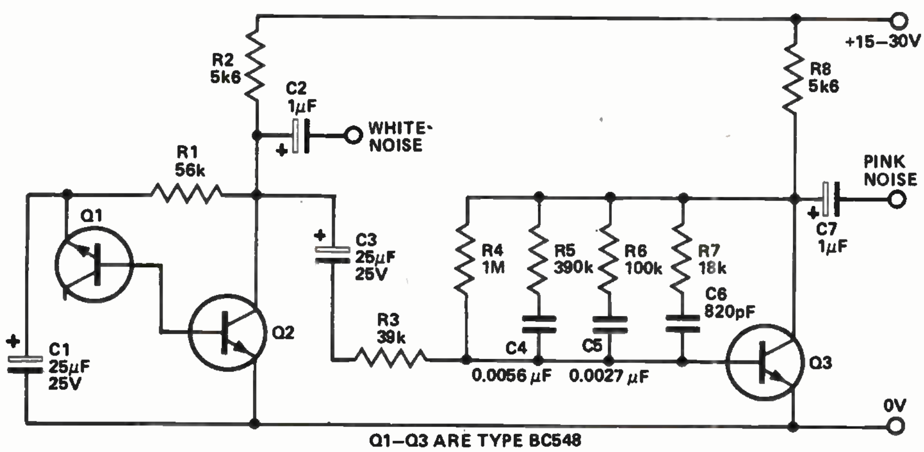


Fig. 1. Circuit diagram of the noise generator.

NOISE is generally an undesirable phenomena that degrades the performance of many measurement and instrumentation systems. It therefore seems strange that anyone should want to generate noise, but this is often the case.

Noise generators are often used to inject noise into radio-frequency amplifiers in order to evaluate their small signal performance. They are also used to test audio systems, and as random signal sources for wind-like effects in electronic music.

There are two commonly used noise source characteristics, 'pink' and 'white'. White noise is so called because it has equal noise energy in equal bandwidths over the total frequency range of interest. Thus, for example, a white noise source would have equal energy in the band 100 to 200 Hz to that in the band 5000 to 5100 Hz.

HOW IT WORKS – ETI 441

In the days when vacuum tubes were in common use the most commonly used form of noise generator was a vacuum-tube diode operated in the current saturation mode. Nowadays noise generators may be very complex indeed. Highly complex digital generators which produce psuedo-random digital noise may cost many thousands of dollars. An example of a simpler type of digital noise source may be found in our synthesizer design (see International Music Synthesizer 4600 ETI December 1973). However for audio work of a general nature the most commonly used, and the simplest, method is to use a zener diode as a noise generator.

Transistor Q1 is in fact used as a zener diode. The normal base-emitter junction is reverse-biased and goes into zener break-down at about 7 to 8 volts. The zener noise current from Q1 flows into the base of Q2 such that an output of about 150 millivolts of white noise is available.

The 'zener', besides being the noise source, also biases Q2 correctly, and the noise output of Q2 is fed directly to the White Noise output.

To convert the white noise to pink a filter is required which provides a 3 dB cut per octave as the frequency increases. A conventional RC network is not suitable as a single RC stage gives a cut of 6 dB per octave. Hence a special network of Rs and Cs is required in order to approximate the 3 dB-per-octave slope required. Since such a filter attenuates the noise considerably an amplifier is used to restore the output level. Transistor Q3 is this amplifier and the pink noise filter is connected as a feedback network between collector and base in order to obtain the required characteristic by controlling the gain-versus-frequency of the transistor. The output of transistor Q3 is thus the pink-noise required and is fed to the relevant output socket.

PARTS LIST — ETI 441

R1	Resistor	56k	½W	5%
R2	"	5k6	½W	5%
R3	"	39k	½W	5%
R4	"	1M	½W	5%
R5	"	390k	½W	5%
R6	"	100k	½W	5%
R7	"	18k	½W	5%
R8	"	5k6	½W	5%
C1	Capacitor	25µF	25V	electro
C2	"	1µF	25V	electro
C3	"	25µF	25V	electro
C4	"	0.0056µF		polyester
C5	"	0.0027µF		polyester
C6	"	820pF		ceramic
C7	"	1µF	25V	electro

Q1-Q3 Transistor BC548, BC108 or similar
PC board ETI 441
CASE
BATTERIES
OUTPUT SOCKETS

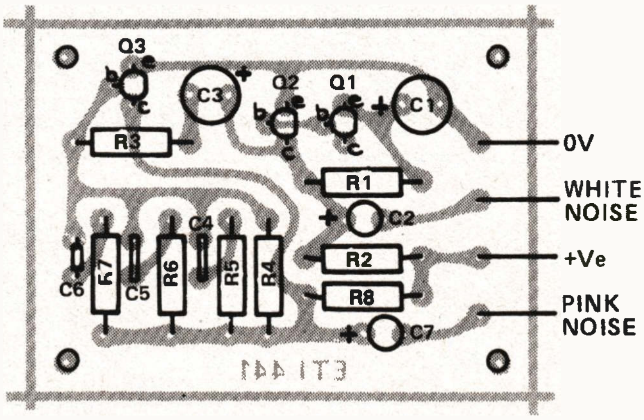
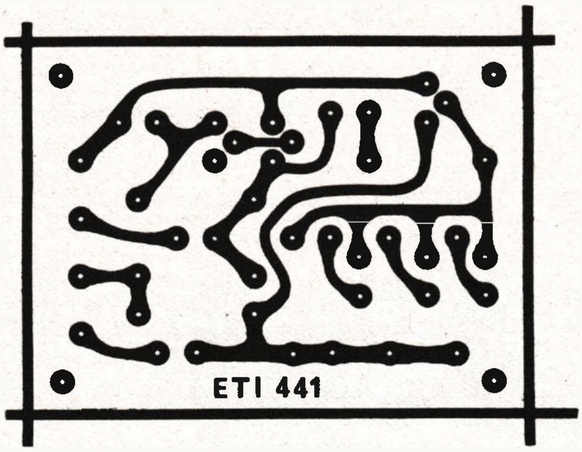


Fig. 2. Component overlay.



Printed circuit layout. Full size 67 x 49 mm.

If white noise is filtered or modified in any way it is referred to as coloured noise or, often more specifically, as 'pink' or 'grey' noise. The term pink noise should be restricted to the noise characteristic that has equal energy per percentage change in bandwidth. For example with true pink noise the energy between 100 Hz and 200 Hz should equal that between 5000 Hz and 10 000 Hz (100% change in both cases).

Pink noise therefore appears to have more bass content than does white noise, and it appears to the ear to have a more uniform output level in audio testing. To change white noise to pink noise a filter is required that reduces the output level by 3 dB per octave (10 dB per decade) as the frequency is increased. The ETI 441 Noise Generator is designed to provide both white and pink noise as required.

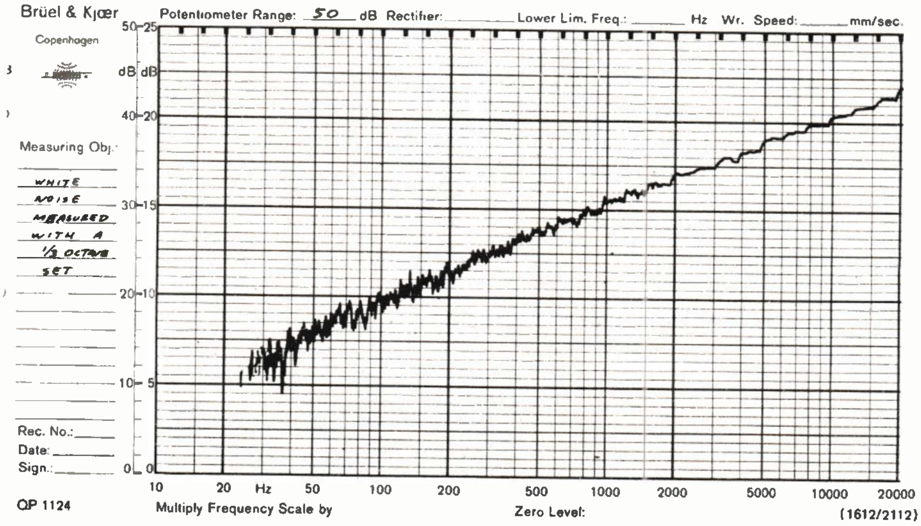
CONSTRUCTION

Construction is relatively simple and almost any of the common methods, such as Veroboard or Matrix board, may be used if desired. For neatness and ease of assembly it is hard to beat a proper printed-circuit board and for this reason we have provided details of a suitable board.

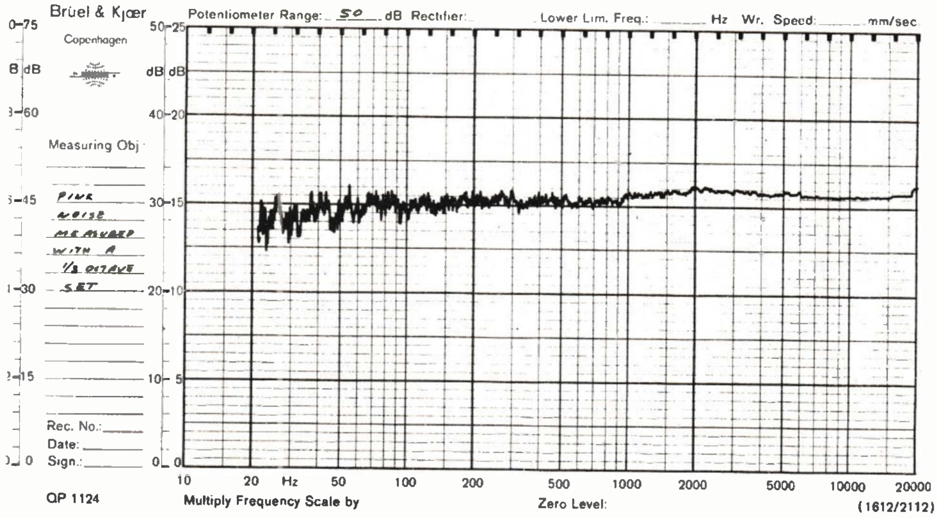
Almost any type of NPN transistor will do for the generator provided that the one used for Q3 has a gain of 100 or more. If BC548 type are used watch out for the two different pin connections used by different manufacturers.

For use as a separate instrument in general experimentation the unit will need to be powered by a pair of nine-volt batteries. However if the unit is to be built into some other piece of equipment, as is often the case, any supply within the equipment which has an output of between 15 and 30 volts dc will be suitable.

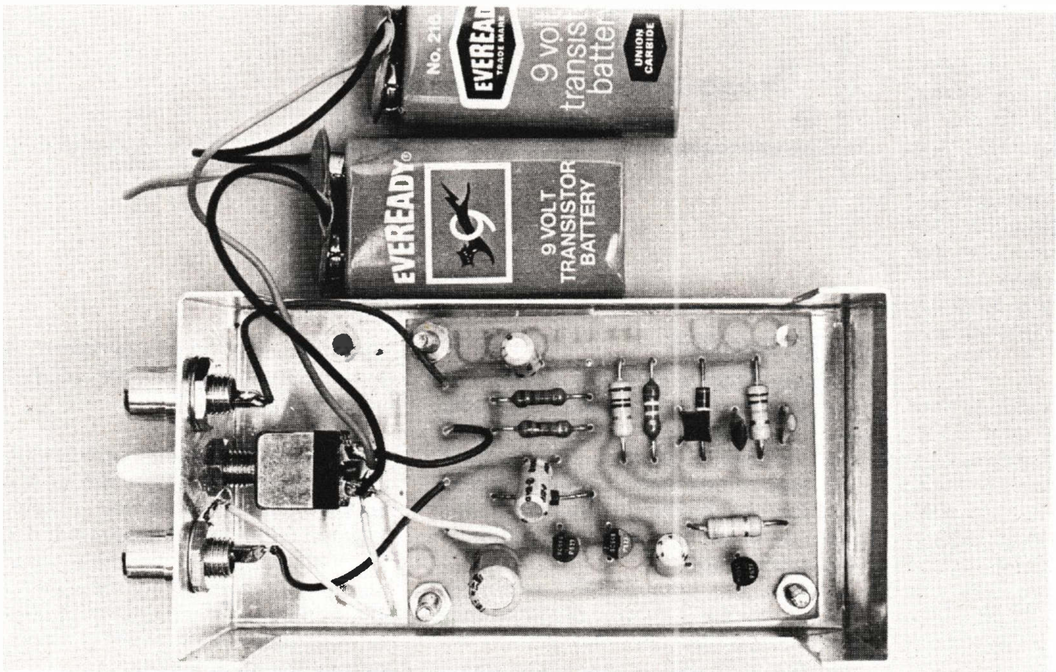
AUDIO NOISE GENERATOR



Amplitude of white noise versus frequency as measured with a one-third octave filter set.



Amplitude of pink noise versus frequency as measured with a one-third octave filter set.



Internal layout of the generator.

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MODEL NC-310 DE LUXE 1 WATT 3 CHANNEL C.B. TRANSCEIVER
- **WITH CALL SYSTEM**
- **EXTERNAL AERIAL CONNECTION**

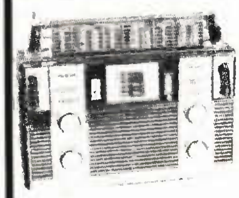
SPECIFICATIONS, NC-310
Transistors: 13
Channel Number: 3, 27.24 OMHz Citz. Band
Transmitter Frequency Tolerance: ±0.005%
RF Input Power: 1 Watt
Tone Call Frequency: 2000 Hz
Receiver type: Superheterodyne
Receiver Sensitivity: 0.7μV at 10 dB S/N
Selectivity: 45 dB at ±10 kHz
IF Frequency: 455 kHz
Audio Output: 500 mW to External Speaker Jack
Power Supply: 8 UM-3 (penlite battery)
Current Drain: Transmitter: 120-220mA
Receiver: 20-130mA.

$49.00 each or $95 a pair.
Post & pack $1.50 per unit.

1 watt 2 channel transceiver with call system. 27.240 MHz. 12 transistor. PMG approved type.

SPECIFICATIONS: Transmitter — Crystal Controlled: 1 Watt input power to RF stage. Operating frequency — Any 2 channels in the 11-meter Citizens Band. Receiver — Crystal-controlled superheterodyne circuit with 455 Kc IF. Antenna — Built-in 60" telescopic whip antenna. Audio Output — 0.8 Watt maximum. Power supply required — 12 volts DC (Eight 1.5 volt DC battery cells). Loudspeaker — 2¼" PM type (built-in) function as microphone on transmit.

$39.00 each or $75 a pair.
Post & pack $1.50 each unit.



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a truly portable communications receiver, based on the WADLEY LOOP principle, the same principle as applied in the DELTAHET and RACAL receivers. A truly crystal-controlled highly sensitive multiple-heterodyne portable receiver of exceptional stability with continuous, uninterrupted coverage from 500 kHz to 31MHz.
BARLOW-WADLEY XCR-30 features include: Selectable USB/LSB, CW & AM reception, frequency read-out 10kHz throughout the entire range, calibration accuracy within 5kHz, antenna resonator, tuning signal-strength meter, zero-set control, clarifier-vernier tuning, MHz & kHz tuning controls, telescopic antenna. Power source: 6 type D dry cells: provision for external DC power supply. Weight 9 lbs; size 11½ x 7½ x 4in.

All for $275 F.O.R.

When not in use or for carrying, the top meter/megahertz scale flips down flush with the case and clear of the handle.

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$6.95 Post Free.

MODEL C-7077/P MULTIMETER. Specifications: 100,000 ohms/volt DC; 10,000 ohms/volt AC; DC volts — 5,5; 25; 50; 250; 500; 1,000. AC volts — 10; 50; 250; 500; 1,000. DC amps — 10μA; 2-5 mA; 25 mA; 500 mA. Ohms — 10 kΩ; 1 MΩ; 10 MΩ; 100 MΩ. Centre scale — 150Ω; 15 KΩ; 150 KΩ; 1-5 MΩ. Decibel — -20 to +22 dB. Dimensions — 151 x 102 x 48 mm Diode protected movement. Carrying case available Model C.

$27.95 P&P $1.50.

MODEL OL64 D/P MULTIMETER. Very ruggedly constructed this model is particularly suitable for workshops. It features special scales for measurement of capacitance and inductance. Diode protested movement: **Specifications:** 20,000 Ohm/Volt DC. 8,000 Ohm/Volt AC. DC volts — 0.25; 1; 2.5V; 10; 50; 250; 1,000; 5.000. AC volts — 10; 50; 250; 1,000. DC amps: 50μA; 1 mA; 50 mA; 500 mA; 10 A. Ohms — 4 KΩ; 400 KΩ; 4 MΩ; 40 MΩ. Centre scale — 40Ω; 4,000Ω; 40,000Ω; 400,000Ω. Decibel: —20 to +62 dB, Dimensions: 6" x 4-1/5" x 2"; 152 x 107 x 51 mm. Capacitance: 250 pF to 0.02 uF. Inductance — 0/5000H Carrying case available Model C.

$22.50 P&P $1.50.

MODEL AS100 D/P MULTIMETER. This meter features double zener diode meter protection and 3½" full view easy to read 2 colour scale. It is fitted with polarity reversing switch and housed in a strong moulded case with carrying handle. **Specifications:** 100,000 ohm/volt DC. 10,000 ohm/volt AC. DC volts — 0.3; 12; 60; 120; 300; 600; 1,200. AC volts — 6; 30; 120; 300; 600; 1,200V. DC amps — 2 KΩ; 200 KΩ; 20 MΩ; 200 MΩ. Centre scale — 20Ω; 2,000Ω; 20,000Ω; 200,000Ω; 20 MΩ. Decibel — —20 to +57 dB. Dimensions — 7-3/5" x 5-2/5" x 2-3/5" 193 x 137 x 66 mm. Carrying case available model I.

$37.50 P&P $1.50.

SCOOP PURCHASE

200-H, p.p. 75c. 90 quadrant meter. Pocket size. AC V: 10V, 50V, 100V, 500V, 1000V (10,000 ohm/V). DC/V: 5V, 25V, 50V, 250V, 500V, 2500V (20,000 ohms/V). DCA/A: 50uA, 2.5 mA, 250 mA. OHM: 60k ohm, 6M ohm. Capacitance: 100pF to 0.1 uF, .001uF to .1uF. dB: —20 dB to +22 dB. Audio Output: 10V, 50V, 120V, 1000V AC. Approx. size: 4½" x 3¼" x 1-1/8"

$13.50 With FREE leather carry case. $1.50 Postage.

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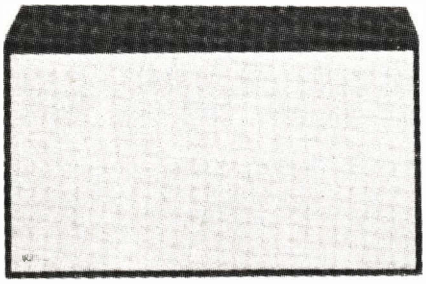
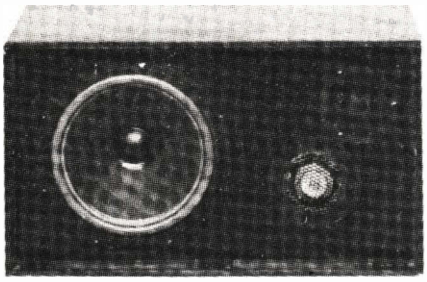
THE AR 3a/IMPROVED an evolutionary new SPEAKER SYSTEM

AR Acoustic Research

A TELEDYNE COMPANY





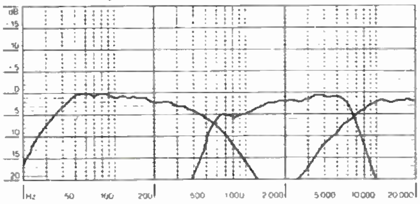
The AR-3a/Improved is the best home speaker system we know how to make. It has been designed to reproduce music as accurately as present-day knowledge of acoustics and electronics permits.

In addition to incorporating the 305mm (12in) bass driver with which AR introduced acoustic suspension to home listeners, the AR-3a/Improved also uses the two miniature hemispherical dome speakers developed for the AR-3a to offer an unprecedented degree of accuracy at middle and high frequencies.

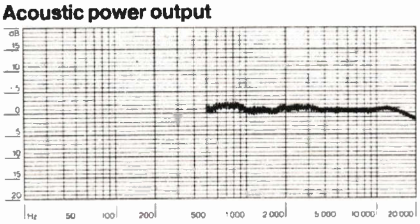
Concepts and techniques developed for the AR-LST and other AR speaker systems have now enabled AR engineers to improve the spectral energy characteristics of the AR-3a and further reduce its already small degree of coloration, while retaining all the virtues of the original design. These improvements have been accomplished by means of significant changes in the design of the crossover: all other components, including driver units and cabinet, are exactly the same as those of the AR-3a.

The AR-3a/Improved is capable of a more linear spectral energy output than was the AR-3a. A two-position switch makes it possible to tailor this characteristic for maximum realism under either reverberant or relatively damped listening conditions.

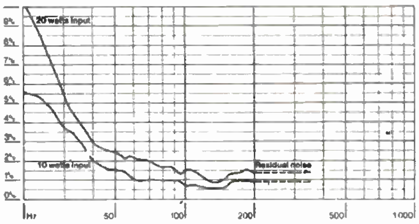
On-axis response



Acoustic power output



Woofer harmonic distortion



Drive units: 305 mm (12 in) acoustic suspension woofer, 38 mm (1½ in) midrange hemispherical dome, 19 mm (¾ in) high-frequency hemispherical dome

Crossover: 575 Hz, 5000 Hz
Impedance: 4 ohms nominal

Controls: Midrange and high-frequency driver level controls

Amplifier: Up to 100 watts per channel
Size: 356 x 636 x 289 mm deep (14 x 25 x 11⅜ in)
Weight: 24 kg (53 lb)
Woofer resonance: Free air 18 Hz, in enclosure 42 Hz
Volume of enclosure: 48.2 litres (1.7 cu ft)

'... the best speaker frequency response curve we have ever measured using our present test set-up ... virtually perfect dispersion at all frequencies ... AR speakers set new standards for low-distortion, low-frequency reproduction, and in our view have never been surpassed in this respect'. *Stereo Review*

'On any material we fed to them, our pair of AR-3a's responded neutrally, lending no coloration of their own to the sound ... the speakers sounded magnificent, filling the place with a lot of clean, musical sound and an excellent stereo image ... Our tests of the AR-3a simply confirm the manufacturer's design aims and claims for this system'. *High Fidelity*

'The harmonic distortion at bass frequencies was outstandingly low ... The high-frequency dispersion is the widest of any speaker we have tested ... a new high standard of performance at what must be considered a bargain price'. *Audio*

'Acoustic Research have achieved what they set out to do – a first class loudspeaker by any standard'. *Hi-Fi News*

'Finest bass performance I have heard or measured'. E J Jordan, *Wireless World*

The AR guarantee
The workmanship and performance in normal use of AR speakers are guaranteed for 5 years from the date of purchase. This guarantee covers parts, repair labour, and freight costs to and from the factory or nearest authorized service station. New packaging if needed is also free.

The acoustic research 3A improved is now on demonstration at these franchised dealers:

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Brash's
Denman Hi-Fi
Douglas Trading
Instrol Hi-Fi
Pantiles Hi-Fi
Mordialloc Electrical

Geelong
Sound Spectrum
(E & B Wholesale)

Perth
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PROJECT 534 CALCULATOR STOPWATCH

An inexpensive calculator modified to provide one-hundredth of a second timing.

FOUR-FUNCTION calculators are now available for as little as $9.95. At those prices, it is cheaper to buy a calculator and throw away the parts that you don't need, than it is to buy a keyboard, display, or calculator chip separately.

Having this in mind we were very interested to receive an application note from National Semiconductor which detailed how to modify one of their calculators for use as a stopwatch. We therefore decided to develop this idea to a full project for a calculator/stopwatch which provides timing with one-hundredth of a second resolution for a cost as low as $17 (including the calculator).

The NOVUS 650 calculator is a simple four-function machine which has a fixed decimal point between the second and third (RH) digits. The calculator does not have floating point, and only works in whole numbers, the decimal point being an indicator only. These features however, whilst detracting from the usefulness of the machine as a calculator, make it ideal for modification, without difficulty, for use as a stopwatch.

Stopwatch operation is made possible by the fact that if '1' is entered into the calculator and the '+' key is continually pressed, the calculator will add '1' to the number displayed each time the '+' key is pressed. Thus, as a stopwatch, the '+' key must be 'pressed' electronically 100 times per second. (If a floating-point calculator were to be used, 0.01 would have to be added each time the key was pressed and this of course is much more difficult to do).

The 100 Hz timebase, required for the key-pressing function, needs to be supplied by means of a crystal and a divider chain or, by some other simple but stable oscillator such as a PUT. For most applications the PUT (programmable unijunction transistor) is quite accurate enough and this, coupled with the fact that the crystal and its dividers are bulky and relatively expensive, led to us choosing the PUT oscillator.

The additional electronics for the stopwatch is all mounted on a separate printed-circuit board which is a very tight fit in the calculator. Soldering to the pins of the calculator IC is also required and unless you have previous constructional experience, especially with soldering, do not attempt this project.

CONSTRUCTION

Due to the unusual nature of this project the constructional procedure given is much more detailed than usual. The constructor is well advised to follow the following steps carefully.

(a) Dissassemble the calculator by removing the battery and the four screws that hold the case together.

(b) Remove the external power socket and disconnect the leads from it to printed-circuit board. Take note

(Text continued on page 50)

SPECIFICATION

Maximum Reading	9999.99 sec (2 hours 46 mins 39.99 secs)
Resolution	0.01 secs
Accuracy (typ)	± 0.2%

Mode — accumulating type, single button start/stop, separate button for clear.

Calculator.

Six digits, four functions, reverse Polish fixed point.

CALCULATOR STOPWATCH

HOW IT WORKS.

With the standard calculator the keyboard controls a three-line by six-line matrix, that is, a calculator key when pressed joins one of three pins, of IC3, to one of six other pins. This gives a maximum of 18 possible combinations of which only 15 are used. The 6 lines are both input and output of the IC, that is they drive the display via IC4 as well as passing keyboard commands to the calculator.

The stopwatch is controlled by an additional push button, which in effect stops and starts the calculator, whilst reset is performed by the front-panel 'clear' key. The push button operates a flip flop formed by IC1/1 and IC1/2. The capacitors around the flip flop change it from a normal RS type to a toggle type. Diode D3, capacitor C4 and resistor R5 set the flip flop into the stop condition on initial switch on. The output of IC1/1 is at zero volts in the 'stop' state and at +9 volts in the 'run' state.

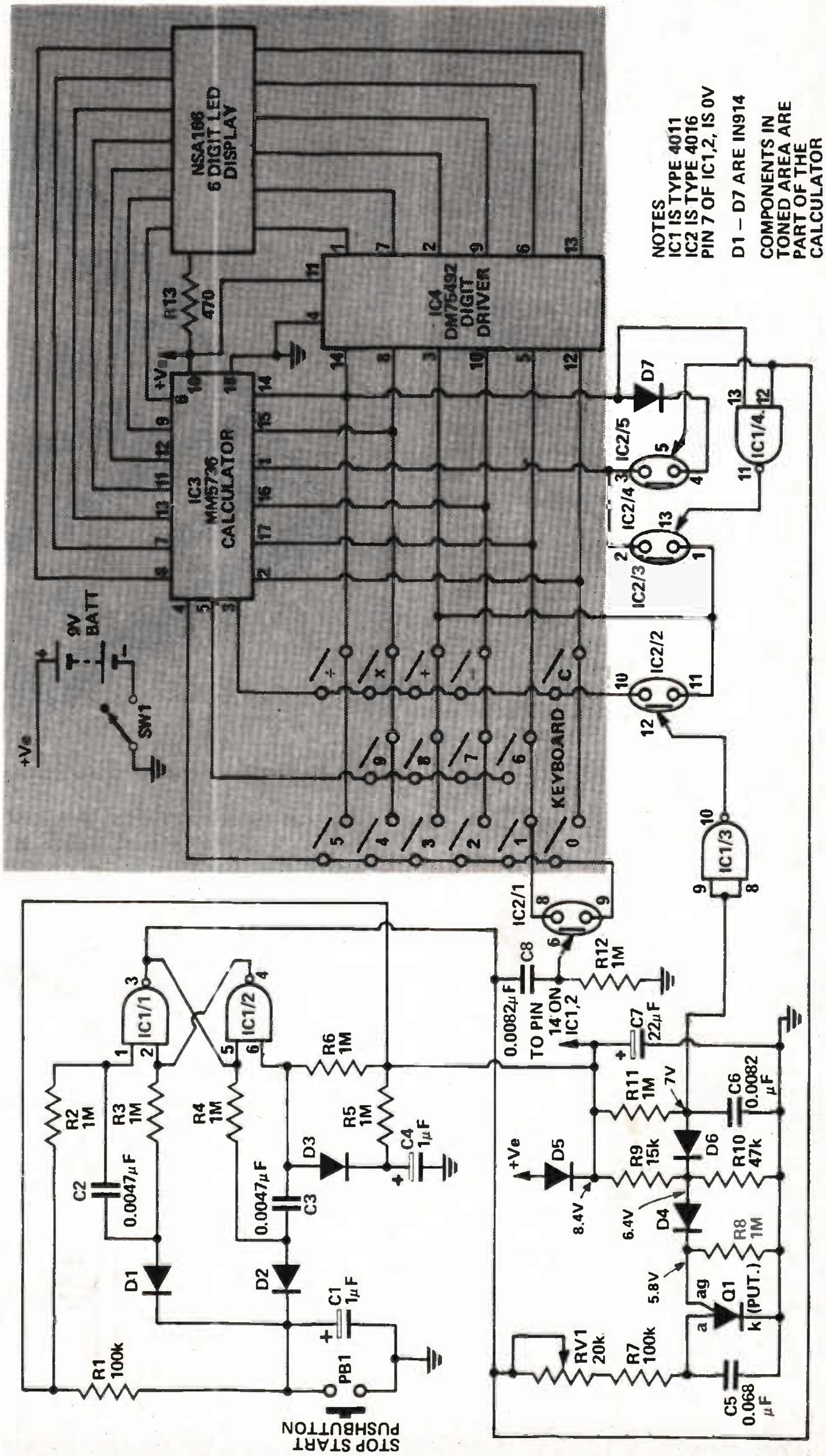
When the output of IC 1/1 goes high capacitor C8, together with R12, provides a 10 ms pulse to the control input of IC 2/1. This is an analogue switch across the '1' key. Thus the closure of this switch is equivalent to pressing the '1' key. When the switch closes capacitor C5 begins to charge via R7. When it reaches about 6 volts (set by R9/R10) the PUT switches on, and C5 is discharged rapidly to a low voltage, the PUT turns off, allowing C5 to recharge. This action takes at place at 100 Hz. The diode D4 is used for temperature compensation. When the PUT fires, terminal 'ag' drops to a low voltage which discharges C6 via D4 and D6. And, although the PUT is on for only a short time, diode D6 isolates C6 allowing it to charge slowly (5 ms) via R11.

The pulse from the PUT is squared by IC 1/3 and is then used to control IC 2/2, which is across the '+' key. The pulse thus causes one to be added to the displayed number 100 times per second.

To operate the calculator, at the rate of 100 pulses per second, it is necessary to disable the calculator debounce circuitry. This is done by IC 2/3, IC 2/4, IC 1/4 and D7. The debounce is disabled only in the 'run' mode, and is still functional in normal calculator operation.

Diode D5 and capacitor C7 decouple the control circuitry from the calculator, as the high peak currents drawn can result in a two-volt ripple, on the nine-volt supply, which otherwise would upset the timing.

Fig. 1. Circuit diagram of the complete stop-watch. Calculator parts are shown in the shaded area.



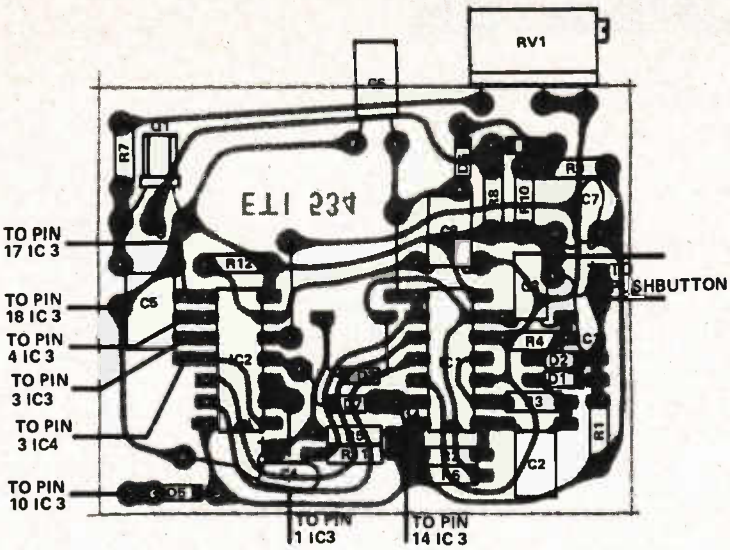


Fig. 3. Component overlay.

PARTS LIST — ETI 534

R9 Resistor 15 k ¼ W 5%
R10 " 47 k " "
R1,7 " 100 k " "
R2,3,4,5 " 1M " "
R6,8,11,12 " 1M " "
R13* part of calculator

RV1 Trim potentiometer 20 k 20 Turn type 84 (Morganite)

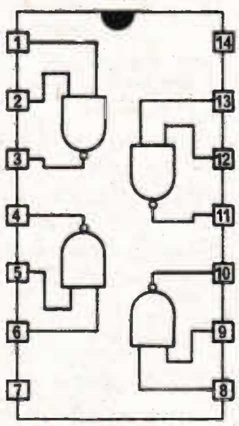
C2,3 Capacitor 0.0047 μF polyester
C6,8 " 0.0082 μF "
C5 " 0.068 μF "
C1,4 " 1 μF Tag tantalum
C7 " 22 μF 16 V Tag tantalum

D1-D7 Diode IN914 BA318 or similar

Q1 Transistor 2N6027 or similar

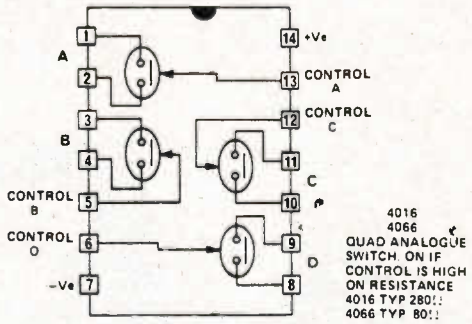
IC1 Integrated Circuit 4011 (CMOS)
IC2 " " 4016 (CMOS)

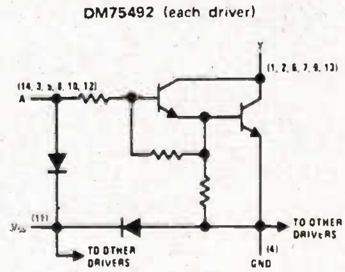
Small push button
PC Board ETI 534
Calculator NOVUS 650

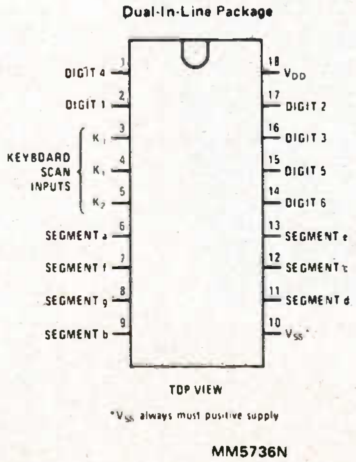


4011
QUAD 2 INPUT
NOR GATE

INPUTS		OUTPUTS
A	B	
0	0	1
0	1	1
1	0	1
1	1	0







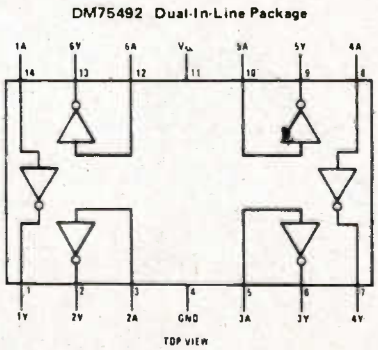


Fig. 2. Component connections.

CALCULATOR STOPWATCH

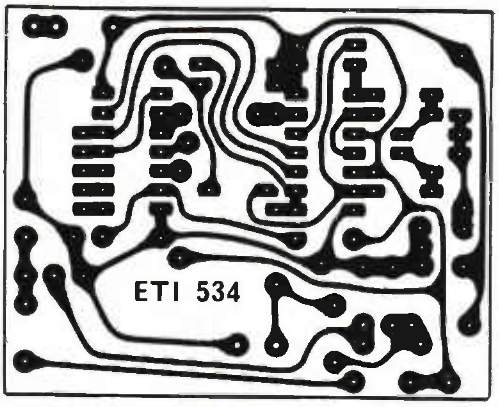


Fig. 4. Printed circuit board layout. Full size 64 x 52 mm.

of the position of these leads as they must be replaced later.

(c) The new pushbutton for the stopwatch must now be mounted into the back cover. The photograph shows the approximate location of this button. Note that the web of plastic, between the battery compartment and the calculator housing, must be cut away on the right-hand side so that the push button may be fitted. To determine the correct position, temporarily reassemble the calculator, without screws. The correct location can now be determined as the button goes between the display board, the calculator board and the battery (yes there is space!)

(d) Due to the curved case of the calculator we did not use the normal mounting method for the push button, but just drilled and filed a hole just large enough to allow the push button to cut its own thread in the plastic. It may also be necessary, however, to epoxy the button into position.

(e) Assemble the printed-circuit board, ETI 534, as shown in the component overlay. The components must be positioned as shown, as the board fits between the calculator board and the keyboard and space is very limited

(f) Attach thin insulated wires to the points shown on the overlay and leave them about 75 mm long.

(g) To obtain a little more space, trim all component leads on the back of the calculator board, including those of the calculator IC, as close to the board as possible. Now cut the printed-circuit track on both sides of pin 1 of the MM5736 calculator IC (pin 1 is the pin next to the ● mark) Using a single strand of flexible wire rejoin the tracks on both sides of pin 1, leaving pin 1 isolated.

(h) Position the control board, ETI 534, alongside the calculator board (see photo). Due to space limitations the wires from the control board have to soldered directly onto the pins of the calculator ICs.

(j) Check very carefully the point to which each wire must be connected, cut it to length (not too long), and solder it directly to the specified pin. The ICs are numbered anticlockwise from the '●' mark.

(k) Reconnect the power wiring from the external socket.

(l) Connect the push-button switch.

(m) Check the calculator before final assembly as follows:-

Connect the battery and switch on.

Clear the display and check all keys and calculator functions.

Clear the display

Press the push button once. The calculator should now count up by ones at 100 times per second.

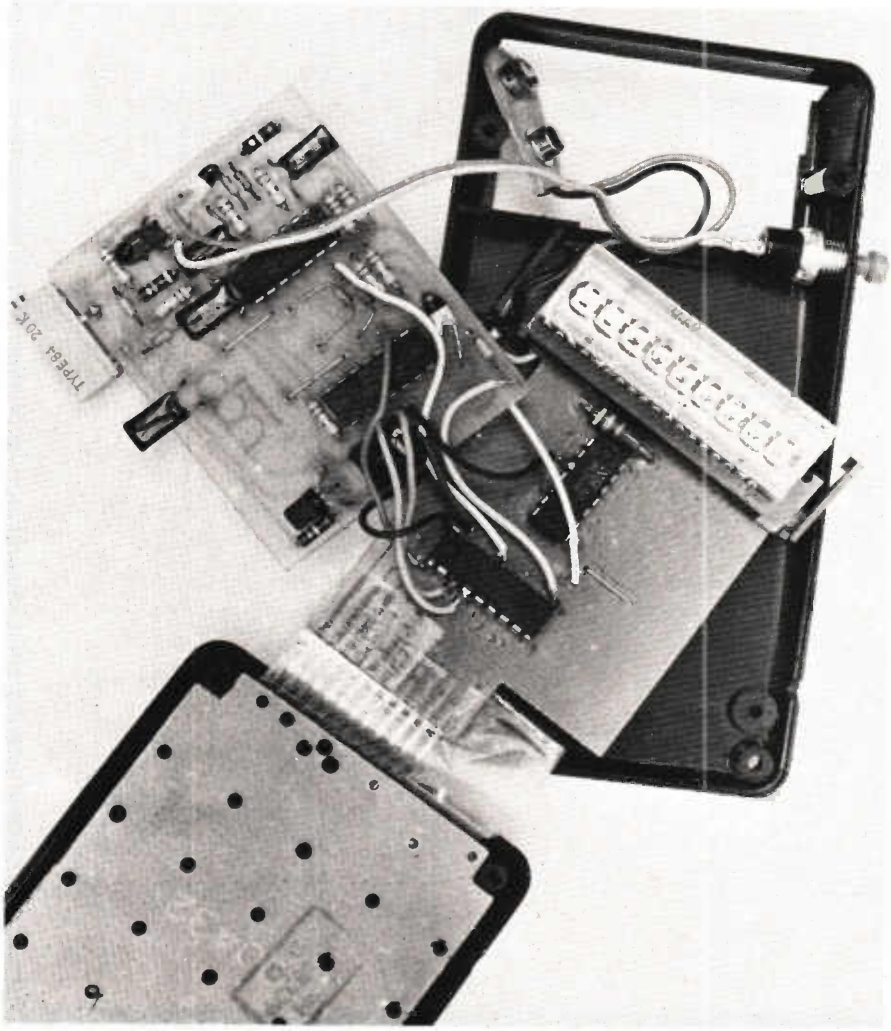
(n) If a frequency counter or an oscilloscope is available connect to the junction of R11 and C6 and adjust for 100 Hz. If an oscilloscope is used sync the cro from the mains and beat the 100 Hz against that.

(p) Fold the control board on top of the calculator board making sure that none of the leads is on top of any of the ICs thus preventing the board from going right down.

(q) Cut a small hole in the side of the case to allow access to RV1.

(r) Assemble the calculator completely again making sure that the leads do not foul anything and that the calculator fits together without

The calculator as modified and before final assembly.



needing to be forced.

(s) Check the accuracy of the stopwatch by timing, over a long period, using a known accurate source (eg telephone time service) and make successive adjustments of RV1 to give correct results.

USING THE STOPWATCH

The conventional stopwatch has a single button which starts, stops, and resets, the timing. The ETI stopwatch, on the other hand, uses the side button for start/stop and the existing CE/C key for reset.

This configuration allows the stopwatch to be used for applications where accumulative timing is required. For example where three separate runs must be timed for a total time, the stopwatch is not reset between runs but merely started and stopped for each run.

A further advantage is that timing may be commenced from a reading preset by the keyboard. This is done by first clearing the display and then entering the starting time in one-hundredths of a second. If the '+' button is now pressed before starting, the stopwatch will count up from the entered time, whereas if the '—' button is pressed the stopwatch will count down from the previously entered time to zero.

When using the stopwatch be careful to hold it in such a way that accidental pressing of keys is avoided, as spurious keyboard entries will result in an erroneous reading. ●

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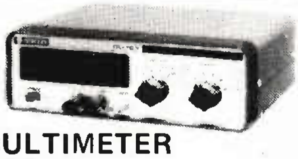

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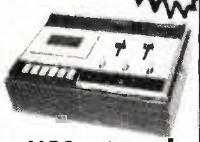

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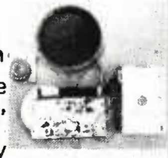

Completely ready wired with volume control and switch. Large tuning dial and complete with 3½" 8 ohms. .6 watt speaker. Battery container included. (Batteries not included) — READY TO GO!!

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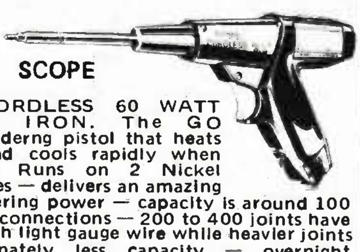

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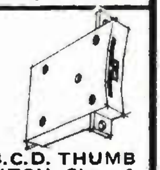

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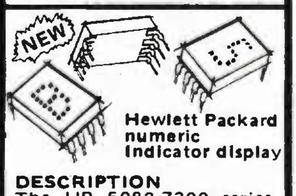

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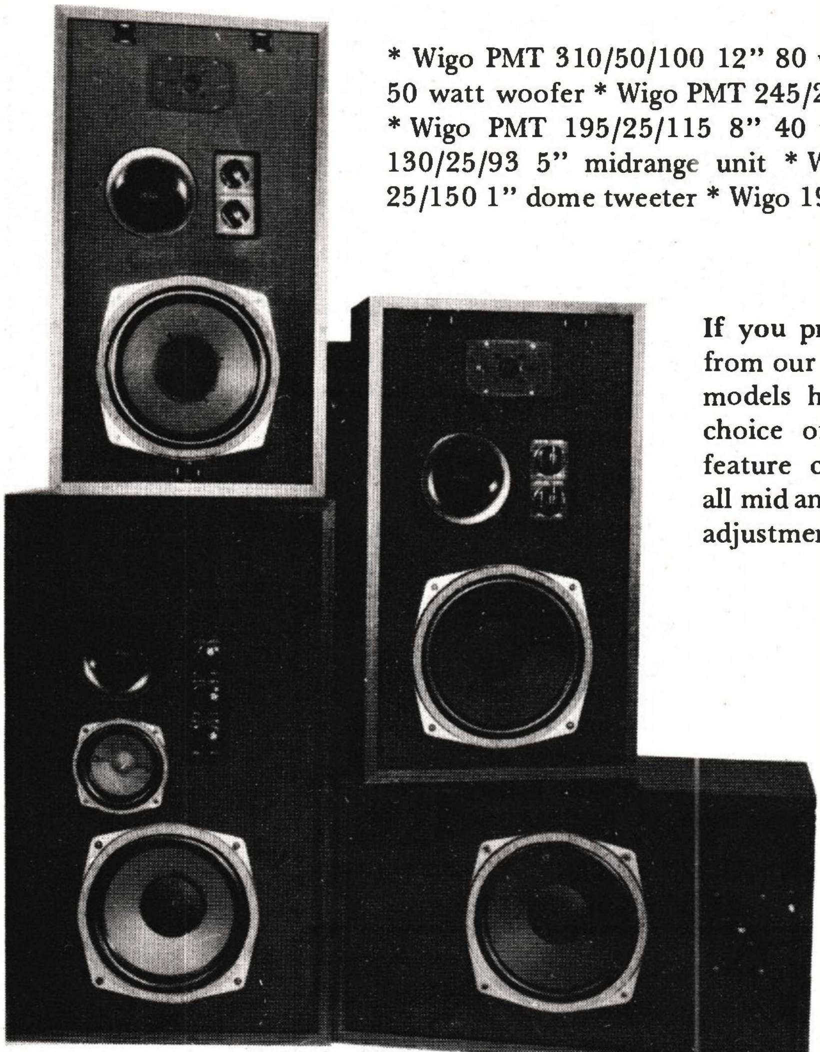

* Wigo PMT 310/50/100 12" 80 watt woofer * Wigo PMT 245/37/100 10" 50 watt woofer * Wigo PMT 245/25/115 10" 40 watt bass/midrange speaker * Wigo PMT 195/25/115 8" 40 watt bass/midrange speaker * Wigo PMM 130/25/93 5" midrange unit * Wigo 37/110 1½" dome midrange * Wigo 25/150 1" dome tweeter * Wigo 19/135 ¾" super tweeter.

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Wigo M102 2-way 40 watt. 8" Bass/mid-2" tweeter. 19" (H) x 10¼" (W) x 9¼" (D)

Wigo M132 2-way 40 watt 10" Bass/mid – 1" dome 25" (H) x 14½" (W) x 9¼" (D); Wigo M133 3-way 40 watt 10" Bass – 1½" dome – ¾" dome 25" (H) x 14½" (W) x 9¼" (D); Wigo M203 3-way 50 watt 10" Bass – 1½" dome – ¾" dome 25" (H) x 14½" (W) x 12½" (D); Wigo M254 4-way 50 watt 10" Bass – 5" mid – 1½" dome – ¾" dome 29" (H) x 17" (W) x 12" (D).

Wigo M504 4-way 80 watt. 12" Bass – 8" mid – 1½" dome – ¾" dome. 37" (H) x 19¼" (W) x 15¾" (D).

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RF SIGNAL GENERATOR

simple unit for servicing AM receivers

eti PROJECT 129

AN RF SIGNAL generator is an invaluable instrument for AM radio servicing and alignment — it greatly simplifies alignment and allows each stage to be checked for gain and frequency response.

Three types of signal are required for these purposes. Firstly, we require an audio signal to check that part of the receiver from the volume control (after the detector) to the speaker. Secondly, we need a modulated RF signal at 455 kHz (430 to 480 kHz available for non-standard receivers) for checking and aligning IF stages, and lastly, we need a modulated RF signal in the range 500 to 1600 kHz to check out the RF amplifier and converter.

In addition the level of the generator output should be adjustable so that AGC action may be checked out, and so that optimum levels may be chosen for servicing and gain checks. All the above requirements are met by the ETI 129 generator and, since only one of the available signals is used at any one time, a common level control is used for all these outputs.

In our generator the provision of IF frequencies from 430 to 480 kHz, as well as catering for non-standard receivers, allows receiver IF selectivity to be checked.

CONSTRUCTION

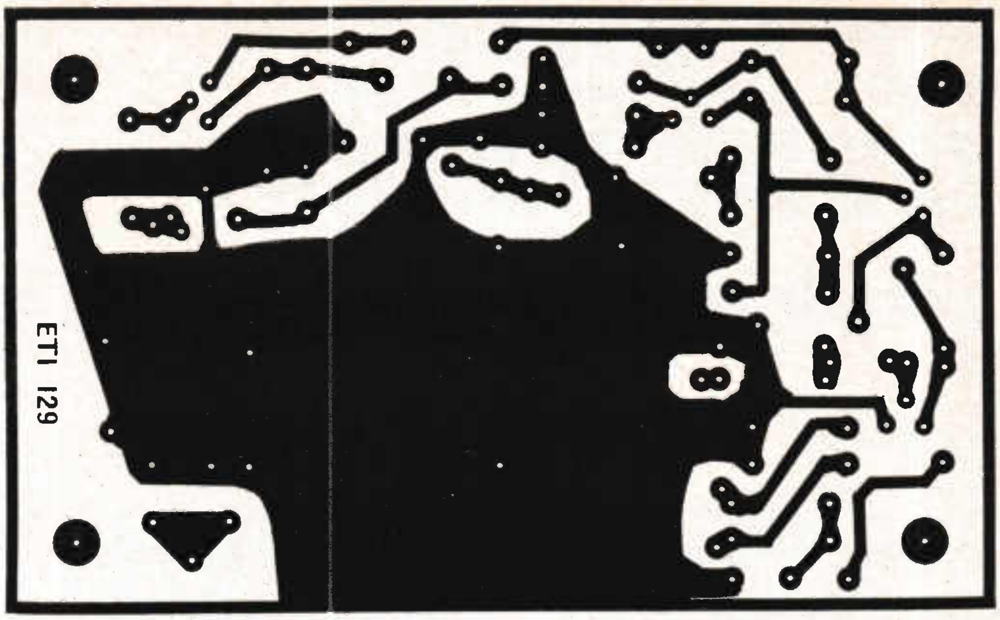
The prototype instrument was mounted in an aluminium box having external dimensions of 145 x 115 x 90 mm. Layout of the circuitry is important and for this reason the printed-circuit board layout provided should definitely be used. Take care when assembling components to the printed-circuit board to correctly orientate capacitors C9, C11 and C15, transistors Q1 to Q4 and diode D1.

The variable capacitor is mounted onto the component side of the printed-circuit board but spaced from it by about 2 mm (an oversized nut may be used). The mounting of the board and variable capacitor assembly to the front panel and reduction-drive assembly may best be understood by referring to Fig. 3. Note that the board is mounted by four standoffs and that rubber grommets are used to allow the board to move slightly — for this reason the screws should not be tightened too much. This method is used to avoid the expense of using a flexible drive to the variable capacitor.

The six-to-one slow-motion drive is mounted to the front panel by two 15 mm long bolts. The drive is spaced back from the front panel by 4 mm long spacers.

The remaining controls are mounted straight onto the front panel as shown in the photograph.

RF SIGNAL GENERATOR



Scotchcal front panels, ready to stick on are available from Electronics Today at $3.00 each. Send stamped addressed envelope — size at least 150 x 120mm. Address to Scotchcal Offer, Electronics Today, 15 Boundary St, Rushcutters Bay, NSW 2011.

Printed-circuit board layout. Full size 129 x 80 mm.

CALIBRATION

High Range. Using a conventional AM receiver tune to a station at the top end of the frequency band. Set the pointer of the RF generator to indicate the frequency of the station being received and couple the generator to the receiver.

Adjust capacitor C3 until the signal from the generator can be heard interfering with the station. This will take the form of a whistle which, as C3 is tuned, will go from a high frequency to a low frequency and then back to a high frequency again. The correct tuning point is where the frequency is at its lowest, i.e. in the middle. The level of the generator signal may have to be increased to obtain the correct point with accuracy. This procedure is called

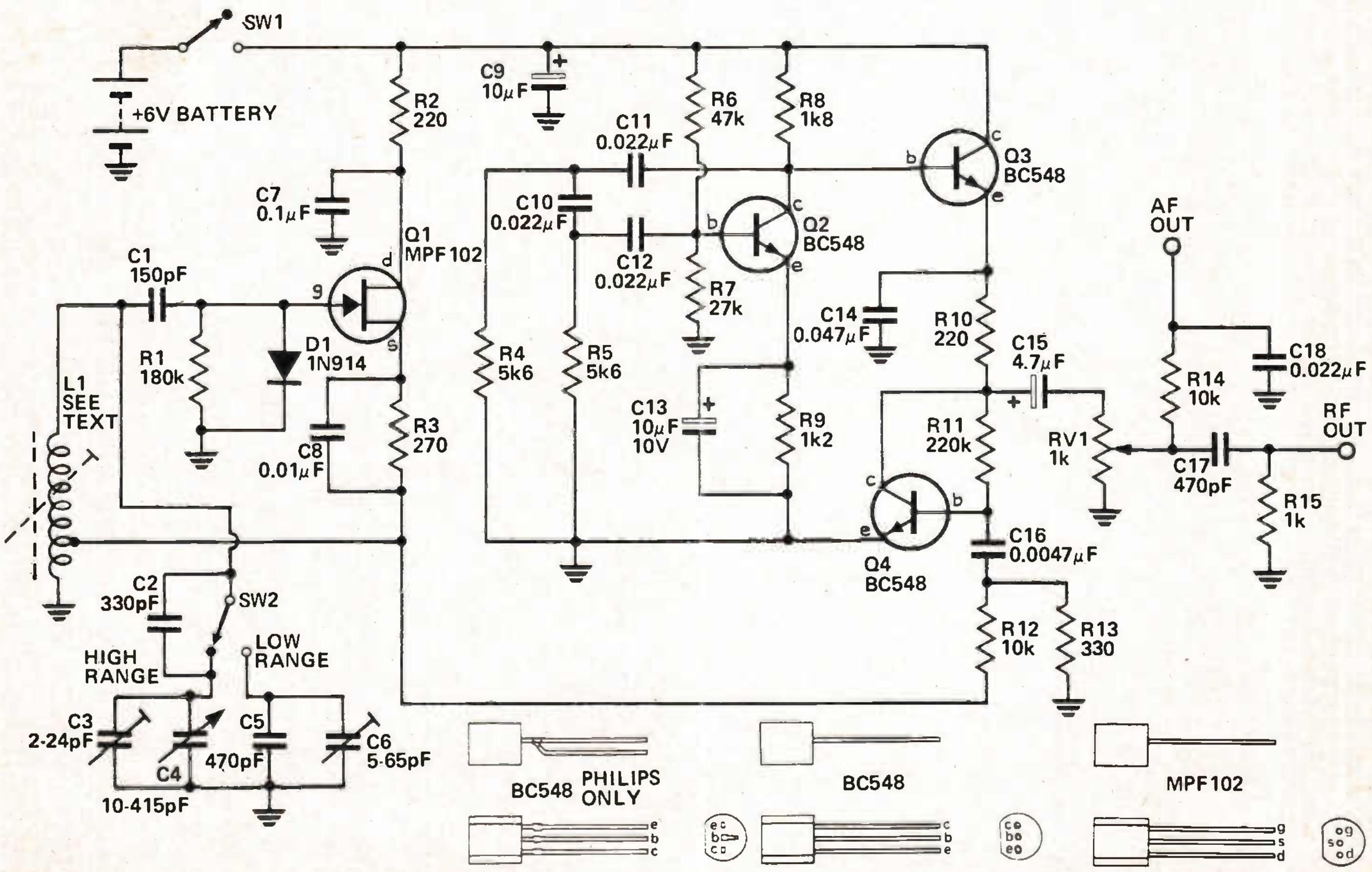


Fig. 1. Circuit diagram of the modulated RF generator.

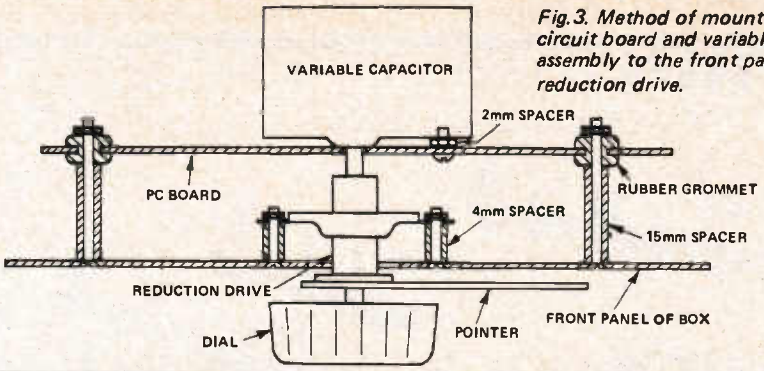


Fig.3. Method of mounting printed-circuit board and variable capacitor assembly to the front panel and reduction drive.

PARTS LIST — ETI 129

R2,10	Resistor	220	¼W 5%	C10,11	Capacitor	0.022µF	polyester
R3	"	270	" "	C12,18	"	0.022µF	polyester
R13	"	330	" "	C14	"	0.047µF	polyester
R15	"	1k	" "	C7	"	0.1µF	polyester
R9	"	1k2	" "	C15	"	4.7µF	10V electrolytic
R8	"	1k8	" "	C9,13	"	10µF	10V electrolytic
R4,5	"	5k6	" "				
R12,14	"	10k	" "	Q1	Transistor	MPF102	or similar
R7	"	27k	" "	Q2,3,4	"	BC548	or similar
R6	"	47k	" "				
				D1	Diode	IN914	or similar
R1	"	180k	" "				
R11	"	220k	" "	SW1	Switch	SPST	toggle
				SW2	"	SPDT	toggle
RV1	Potentiometer	1k Lin rotary.					
				L1	Inductor	See table 1.	
C3	Capacitor	2-24pF Philips 2222-808-00006		PC board ETI 129			
				Metal box 145 x 115 x 90 mm			
C6	"	5-65pF Philips 2222-808-01001		Front panel			
C1	"	150pF ceramic		6 to 1 Reduction drive.			
C2	"	330pF ceramic		Four rubber grommets			
C4	"	10-415pF Roblan variable		Four 15mm long spacers*			
				Two 4mm long spacers*			
				Two 2mm long spacers*			
C5,17	"	470pF Ceramic		Three terminals (red, black, green)			
C16	"	0.0047µF polyester		Nuts & bolts etc.			
C8	"	0.01µF polyester		*Spacers may be cut from longer sections.			

'zero beating'.

Now tune the receiver to a station at the low end of the band. Again set the pointer of the RF generator to the frequency at which the station operates and adjust the slug of L1 for zero beat in the same manner as for the high end.

Repeat the procedure for both the high and low ends of the band until there is no change at either end.

Low Range. The low range should be calibrated after the high range calibration has been completed.

First set C6 to mid position. Then tune in a station on a broadcast receiver that lies somewhere between either 860 and 960 kHz or 1290 and 1440 kHz. These two bands are twice and three times the generator IF band respectively. That is, we are working on the second or third harmonic of the generator respectively. Divide the actual frequency of the tuned-in station by two (for stations between 860 kHz and 960 kHz) or by three for stations between 1290 and 1440 kHz. Now set the pointer on the RF generator to this frequency. Adjust the capacitor C6 for zero beat as detailed for the high range.

Refer to any standard textbook for alignment procedure for AM receivers.

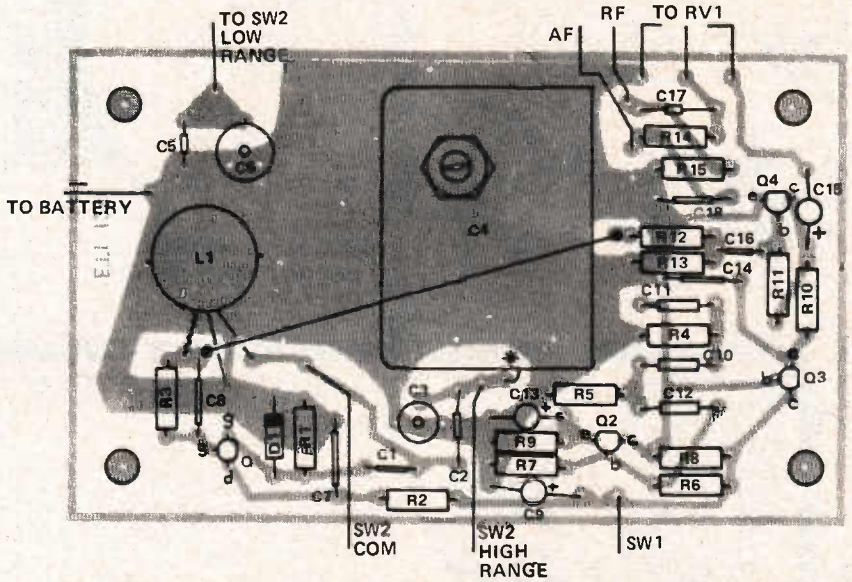


Fig. 2. Component overlay for the RF generator. Note the wire link between R12 and C8 which should be installed before fitting C4. Also note the connection from C4 to the board where shown by the asterisk.

HOW IT WORKS — ETI 129

The circuit may be sub-divided into three basic sections. These are:–

a) RF or carrier oscillator.

b) AF or modulation oscillator.

c) Modulator and buffer amplifier.

a) Transistor Q1 is connected as an Hartley oscillator. The positive feedback necessary for oscillation is provided from the source terminal of Q1 back to the gate via coil L1. The frequency of oscillation is determined by coil L1 in conjunction with capacitors C2 through C6.

Two ranges are provided, 500 kHz to 1600 kHz with L1, C3 and C4; and 430 to 480 kHz with L1, C2, C5 and C6. Diode D1 is used to develop a negative bias across R1 which thus limits the level of oscillation, and hence prevents damage to the gate of Q1.

b) Transistor Q3 is connected as a phase-shift oscillator. The network C10,C11, C12, and R3, R4 provides about 180° phase shift of the signal at the collector of Q3, and the feedback to the base of Q3 is therefore positive – causing oscillation. The frequency of oscillation is about 600 Hz.

c) Transistor Q4 is a class 'A' amplifier which is biased by the half-supply method (R10 and R11) the operating supply being obtained from emitter-follower ,Q3. The output of Q3 is the sine-wave from the phase-shift oscillator. Because of R11 any change at the junction of Q3 and R10 causes a corresponding change in the emitter current of Q4. The emitter current of Q4 therefore varies at the rate of 600 Hz. The emitter resistance of a transistor depends on the emitter current of that transistor and the gain depends on the ratio of the collector load, R10 to the emitter resistance. Since the emitter resistance is varying at 600 Hz, the gain of the transistor will also be varying at 600 Hz and so the RF signal fed to the base of Q4 from Q1 by C16 is modulated by the audio signal.

The signal across R10 is fed to RV1 by C15 and this signal consists of two components – the modulated RF and the audio tone.

After attenuation by RV1 the signals are separated by high and low pass filters to the AF and RF outlets.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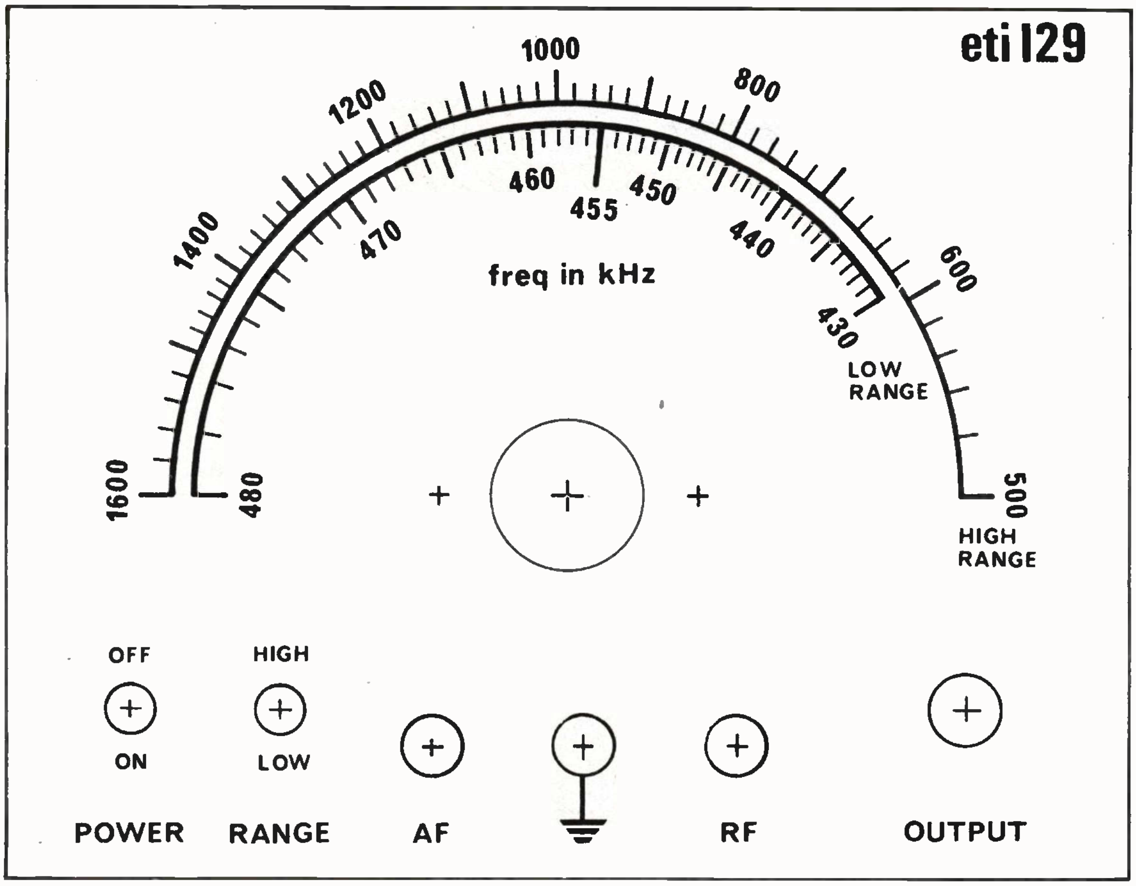


Fig. 4. Front panel artwork. Full size 148 x 116 mm.

COUPLING TO RECEIVER

Method 1. To ferrite rod coil. Connect one end of a length of ordinary hook-up wire to the RF OUT jack and then wrap about two turns of the other end of the wire around and over the aerial coil on the ferrite rod.

Method 2. To an IF amplifier. Connect a wire to the RF OUT jack and to its other end connect a 0.001 capacitor and a 1 k resistor in series. To inject the signal into the IF stage just connect the free end of the resistor to the base of the IF stage transistor.

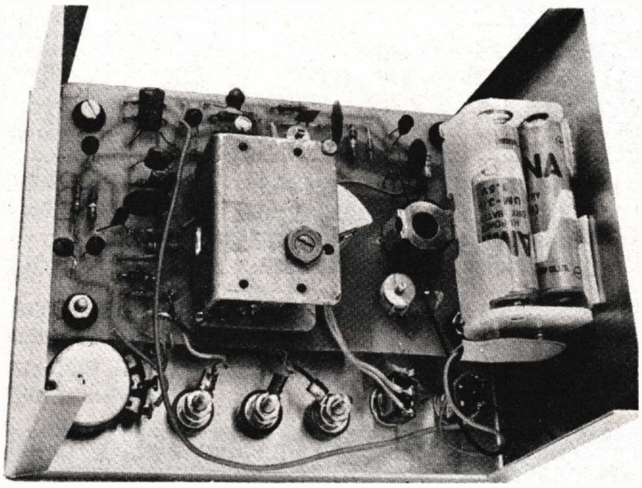
In both the above methods if insufficient signal level is available an earth connection may also have to be made between the generator and the receiver.

Method 3. Audio testing. Use a length of wire as before but with a series capacitor of about 0.47μF. Note that an earth connection will definitely be required in this case. Once again the best place to inject a signal is straight into the base of the transistor. ●

TABLE 1

L1	20 turns 0.5 mm enamelled copper wire tapped at four turns from grounded end.
CORE	Philip potcore P18 series, material 3B7 or 3H1, μe = 220. Part No 4322– 022 – 24280 or 4322 – 022 – 24080
FORMER	4322 – 021 – 30270
ADJUSTOR	4322 – 021 – 31080
CLIP	4307 – 021 – 20000

One each of core, former, adjustor and clip required to assemble one complete coil.



Internal view of the generator.

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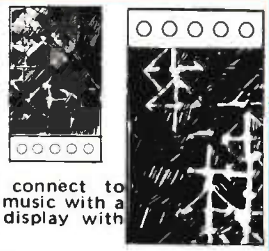

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Frequency Counter ETI 118.

As featured in the August issue of this magazine. The ETI 533 is required to be purchased for this unit. Kit includes case and power supply, KIT $49.50., P&P $2.00.

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	Bulk Disc. price	Qty. in pack		Bulk Disc. price	Qty. in packs
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SD7402	$3.40	10	SD7490	$6.00	10
SD7403	$3.40	10	SD7491	$2.25	2
SD7404	$3.40	10	SD7492	$3.40	5
SD7405	$3.40	10	SD7493	$6.00	10
SD7408	$3.40	10	SD7495	$2.50	2
SD7409	$3.40	10	SD7496	$3.00	2
SD7410	$3.40	10	SD74107	$3.00	5
SD7413	$4.90	10	SD74121	$3.40	5
SD7416	$4.90	10	SD74123	$4.00	5
SD7420	$3.40	10	SD74141	$4.30	5
SD7430	$3.40	10	SD74151	$4.30	5
SD7438	$3.40	10	SD74153	$4.30	5
SD7440	$3.40	10	SD74160	$5.70	5
SD7441	$3.70	5	SD74161	$5.70	5
SD7442	$3.40	5	SD74162	$5.70	5
SD7446	$2.75	2	SD74613	$5.70	5
SD7451	$3.40	10	SD74164	$5.70	5
SD7473	$5.90	10	SD74165	$2.50	2
SD7474	$5.90	10	SD74175	$5.00	5
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SD7476	$3.00	5	SD74193	$5.00	5

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MB4 400V., 1A bridge	$4.60	4
MB10 1000V., 1A bridge	$5.80	4
PA40 400V., 10A, bridge	$5.60	1
PB40 400V., 25A, bridge	$6.30	1
DL727 .3" 7 segment read-out	$2.30	1
DL747 .6", 7 segment read-out	$2.90	1
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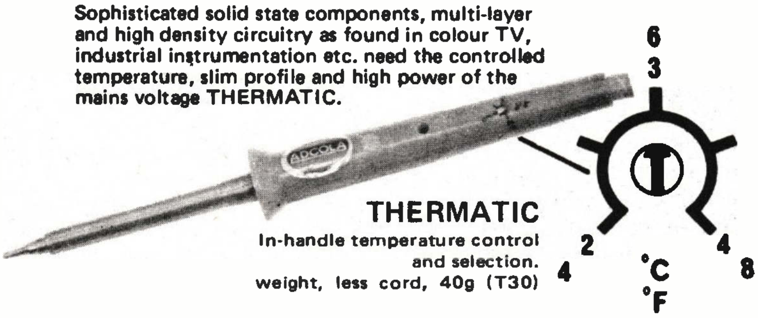

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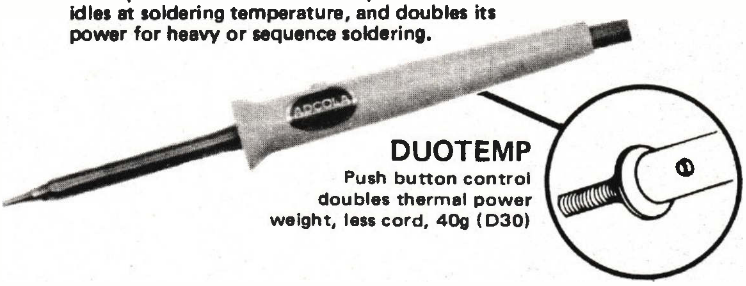

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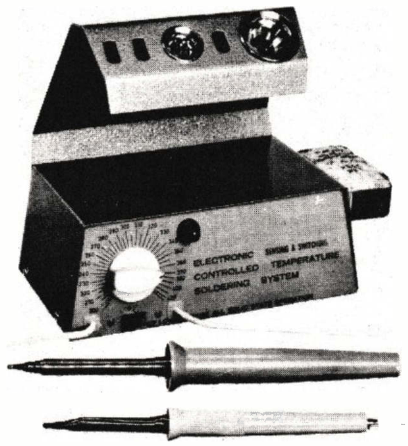

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DESIGN YOUR OWN FM RECEIVER PART 3

Brian Dance explains . . .

PHASE LOCKED LOOPS are very attractive for use in FM receivers, since they can replace a complete IF circuit and they require no coils. Unfortunately the phase locked loops available until recently have been suitable for communications receivers but not for high fidelity work. However, the recent development of the NE563 device by Signetics has greatly changed the position. The 563 is a new device containing about 180 transistors which can be used in the circuit shown in Fig. 16.

The incoming 10.7 MHz signal from the front-end unit is fed to pin 7 of the NE563. It is then amplified by up to 60 dB in a high gain amplifier/limiter circuit which has a bandwidth of 22 MHz. The output of the limiter at pin 5 has an impedance of about 270 ohms, so the additional series resistor R2 increases this to the value required by the ceramic filter F for correct matching. On the output side of this filter, R1 in parallel with the input resistance at pin 2 (about 1250 ohms) makes a suitable impedance match for the filter.

The 9.8 MHz quartz crystal connected between pins 1 and 16 forms part of a 9.8 MHz local oscillator circuit. The signal from the latter is mixed with the incoming 10.7 MHz and the resulting difference frequency of 900 kHz is fed by an internal connection to the phase locked loop section of the device.

The voltage controlled oscillator of the phase locked loop will free run at a frequency determined by the value of C12. If this free running frequency is reasonably close to the 900 kHz input frequency, the loop will lock onto the frequency of the input signal. The error voltage which keeps the loop in lock will vary with the frequency of the incoming signal. Thus this error signal is the required audio voltage when the incoming signal is a frequency modulated one.

The audio output appears at pin 10 superimposed on a steady voltage. The filter R9-C13 provides the normal de-emphasis of 50 μs time constant, whilst R10 and C14 provide some attenuation of RF frequencies. A series capacitor must be employed in both the stereo and monaural output circuits to block the steady voltage at pin 10.

The loop filter connected to pins 13 and 14 controls the bandwidth of the demodulator circuit. The impedance at these pins is typically 6.2 k. If R8 is reduced in value the bandwidth – and hence the noise level at the output – will be reduced, but the centre frequency must then be more carefully matched to the input frequency.

The limiter circuit feeds the stage which provides AGC at pin 4. The variation of the pin 4 voltage with the input signal level is shown in Fig. 17. The limiter also provides muting current to pin 8 where the output impedance is about 20 k. When the potential at this pin falls below about 1.1 V, the circuit is muted. The muting level is set by VR1. The writer has found the action of this muting

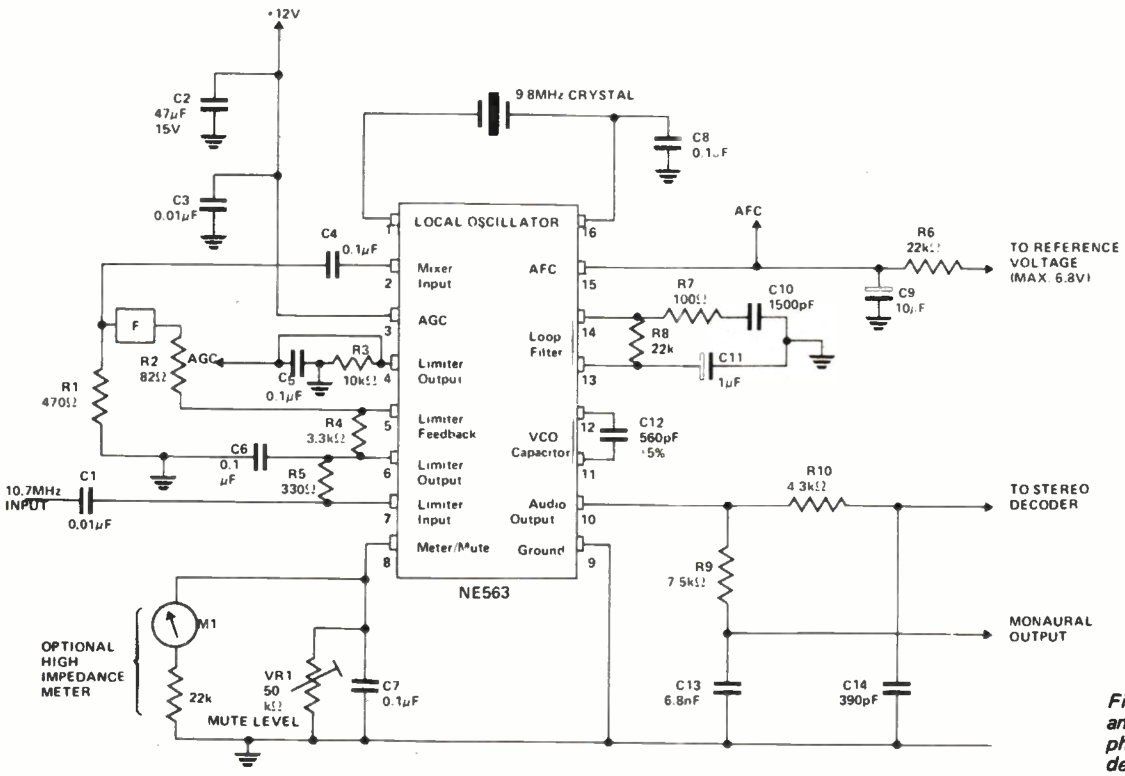

Fig. 16. A typical NE563 amplifier, mixer and phase locked loop demodulator circuit.

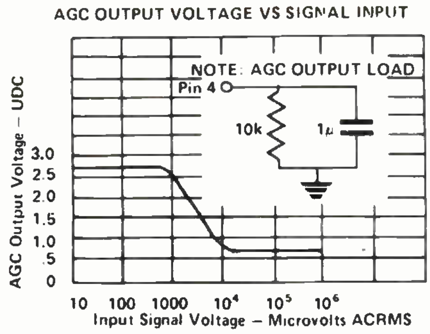

Fig. 17. Typical NE563 AGC characteristic.

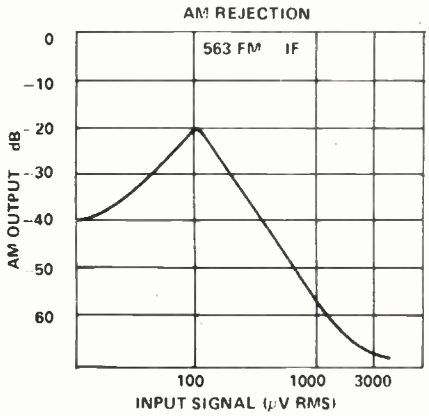

Fig. 18. NE563 AM rejection plotted against input voltage.

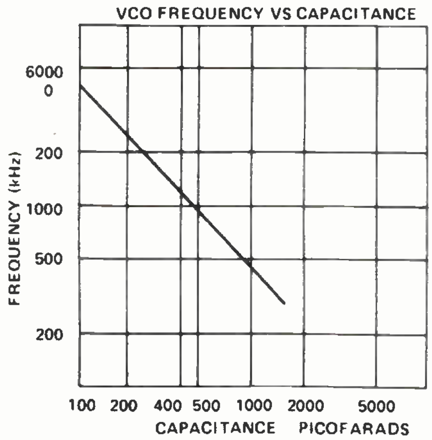

Fig. 19. VCO free running frequency plotted against the capacitance connected between pins 11 and 12.

circuit to be extremely good. Any signal of reasonable strength will raise the potential of pin 8 above 1.1 V when VR1 is suitably adjusted, but inter-station noise is eliminated. If muting is not required, pin 8 may be left unconnected.

A signal strength meter, M1, may be used if desired, but it must have a reasonably high impedance. The readings of this meter vary with the setting of VR1. A meter with a full scale deflection of about 5 V is suitable. The meter deflection is a logarithmic function of the input voltage over a very wide range (from 10 uV to at least 0.5 V).

The NE563 requires a power supply voltage in the range + 10 to + 15 V, the current required being typically 38 mA (maximum 42 mA). The power dissipated in this complex device renders it warm to the touch and results in some drift of the centre frequency for the first minute or so after power is first applied; however, this has no effect except when one wishes to receive very weak signals. The internal circuit of the NE563 provides a typical hum rejection of about 33 dB.

PERFORMANCE

The total harmonic distortion at the NE563 output is quoted as 0.4 per cent, this value having been measured at a modulating frequency of 1 kHz when the deviation was the normal maximum of ± 75 kHz. The audio output voltage is about 0.4 V rms. The AM rejection is shown in Fig. 18 for various input signal levels. This rejection is excellent and input levels exceeding a few millivolts and is probably better than that offered by other well known circuits at such levels.

The input sensitivity is about 9 μV for a 30 dB signal to noise ratio at 10.7 MHz (allowing for a 6 dB loss in the ceramic filter), whilst the corresponding level at the mixer input is about 1 mV. The capture and lock ranges are about 250 kHz and 290 kHz respectively for the circuit of Fig. 16 at input levels exceeding 1 mV. They fall with decreasing input levels, reaching about 80 kHz and 140 kHz at an input of 10 μV.

The NE563 device can, of course, be used at other frequencies than those suggested in the circuit of Fig. 16. The phase locked loop section can be operated at frequencies of less than 1 kHz up to several megahertz. The VCO capacitor required for various phase locked loop operating frequencies can be obtained from Fig. 19.

The writer has used 9.8 MHz crystals made by several different manufacturers (in the circuit of Fig. 16) with satisfactory results.

An economical Taiyo ceramic resonator type CR-9.8 has also been used instead of a 9.8 MHz crystal, but a few circuit modifications are required. The capacitor C8 can be omitted and the resonator connected in parallel with a 2.2 k resistor and a 5 pF capacitor between pins 1 and 16. The NE563 will oscillate if one merely connects a capacitor between pins 1 and 16, but the frequency will drift considerably. A 22 pF capacitor will produce oscillation at about 9.8 MHz.

A crystal oscillator is less likely to produce spurious oscillations than the ceramic resonator. Although one has the additional cost of the crystal, the circuit is very simple and ideal for the amateur constructor. Problems may occur with this type of circuit if the input contains spurious frequencies.

The demodulated signal is a multiplex one containing a number of separate parts as shown in Fig. 20. They are:

(1) The normal audio signal which has a waveform representing the sum of the signals in the left and right hand channels. If monaural reception is being employed, this sum signal is used as the audio output. As shown in Fig. 20, the maximum frequency of this signal is 5 kHz.

(2) A low level 19 kHz pilot tone which is synchronised with a 38 kHz sub-carrier. This pilot tone is required for the operation of the stereo decoder circuit.

(3) A left minus right signal which is modulated onto a 38 kHz sub-carrier. This signal is proportional to the sound amplitude in the left channel minus that in the right channel, the maximum frequency in each channel being 15 kHz. Thus the modulated left minus right signal occupies a frequency band of 38 + 15 kHz – that is from 23 kHz to 53 kHz as shown in Fig. 20. There is a small gap in this signal at 38 kHz, since no audio frequencies below about 30 Hz are transmitted.

(4) The 38 kHz sub-carrier itself is suppressed at the transmitter to a level of not more than 1% of the total signal.

It can be seen from Fig. 20 that a

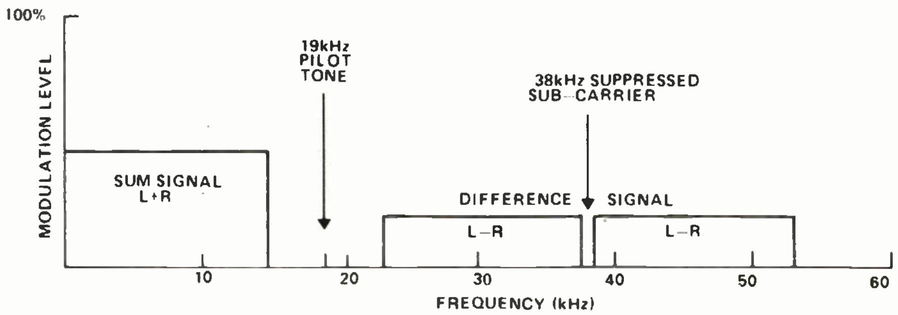

Fig.20. The frequency spectrum of a stereo multiplex signal.

stereo signal requires a much greater bandwidth than a simple monaural signal. This inevitably means that at a given input level from the aerial the signal to noise ratio will be worse for stereo reception than for monaural reception — actually about 30 dB worse.

The pilot tone is normally switched off at the transmitter when a monaural signal of more than a few minutes duration is being transmitted. This automatically ensures that the stereo decoder in the receiver is switched to the monaural state for the optimum signal to noise ratio.

A number of types of stereo decoder circuit have been published. For example, in the switching type the 19 kHz pilot tone is obtained from the multiplex signal by means of a tuned circuit and is doubled in frequency to re-generate the 38 kHz suppressed sub-carrier; the latter is used to switch the multiplexed input signal. Apart from the necessity of setting up the tuned circuit, such systems have the disadvantage that they do not provide the best channel separation.

In this article, only modern phase locked loop decoding circuits will be discussed, since they provide optimum performance with circuit simplicity and ease of adjustment. The frequency of the loop automatically locks onto a harmonic of the pilot tone and any normal changes of the component values with time or temperature will not affect the performance. Circuits of this type provide excellent channel separation (typically better than 40 dB) and employ an integrated circuit designed especially for the application.

The CA3090 is a unique stereo decoder integrated circuit first introduced by RCA in mid-1971 as the CA3090Q. An improved version was made available in 1973 under the coding CA 309AQ. Both devices are encapsulated in 16 pin quad-in-line packages which require a supply of about 22 mA at 12V.

Unlike other phase locked loop decoders, these devices have voltage controlled oscillators which are tuned by a 2 mH inductance. The use of an inductance tuned oscillator is said to result in better stability at extremes of temperature (which may be useful in car radios) and better stability as the circuit ages.

The CA3090AQ has the following advantages over the CA3090Q:

(i) It can drive directly a stereo indicator lamp, which requires a current of up to 100 mA. (This indicator lamp is illuminated when the 19 kHz pilot tone causes the loop to lock, showing the circuit is switched to the 'stereo' mode).

(ii) The steady voltage level at the stereo defeat/enable contact (pin 4) controls the operating mode, this voltage level being independent of the pilot tone level, provided that the latter is above a certain minimum level.

(iii) The CA3090AQ is capable of providing rather lower distortion than the CA3090Q.

CIRCUIT

The fairly complex internal circuit of the CA3090AQ is shown in block form in Fig. 21 together with a typical external circuit. The demodulated multiplex signal from the receiver detector is applied to pin 1 of the CA3090AQ where the input impedance is about 50 k. The low distortion pre-amplifier stage feeds the signal to

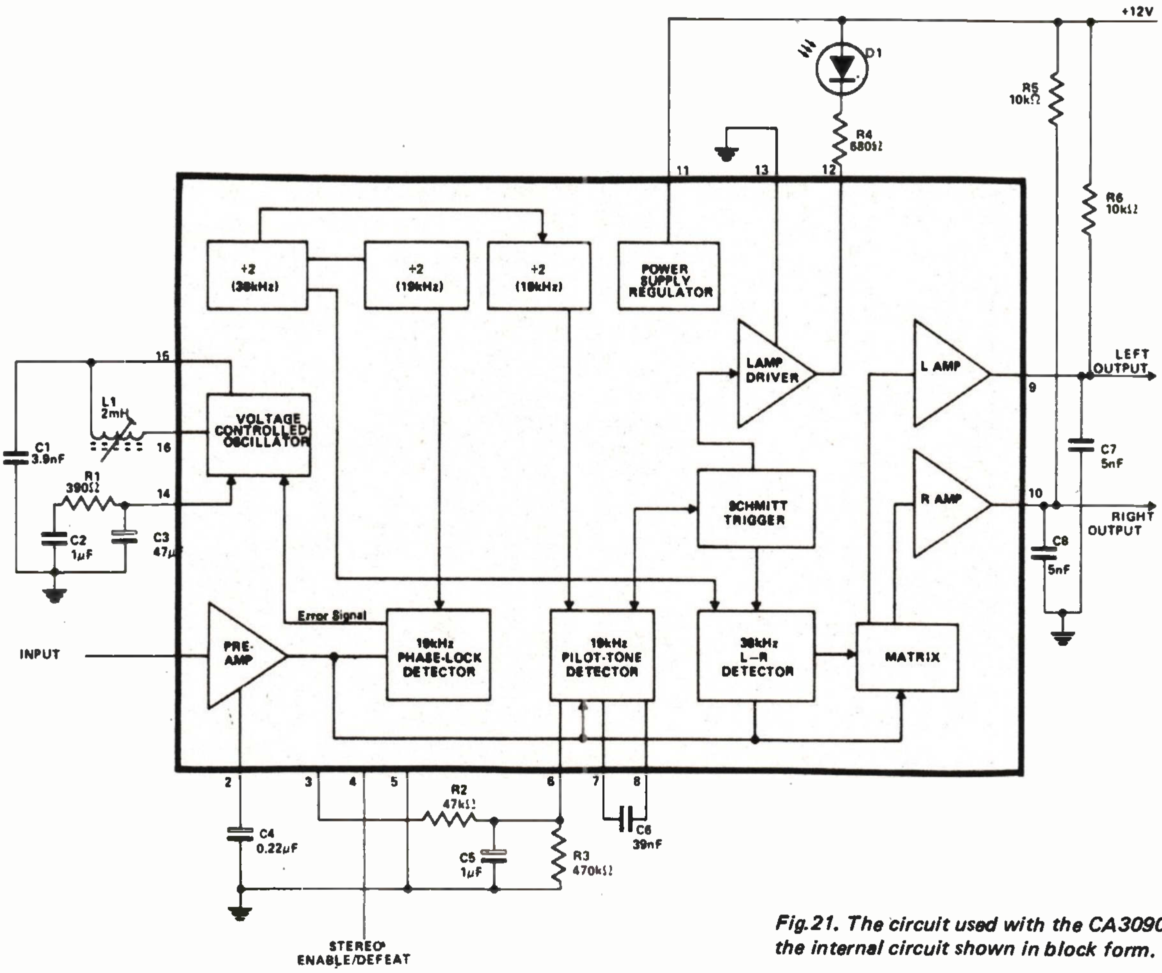

Fig.21. The circuit used with the CA3090AQ with the internal circuit shown in block form.

both the 19 kHz and the 38 kHz synchronous detectors.

The voltage controlled oscillator generates a 76 kHz signal which is divided in frequency to produce a 38 kHz signal and two 19 kHz signals in phase quadrature. The 19 kHz pilot tone from the demodulator circuit is compared with the locally generated 19 kHz signal. An error signal is generated which is used to control the voltage controlled oscillator frequency so that it remains locked with the harmonic of the pilot tone.

A second synchronous detector detector compares the locally generated 10 kHz signal with the 19 kHz pilot tone. If the amplitude of the latter exceeds a certain value set by an externally adjustable threshold voltage, a Schmitt trigger circuit is energised. The signal from the Schmitt trigger operates the lamp driver circuit which switches the stereo indicator lamp on or off. It also switches the circuit from monaural to stereo operation.

The output signal from the 38 kHz detector and the multiplex signal from the pre-amplifier are applied to a matrix circuit which produces the left and right hand audio signals; the latter are applied to their respective internal amplifiers. The external capacitors C7 and C8 provide the normal 50 µs de-emphasis.

A light emitting diode, D1, in series with the resistor R4 is shown in Fig. 21. LEDs consume much less current than tungsten filament lamps and are more reliable. However, D1 and R4 may be replaced by a small lamp, consuming not more than 100 mA, if desired.

The core of the inductance L1 should be set half way between the points at which the indicator lamp just switches as the core adjustment is changed. The centre frequency of the voltage controlled oscillator is then very close to 76 kHz. The capture range of the loop is typically ± 10% of the centre frequency.

A 2mH coil especially designed for use with the CA3090 device is the Toko type YXNS 30450NK which has its adjuster colour coded blue. It employs 270 turns on a ferrite core which provides a Q factor of about 118. The connections are made to the two pins on the opposite side to the row of three pins on the base of this coil.

If the voltage applied to pin 4 of the CA3090AQ exceeds about 1.2 V, the device is switched to the stereo mode. At lower voltages it is switched to the monaural mode. The tolerance range of the pin 4 voltage is 0.9 V and 1.6 V. The CA3090AQ may be used without the stereo defeat and enable function if a suitable control voltage is not readily available; in this case pin 14 should be directly grounded.

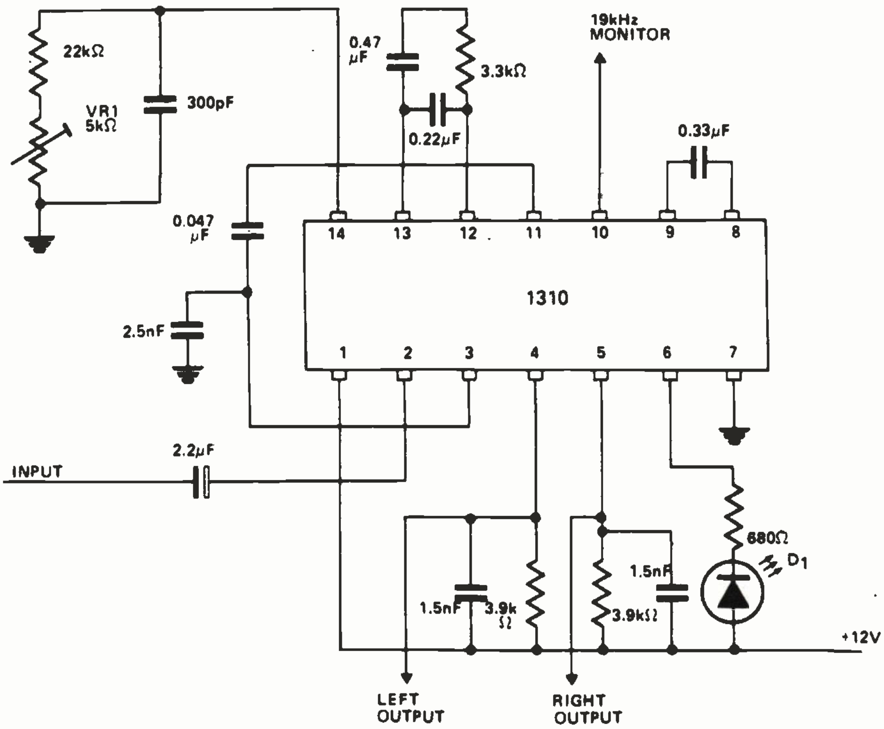

Fig.22. A stereo decoder circuit using the LM1310 type of device.

The CA3090AQ provides a typical 2nd harmonic distortion level at the outputs of 0.2%, whilst the 3rd, 4th and 5th harmonic distortion is typically less than 0.1%. The channel separation is typically 40 dB (minimum 25 dB).

OTHER DECODER ICs

Another type of stereo decoder which requires no external inductance first appeared in 1972 as the Motorola MC1310P. This is a phase locked loop device operating on similar principles to the CA3090AQ. The frequency is set by a preset resistor rather than an inductance.

The LM1310 (National Semiconductor) device is a 14 pin dual-in-line circuit equivalent to the Signetics MC1310. Other equivalents are the RCA CA1310E and the Texas Instruments SN76115N. These devices can be used in the type of circuit shown in Fig.22.

Rather similar devices are available in 16 pin dual-in-line cases in which an emitter follower is included in each output circuit. The type of circuit which can be used with these devices is shown in Fig. 23. The de-emphasis components are in the pin 3 and pin 6 circuits, whilst the emitter follower outputs appear at pins 4 and 5. Devices of this type include the LM1301E from National Semiconductor, the MC1310E from Signetics, etc.

The National Semiconductor LM1800 device can also be used in the same circuit as that shown in Fig. 23, but has the additional advantage that it contains a built-in circuit for providing 45 dB power supply ripple rejection. The RCA type CA758E and the Motorola MC1311P are similar devices.

The only adjustment which must be made to the circuits of Fig. 22 and 23 (before use) is the setting of the free running frequency of the phase locked loop by means of VR1. If a frequency counter is available, pin 10 of Fig. 22 or pin 11 of Fig. 23 may be connected to the input of the counter and VRI adjusted until the signal from the device has a frequency of 19 kHz. (The amplitude of the signal is about 3 V peak).

Most readers will find it easier to adjust VRI until the stereo indicator lamp remains illuminated at the lowest possible signal level. This adjustment is very easy and causes no problems whatsoever.

The capture range is typically 3%. It can be increased by reducing the capacitance from pin 14 of Fig. 22 or pin 15 of Fig. 23 to ground and increasing the resistors (in parallel with this capacitor) in proportion. However, these alterations are likely to cause increased beat note distortion at high signal levels due to oscillator phase jitter.

The capacitor between pins 8 and 9 of Fig. 22 (or between pins 9 and 10 of Fig. 23) controls the stereo-monaural switching delay. The switching time constant is equal to its value multiplied by about 53 k. If pin

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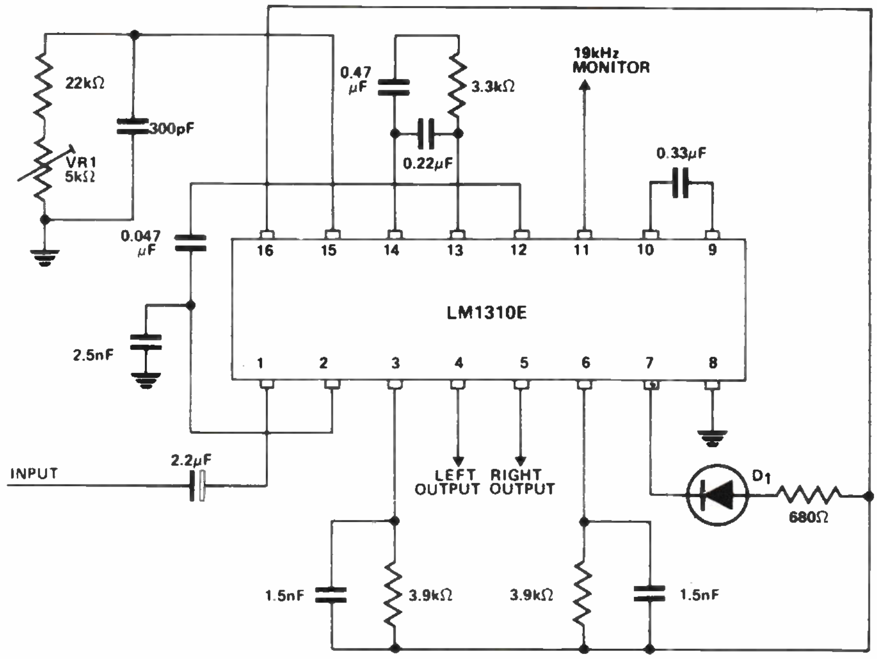

Fig.23. A stereo decoder circuit using the LM1310E type of device.

8 of Fig. 22 or pin 9 of Fig. 23 is earthed, the circuit operates only in the monaural mode.

There is some variation in the power supply ratings of the devices offered by various manufacturers. For example, the National Semiconductor devices are specified as operating over the range 10 to 24 V and the Signetics devices 8 to 16 V, whilst the RCA 1310E has a supply voltage rating of 8 to 14 V and the CA758 of 10 to 16 V. These ratings should be strictly observed for the particular device employed. The current drawn is of the order of 30 mA.

The audio output voltage is typically 485 mV rms from both the circuit of Fig. 22 and that of Fig. 23. The minimum value of the load resistors in Fig. 22 is affected somewhat by the power supply voltage. The circuit of Fig. 23 does not suffer from this limitation, since the emitter follower outputs provide a low output impedance.

Readers requiring further information on this topic are advised to consult individual device data-sheets and also to study the report by T. D. Isbell and D. S. Mishler "LM1800 phase locked loop FM stereo demodulator". National Semiconductor Application Note AN-81, June 1973.

STEREO OUTPUT FILTERS

The stereo decoder circuits discussed generate 19 kHz, 38 kHz and 76 kHz waveforms. Although the decoder circuits incorporate about 25 dB and 45 dB rejection of these frequencies, they can still cause trouble when one wishes to feed the output to a tape recorder. Harmonics of these signals may beat with a harmonic of the tape recorder bias oscillator.

This problem can be solved by the addition of a suitable filter to the stereo decoder output. The Toko Company make a number of suitable filters which provide considerable rejection at 19 kHz and 38 kHz.

The Toko BLR-2011-N filter provides a maximum attenuation of 1 dB at frequencies up to 15 kHz and a minimum attenuation of 30 dB at 19 kHz and 38 kHz. This filter is about 42 mm x 34 mm x 20 mm in size. The two inputs from the stereo decoder are connected to the filter, an earth connection made to it and the two outputs taken from the appropriate pins.

The Toko BLR-2007-N is a rather similar filter which provides an attenuation not exceeding 3 dB at frequencies up to 15 kHz and minimum attenuations of 20 dB and 55 dB at frequencies of 19 kHz and 38 kHz respectively. A third Toko low pass filter is the 170 BLR-3107N which has a maximum attenuation of 1.2 dB at frequencies up to 15 kHz and minimum attenuations of 26 dB and 50 dB at 19 kHz and 38 kHz respectively. The crosstalk does not exceed – 45 dB between 50 Hz and 10 kHz, whilst the ripple in the pass band has a maximum value of ± 0.5 dB.

Another type of stereo decoder which requires no external inductance first appeared in 1972 as the Motorola MC1310P. This is a phase locked loop device operating on similar principles to the CA3090AQ. The frequency is set by a preset resistor rather than an inductance.

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Rather similar devices are available in 16 pin dual-in-line cases in which an emitter follower is included in each output circuit. The type of circuit which can be used with these devices is shown in Fig. 23. The de-emphasis components are in the pin 3 and pin 6 circuits, whilst the emitter follower outputs appear at pins 4 and 5. Devices of this type include the LM1301E from National Semiconductor, the MC1310E from Signetics, etc.

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The only adjustment which must be made to the circuits of Fig. 22 and 23 before use is the setting of the free running frequency of the phase locked loop by means of VR1. If a frequency counter is available, pin 10 of Fig. 22 or pin 11 of Fig. 23 may be connected to the input of the counter and VR1 adjusted until the signal from the device has a frequency of 19 kHz (The amplitude of the signal is about 3 V peak).

Most readers will find it easier to adjust VR1 until the stereo indicator lamp remains illuminated at the lowest possible signal level. This adjustment is very easy and causes no problems whatsoever.

The capture range is typically 3%. It can be increased by reducing the capacitance from pin 14 of Fig. 22 or pin 15 of Fig. 23 to ground and increasing the resistors in parallel with this capacitor in proportion. However, these alterations are likely to cause increased beat note distortion at high signal levels due to oscillator phase jitter.

The capacitor between pins 8 and 9 of Fig. 22 (or between pins 9 and 10 of Fig. 23) controls the stereo-monaural switching delay. The switching time constant is equal to its value multiplied by about 53 k. If pin 8 of Fig. 22 or pin 9 of Fig. 23 is earthed, the circuit operates only in the monaural mode.

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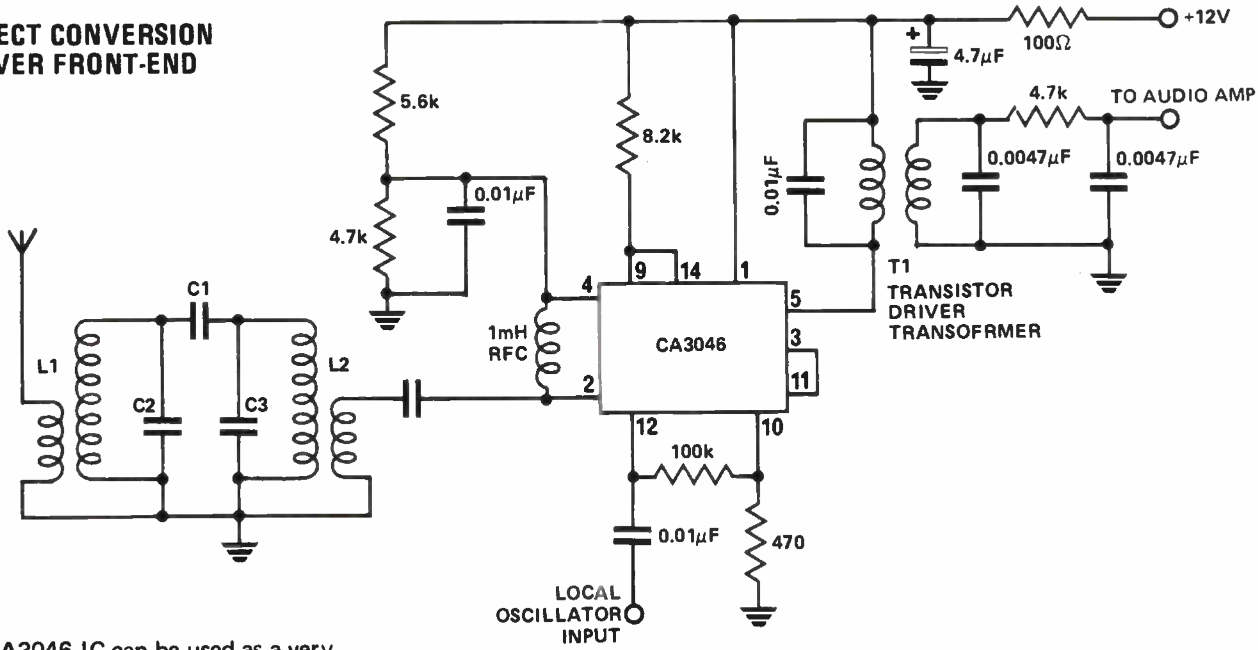
IDEAS FOR EXPERIMENTERS

IC DIRECT CONVERSION RECEIVER FRONT-END

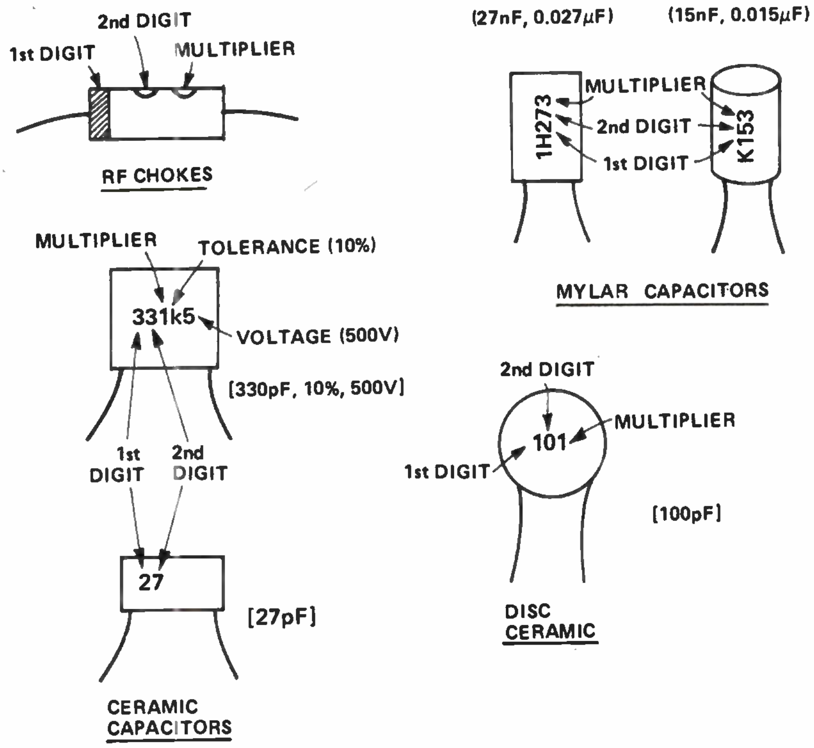


The CA3046 IC can be used as a very efficient mixer in a direct conversion receiver front-end. Some buffering and amplification of the local oscillator is provided and the mixer has a small amount of conversion gain.

The input tuned circuit can be made to suit the desired range. CI is a coupling capacitor that determines front-end selectivity. For 3.5 to 4 MHz, L1 and L2 are 13 turns of #26 B&S enamel wire wound around 2/3 of a Philips toroid type 020-91010. C2 and C3 are 33 pF capacitors parallelled by 3-30 pF trimmers. C1 is 15 pF or larger for more bandwidth.

JAPANESE COMPONENT CODES

Japanese and some other imported components are marked with codes giving value, tolerance etc. as shown above. Colour coded RF chokes use the same colour code as resistors but the value is in microhenries – similar to the Philips RFC coding.



As the name of this section implies, these pages are intended primarily as a source of ideas. As far as reasonably possible all material has been checked for feasibility, component availability etc, but the circuits have not necessarily been built and tested in our laboratory.

Because of the nature of the information in this section we cannot enter into any correspondence about any of the circuits, nor can we produce constructional details.

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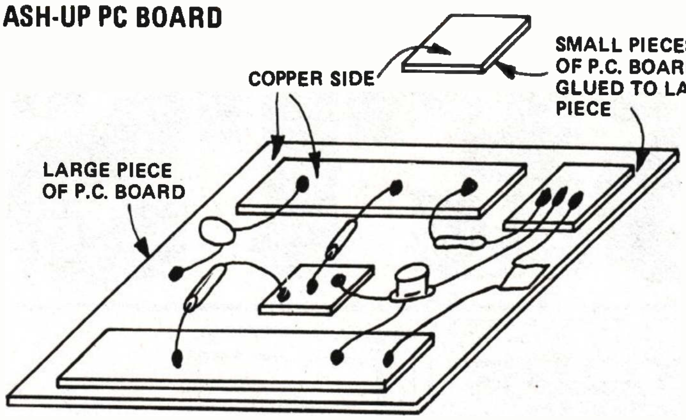
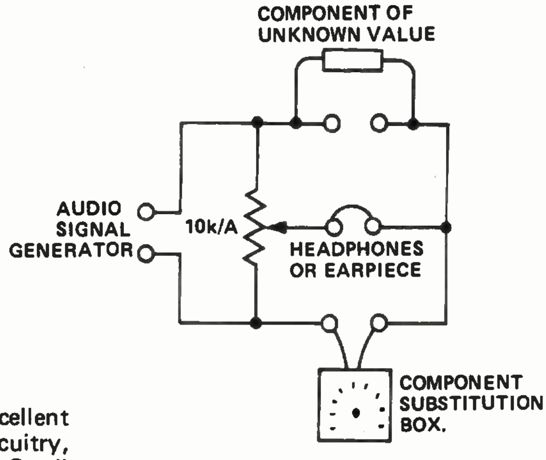
LASH-UP PC BOARD



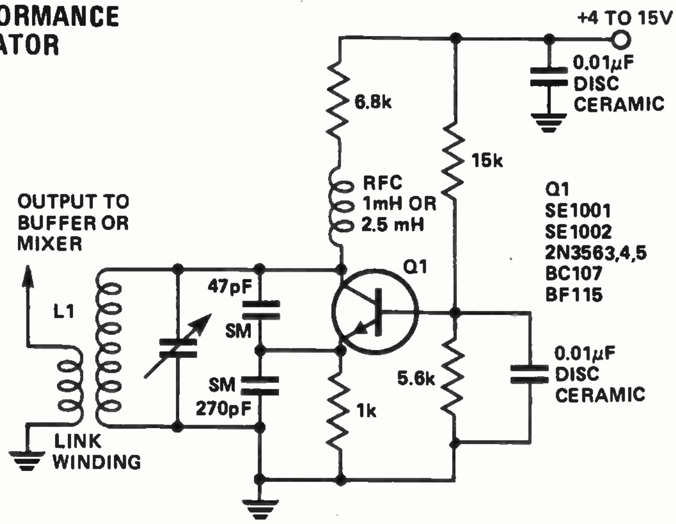
Quick breadboards,or circuit lash-ups can be made with a large piece of p.c. board of suitable size with small, variously shaped, scraps or pieces cemented to it. Single or double-sided p.c. board can be used. Quick drying or 'instant' drying glues that can withstand heat are best, e.g. 'Super 500' or equivalent. It is an excellent form of construction for RF circuitry, particularly VHF-UHF circuitry. Small capacitors can be made in this fashion also. A 5 mm x 5 mm square of 2 mm thick fibreglass p.c. board stuck on a larger piece has a capacitance close to 5 pF.

SIMPLE RLC BRIDGE



A simple RLC bridge can be made from a few components as shown above. The audio generator provides a signal to a bridge network formed by the potentiometer, the component substitution box and the unknown value component. The head phones or earpiece serve as a null detector — alternatively a CRO can be used.

HIGH PERFORMANCE RF OSCILLATOR



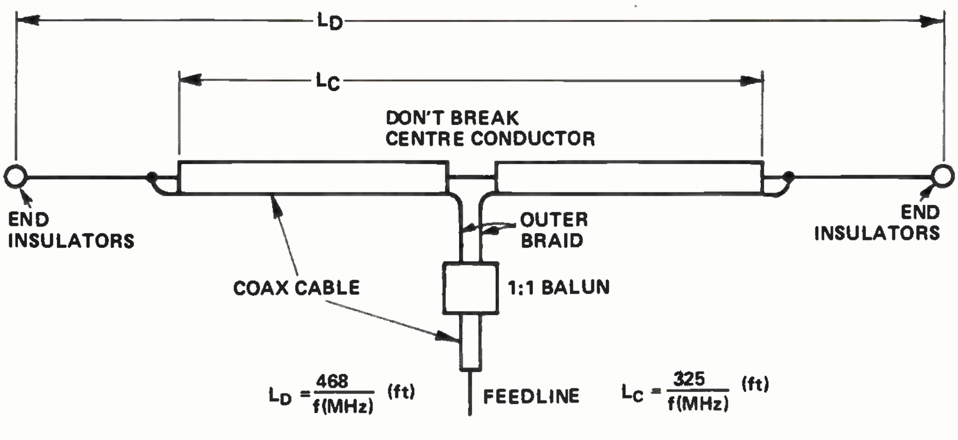
This high performance RF oscillator will produce an output that is level to within ± 10 mV over approximately a 2:1 frequency range. Stability is quite good following warm-up provided the usual precautions are taken. Single point earthing is an advantage.

With the component shown the oscillator will work from 2 MHz to about 25 MHz. L1/C1 should be selected according to the desired range.

Actual output depends on the link winding. The turns ratio of the link winding to L1 should be about 10:1. Couple the link winding to the 'earthy' end of L1. Tight coupling degrades stability. About 300 mV to 500 mV is readily obtained with only loose coupling.

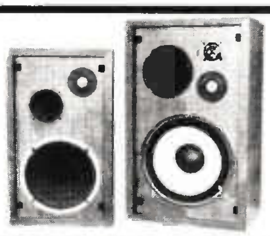
BROADBAND HF DIPOLE

A wire dipole at HF typically has a bandwidth of 4% to 5% for an SWR of 2:1 either side of resonance. The bandwidth can be increased to greater than 17% by constructing the dipole with a portion of it of small diameter (1/4" or 1/8") coaxial cable. Tape the coax to a nylon bearer line, either rope or heavy fishing line to give it strength and support. This is an old tip but not well remembered.



$L_D = \frac{468}{f(MHz)}$ (ft) $L_C = \frac{325}{f(MHz)}$ (ft)

KITSETS



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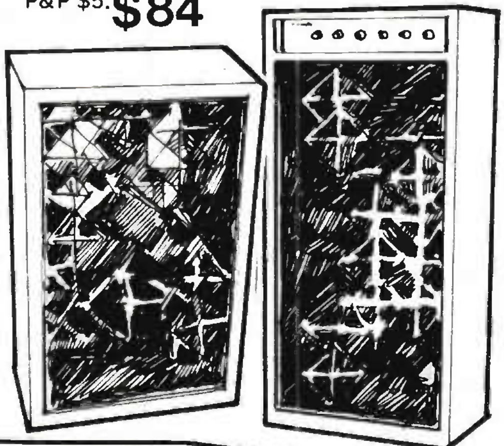

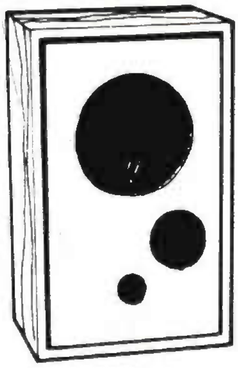

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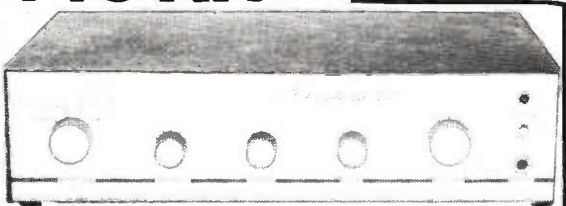

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PROJECT 128 AUDIO MILLIVOLTMETER

Sensitive instrument for 'A' weighted audio noise and signal measurements.

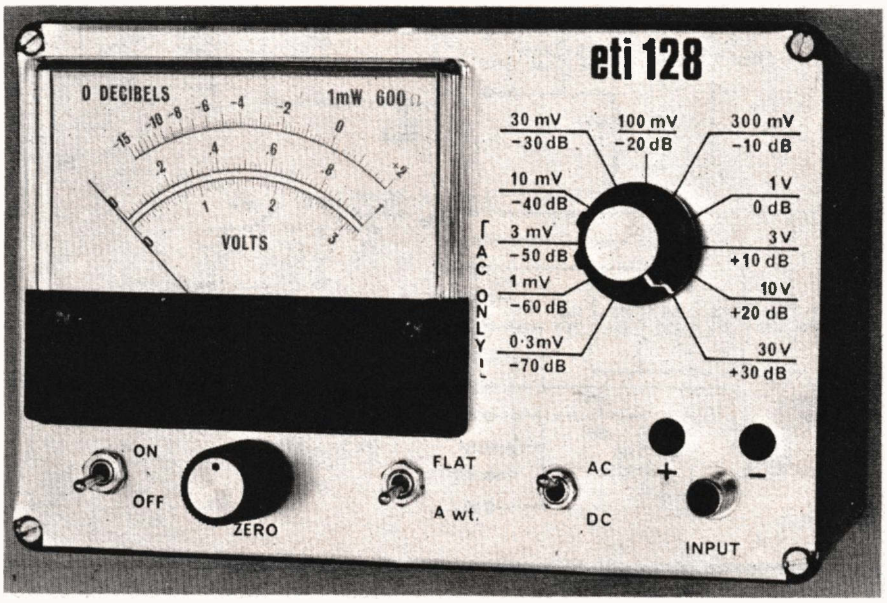
AN ACCURATE and sensitive ac voltmeter is needed for many audio equipment measurements.

Whilst for example, maximum power output is readily measurable with a conventional multimeter, more complex instrumentation is required for measuring noise output (a measurement required when checking signal/noise ratio).

Even signal levels as high as 100 mV, typical output of most pre-amplifiers, are not readily measured with accuracy on a conventional multimeter.

The ETI 128 Millivoltmeter is specifically designed for such measurements whilst also being useful as a general purpose ac/dc voltmeter. The lowest range, of 300 microvolts FSD, allows measurements to 80 dB below one volt, whilst other ranges allow measurements up to 30 volts ac or dc. These ranges cover most of the measurement requirements of audio work.

When measuring noise levels account must be taken of the non-linear characteristics of the ear. For this reason a network has been incorporated which tailors the meter response-versus-frequency to match the subjective response of the ear. Such a network is known as an 'A weighting network' and its use provides a measurement which is realistically related to what is heard. When measurements are made using this network the results must be quoted as being 'A weighted'. Typically this is done by quoting dBA rather than just plain dB.



CONSTRUCTION

The meter is a highly sensitive instrument and for this reason the constructional method given should be followed closely if noise and hum pickup are to be minimized.

A diecast box is used to house the meter as this provides excellent shielding against external signals. The front panel label is made from 'Scotchcal'. This is a specially prepared sheet of thin aluminium which is coated with a photo-sensitive emulsion on one side. The reverse side has a self-adhesive coating, protected by waxed paper, which is peeled off when the material is to be stuck down. As Scotchcal is only available in bulk, ETI is making available ready-to-use front panel labels made from this material. Should you require one of these labels send $3.00 and a stamped, self-addressed envelope (minimum size envelope 190 x 127 mm).

The meter used in the prototype was from Dick Smith Electronics. It measures 100 x 82 mm but requires to be rescaled. The scale as published on page 77 should be cut out and glued over the existing scale taking care not to let glue or dirt enter the meter movement. Any similar meter may be

SPECIFICATION

RANGES	
dc (FSD)	10, 30, 100, 300 mV, 1, 3, 30 V. auto-polarity, LED indication.
ac (FSD)	0.3, 1, 3, 10, 30, 100, 300 mV, 1, 3, 10, 30 V 0 dB = 1 mW into 600 ohms (0.775 V) weighting curves, ac only, flat, 'A' weight
ACCURACY	± 3% nominal
MINIMUM READING	
Open circuit	−76 dB
Terminated 47 k	−85 dB
POWER SUPPLY	
Voltage	+6 and −6 volt (batteries)
Current	approximately 12.5 mA
Battery life	approx 100 hours (8 x 1015 cells)

AUDIO MILLIVOLTMETER

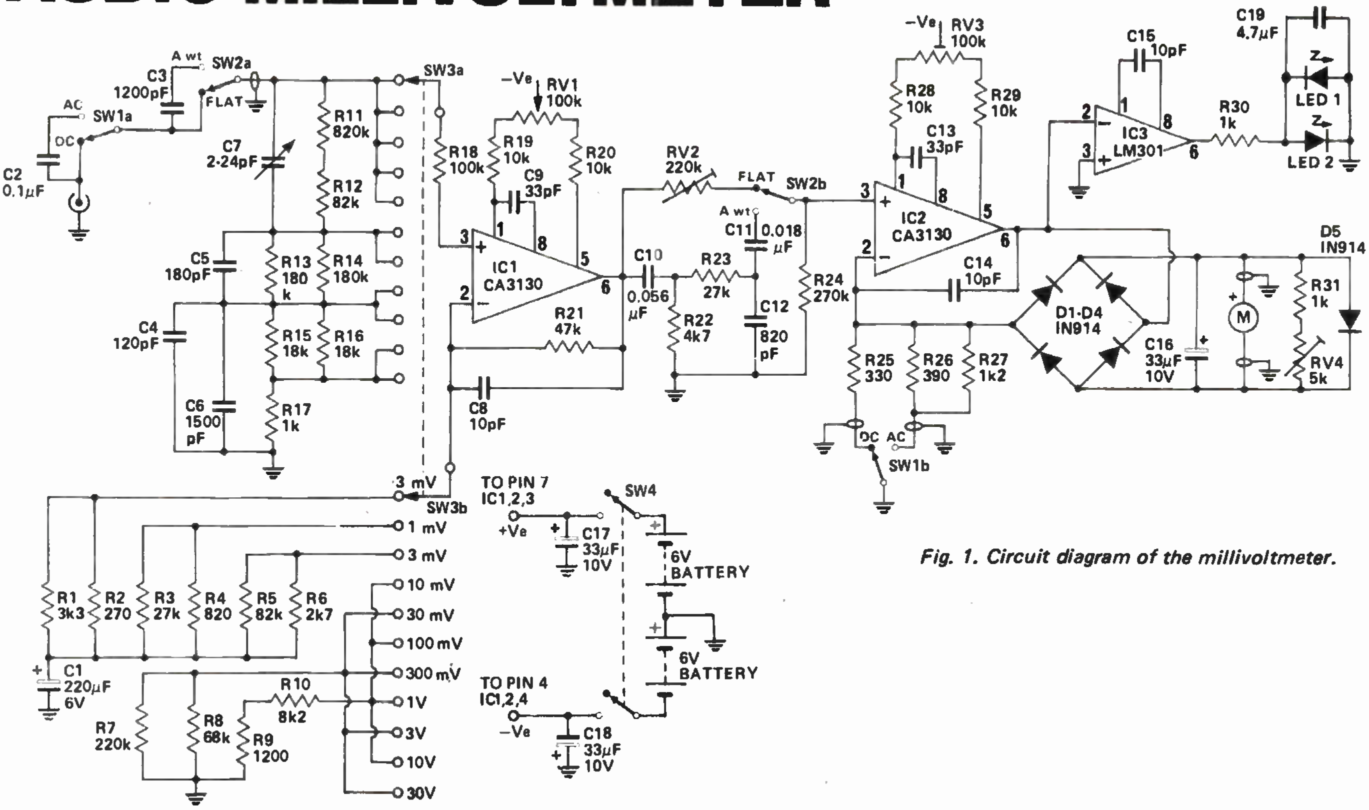


Fig. 1. Circuit diagram of the millivoltmeter.

HOW IT WORKS – ETI 128

The millivoltmeter may be separated into several sections in order to simplify the explanation of its mode of operation. These are:–

(a) Input attenuator.
(b) Input amplifier.
(c) 'A'-weight network.
(d) Meter drive circuitry.
(e) Polarity detector.

The input attenuator consists of resistors R11 to 17 and capacitors C4 to 7, and gives division ratios of 1, 10, 100 and 1000. The capacitors are required to ensure that the division remains accurate at high frequencies.

The input amplifier is a CA3130 operational amplifier where the gain is selected by SW3b. Gains of 190, 60, 19, 6 and 1.9 are available which together with the input divider ratios provide the 11 ranges required. The high gain ranges of 190, 60 and 19 are ac coupled, as the temperature stability of the CA3130 will not allow voltages of less than 10 mV dc to be used. The output of this amplifier is 60 mV when the meter is indicating full scale on any range. A potentiometer, RV1, is provided to adjust the offset voltage on the CA3130 and thus acts as a zero-set control. Since the offset voltage is affected by temperature this control is available externally.

When measuring noise in audio systems a weighting network is often used to give a measurement which is related to the non-linear response of the ear. The most commonly used weighting is known as 'A' weight and this facility is built into the meter. The 'A' weight curve is produced by a network that has a three-pole, high-pass filter and a single-pole, low-pass filter. The main section of this filter is formed by C10, C11, C12 and R22, 23, and R24 (two poles). The third pole is due to C3 and the one megohm combined resistance of R11 to R17. This later section prevents saturation of the input amplifier at low frequencies. Since this filter introduces some loss at 1 kHz, RV2 is incorporated to provide the same loss in the 'flat' mode.

The second IC acts as a meter amplifier. The input signal is rectified by the diode bridge D1 to D4 whilst the amplifier effectively compensates for the diode drops. A preset for offset adjustment, RV3, is provided for this IC. Calibration is performed by adjustment of the shunting resistance, R31 and RV4, across the meter. Due to the full-wave action of the rectifier the meter when on the dc ranges reads uni-directionally regardless of dc polarity. The output of IC2 will however will either be at over one volt positive or one volt negative (voltage drops across the diodes) depending on whether the input voltage is positive or negative. This is compared by IC3 against zero volts and, depending on polarity, either LED 1 or LED 2 will be illuminated. With an ac input both LEDs will be on. These LEDs are therefore the polarity indicators. Capacitor C19 removes any high frequency components which could be coupled into the input, as the LEDs are located next to the input socket.

Due to the difference between the average and the RMS values of a sine-wave a slight change in gain is necessary in the ac mode and, this change is made by SW1b.

used as long as it has 100 microamp sensitivity.

The ac/dc and Flat/'A' weight switches are four-pole types although only the outer two poles are used. The centre two poles are earthed in order to reduce the capacitance between the two outer poles. Such precautions are necessary to prevent any possibility of instability on the most sensitive ranges. The metal bracket which supports the printed-circuit board also acts as a shield between the meter circuitry and the input stages.

Commence construction by assembling components to the printed-circuit board, making absolutely sure that all are mounted in the correct position and with the correct polarity. This should be carefully done — once the meter is

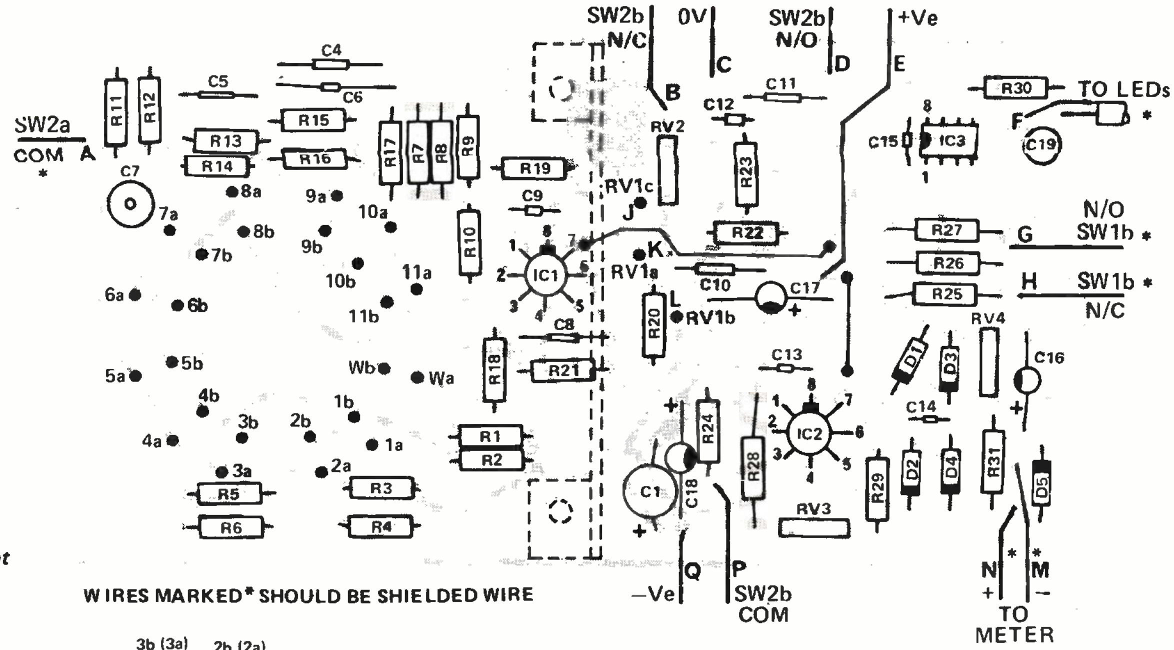


Fig. 2. Component overlay.

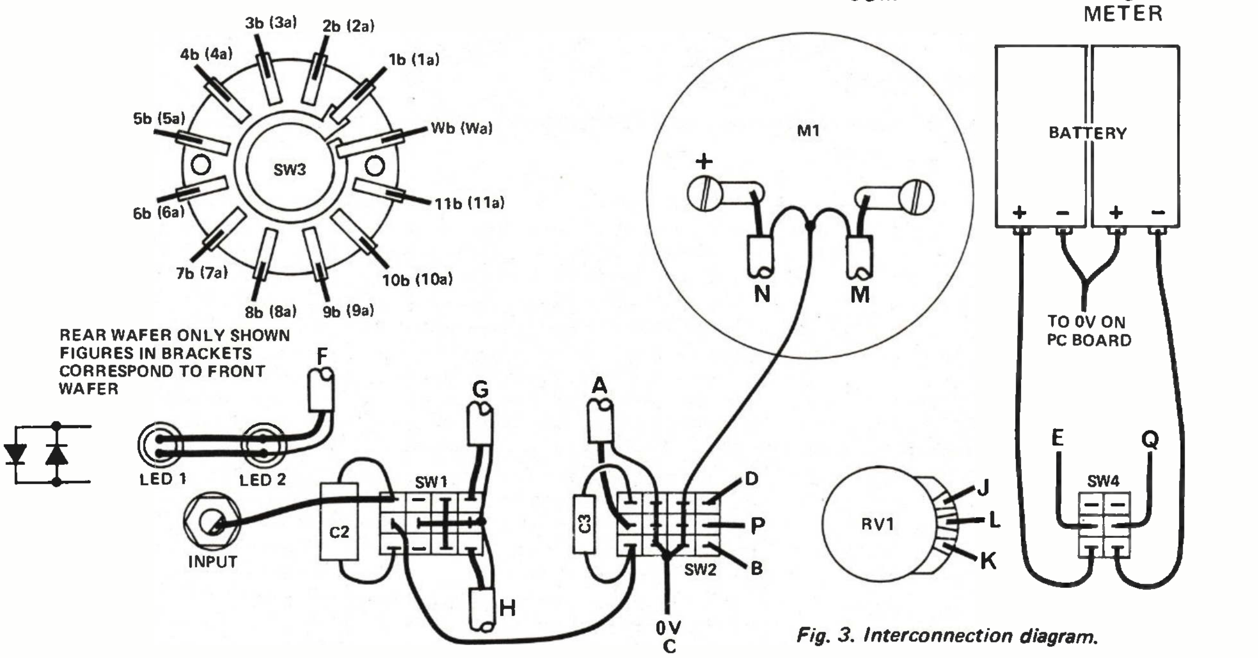


Fig. 3. Interconnection diagram.

fully assembled, it is very difficult to change components.

Assemble the front panel, fitting all switches with the exception of SW3, LEDs, potentiometer, input socket, meter, and the shield. The shield passes between the centre two contacts of the 'A'-weighted switch.

Solder a tinned copper lead to each of the 12 contacts on the rear wafer of switch SW3 (about 25 mm long). Feed these wires through the holes provided in the printed-circuit board (1b to 11b and Wb) making sure that the wiper contact on the switch goes to Wb and that the other wires are inserted in sequence. Do not solder as yet.

Assemble the printed-circuit board onto the shield and the rotary switch to the front panel. We used a 3 mm stack of washers to space the switch back from the front panel so the

PARTS LIST — ETI 128

R2	Resistor	270 ohm	2%	¼W
R25	"	330 ohm	2%	¼W
R26	"	390 ohm	2%	¼W
R4	"	820 ohm	2%	¼W
R17	"	1k	2%	¼W
R6	"	2k7	2%	¼W
R10	"	8k2	2%	¼W
R15,16	"	18k	2%	¼W
R21	"	47k	2%	¼W
R8	"	68k	2%	¼W
R13,R14	"	180k	2%	¼W
R11	"	820k	2%	¼W
R30,31	Resistor	1k	5%	¼W
R9,27	"	1k2	5%	¼W
R1	"	3k3	5%	¼W
R22	"	4k7	5%	¼W
R19,20	"	10k	5%	¼W
R25,29	"	10k	5%	¼W
R3,23	"	27k	5%	¼W
R5,12	"	82k	5%	¼W
R18	"	100k	5%	¼W
R7	"	220k	5%	¼W
R24	"	270k	5%	¼W
RV1	Potentiometer	100k lin rotary		
RV2	"	220k Trim		
RV3	"	100k Trim		
RV4	"	5k Trim		
C7	Capacitor	2-24 pF Philips 2222 808 00006		
C8,14,15	"	10 pF	Ceramic	
C9,13	"	33 pF	Ceramic	
C4	"	120 pF	Ceramic	
C5	"	180 pF	Ceramic	
C12	"	820 pF	Ceramic	
C3	"	1200 pF	polyester	
C6	"	1500 pF	polyester	
C11	"	0.018µF	polyester	
C10	"	0.056µF	polyester	
C2	"	0.1µF	polyester	
C19	"	4.7µF	non polarised electro	
C16,17,18	"	33µF	10V electro	
C1	"	220µF	6V electro	
IC1,2	Integrated Circuit		CA3130	
IC3	"	"	LM301	
D1-D5	Diode	IN914, BA318 or similar		
LED 1,2	5023 or similar with panel mounting			
SW1,2	Toggle switch 4 pole 2 positions			
SW3	Rotary switch 2 pole 11 positions			
SW4	Toggle switch 2 pole 2 positions			
M1	Meter	100µA FSD * see text		
PC Board ETI 128				
Die cast Box 6357p				
Two knobs				
One RCA socket				
Eight AA size batteries				
Two- 4xAA size battery holders				
Shield to Fig. 7				

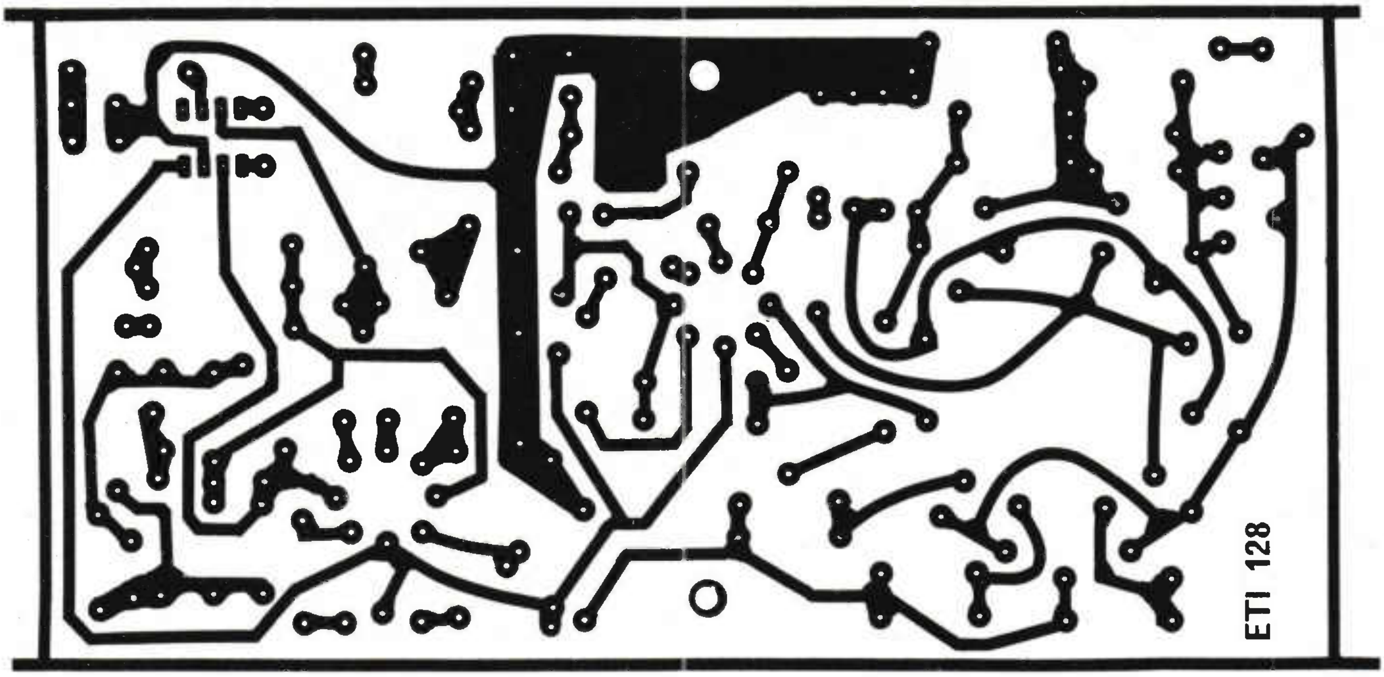


Fig. 5. Printed circuit layout. Full size 170 x 87 mm.

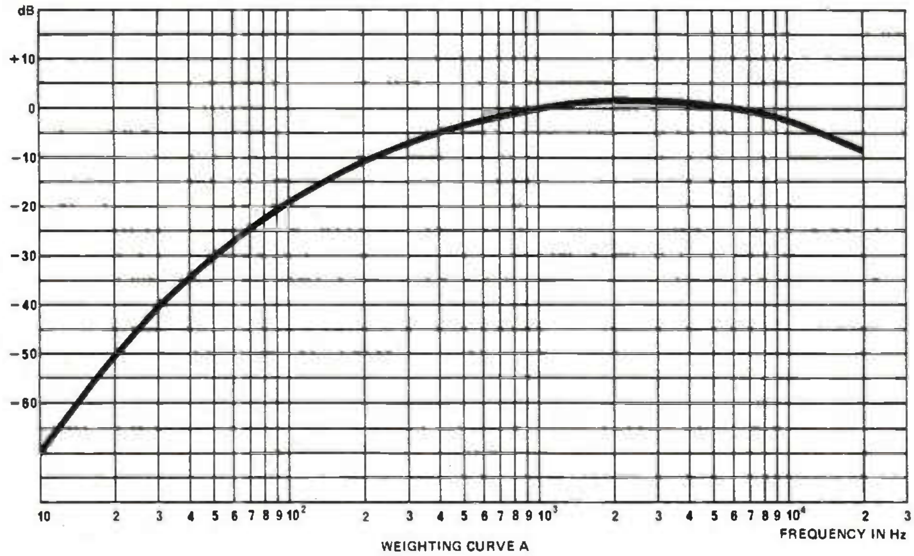


Fig. 4. Curve of 'A' weight response.

control knob would sit down closer to the front panel. Remove any slack in the tinned-copper wires, connecting the switch to the printed-circuit board and ,then solder them to the board. Now remove the printed-circuit board and switch assembly from the front panel. The switch will now be rigidly held onto the board, and the front wafer can now be wired to the board via further tinned-copper links. Make sure that none of these wires is touching.

Add leads to the printed-circuit in the locations shown on the overlay and reassemble the board and switch assembly to the front panel. The components on the front may now be connected to the board by these leads which should be kept as short as possible without placing undue strain on the wires. The only exception to this rule is the wire from SW1a to SW2a which should be kept reasonably well clear of the second pole of SW10. This is best done by running the lead down the front panel along the bottom and then back up to SW2a. Shielded wire should be used where designated on the overlay and wiring diagrams, and this should preferably be of the low capacitance variety.

The LEDs are connected in parallel but in anti-phase, the actual polarities may be determined later if necessary during the calibration procedure.

CALIBRATION

Before commencing calibration, check that the meter performs as it should on all ranges by applying known voltages and checking that a deflection of roughly corresponding magnitude is obtained. Also check that the 'A'-weighted switch appears to work as it should.

1. Short the input, select the 3 mV range and switch on.
2. Allow about 5 minutes for the instrument to stabilize thermally and then adjust RV3 to zero the meter.
3. Select the 10 mV range, dc, and 'flat', and adjust the front panel control RV1 to zero the meter.
4. Remove the short from the input, select the 300 mV range and apply an input having a frequency of less than 500 Hz and a level which gives a convenient indication, eg 0 dB. Change the frequency to somewhere between 10 kHz and 50 kHz making sure that the input level is the same in both cases, and adjust capacitor C7 so that the meter reads the same in both cases.
5. Apply an ac input signal and switch between ac and dc. The reading

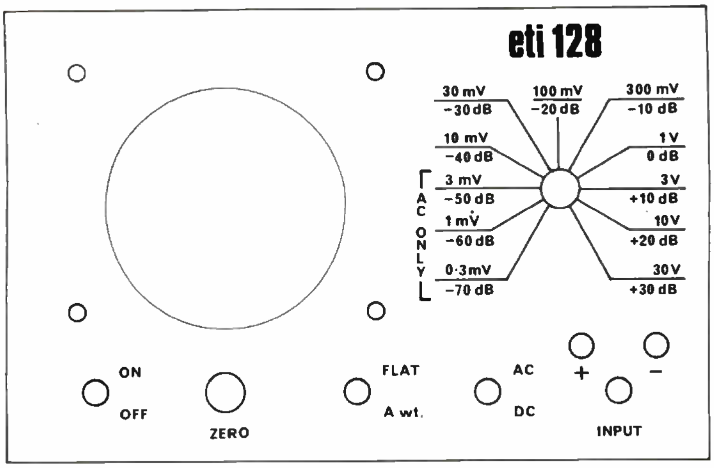


Fig. 6. Front panel artwork. Full size 189 x 121 mm.

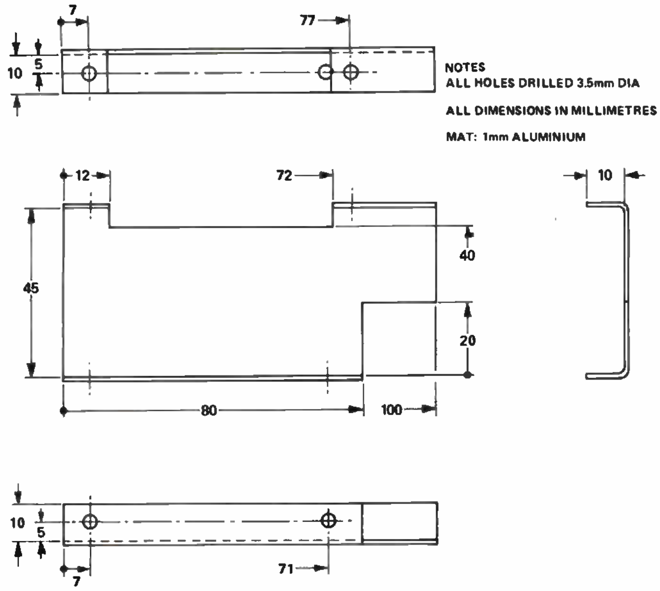


Fig. 7. Details of shield-support bracket.

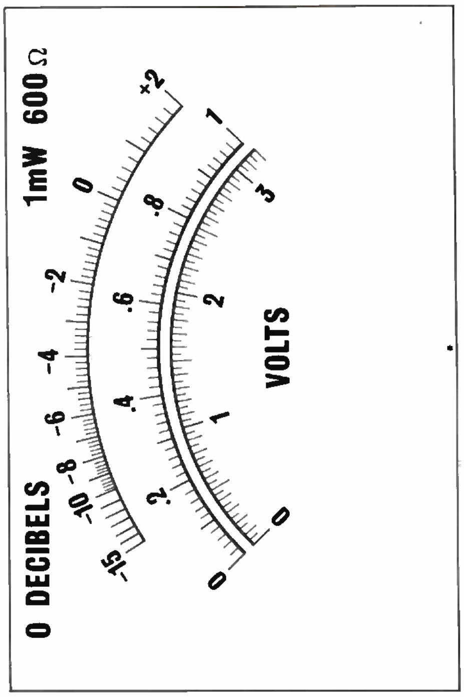
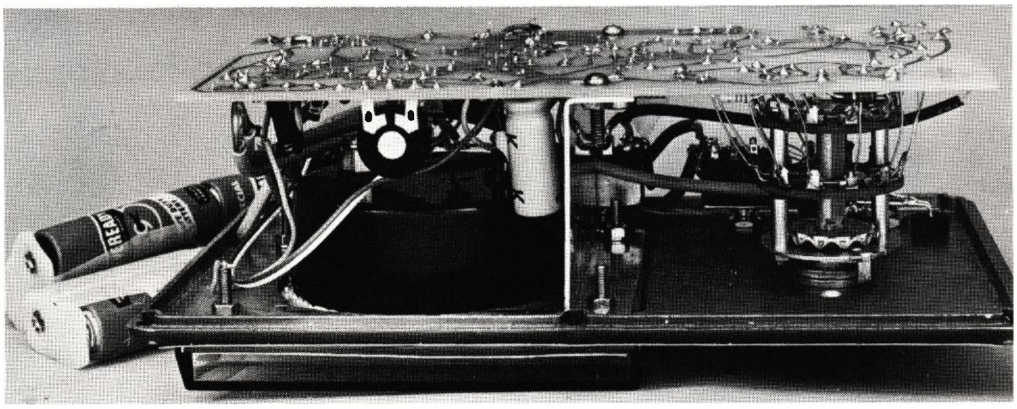


Fig. 8. Artwork for meter (shown full size).



This internal view of the meter shows on the right, how the range switch is wired to the printed-circuit board. Note also the shield.

on ac should be about 10% higher than on dc. If it is 10% lower the leads to switch SW1b should be reversed.

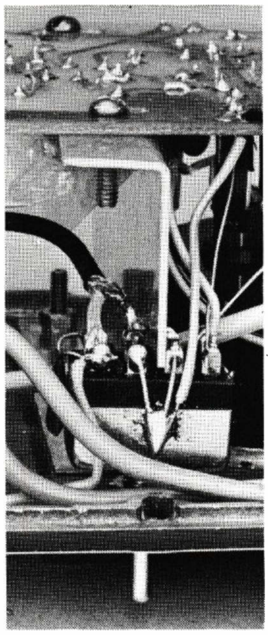
6. In the ac mode select 'A'-weight and apply a 1 kHz signal of sufficient level to obtain a 0 dB indication on the 1 volt range. Vary the frequency over the whole audio range and check that the response as shown in Fig. 4 is obtained.

7. Go back to 1 kHz and check that zero dB is indicated in the 'A'-weight mode. Now select 'flat' and adjust RV2 to obtain the same reading.

8. Apply an accurately known voltage with the instrument set to the flat and ac modes and adjust RV4 to give the correct reading.

9. Apply a dc input of known polarity and check that the correct LED illuminates. If not, reverse the leads to the LEDs.

This completes the calibration and the instrument should now give accurate readings on all ranges and at all frequencies within the specified range. ●



Note how the shield passes between the earthed, centre contacts of the 'A' weight switch.

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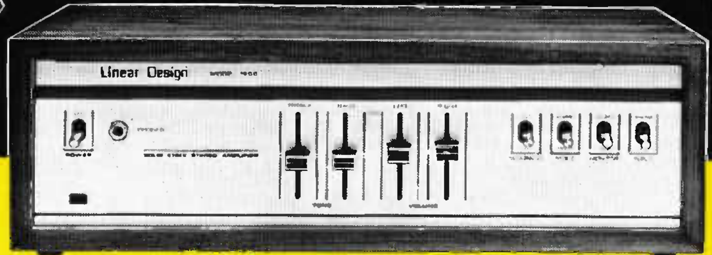

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ELECTRONICS —it's easy! PART 26

Code converters and display systems.

IT IS both necessary and convenient to transfer data between sub units of a digital system, by means of some kind of code. We have seen in the previous section how counting stages are sometimes arranged to count in BCD (Binary Coded Decimal), and how this form of code must then be 'converted' into another form that is suitable for the particular kind of display device used. Thus codes and code converters are of great importance in digital instrumentation.

There are a multitude of digital codes in use for communication, data interchange, and for numerical manipulation and display. Although many of the earlier codes used have now been discarded, there are still dozens in use. In this section we will not discuss codes like ASCII, Baudot, Excess 3 etc, which are computer and communication codes, but restrict ourselves to those codes and converters which are concerned with counting and display.

The main counting codes used in instrumentation are binary and BCD. Octal and Excess 3 are other counting codes used in computers but seldom in instrumentation. Converters are needed to change from any one of these codes to any other, and between any one code and decimal or vice versa. In addition the counting code in use needs to be converted into a form suitable for driving particular kinds of display (seven-segment, dot-matrix and neon tube, etc).

For example we find converters for binary to BCD, binary to decimal, BCD to seven-segment, and BCD to decimal, to mention just a few of the possible combinations.

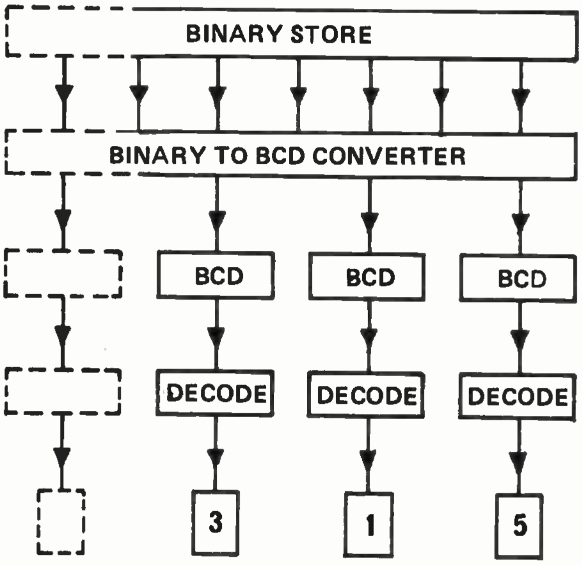


Fig. 1. Basic arrangement of binary to BCD converter and display decoders.

BINARY TO BCD CONVERSION AND VICE VERSA

To convert binary to BCD a common method is to set a binary counter — see Fig. 3 — to the desired number either by direct counting upward from zero, or by transferring the value across from another stage with a parallel converter. Clock pulses are then fed into both this binary counter, now set to count back down to zero, and to an up-counting BCD counter. A detector senses when the binary counter reaches the 0000 state upon which any further changes in the count state of both units are inhibited. The BCD equivalent of the binary number is now held in the BCD counter.

At this point the BCD number is cleared into a store or is available for any other system need, the binary counter is reloaded and the process repeated to convert the next number from binary to BCD.

The reverse, BCD to binary, is accomplished in the same manner except this time the roles are reversed as shown in Fig. 4. The BCD counter is set to the desired number, the clock, when enabled, clocks the BCD counter down to zero and at the same time the binary counter upward. When the BCD counter reaches zero state its outputs logically inhibit the clock input to both counters. The process is repeated for each new number after clearing and resetting the two counters to the correct starting conditions.

This serial method is fairly slow and a much faster method is to use logic gates in a parallel arrangement. The

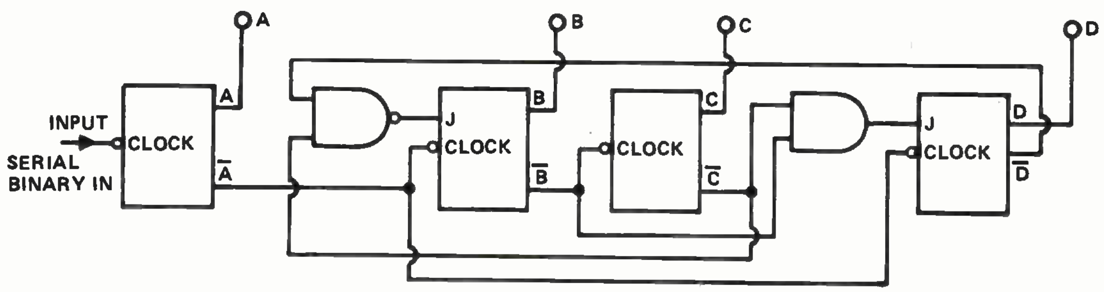


Fig.2. An asynchronous BCD counter provides a parallel BCD coded output which corresponds to the number of pulses fed to the input.

ELECTRONICS -it's easy!

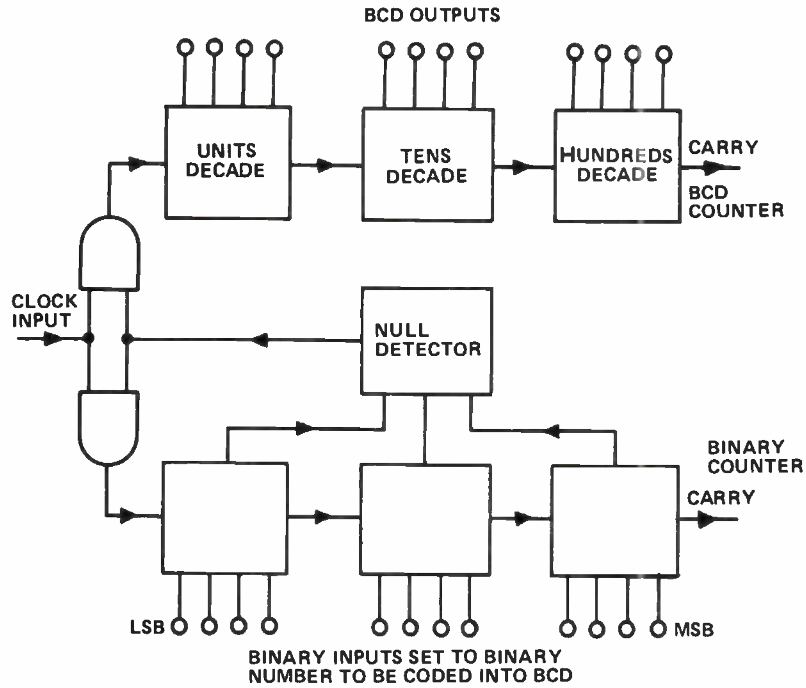


Fig.3. System required to convert a binary number to its BCD equivalent.

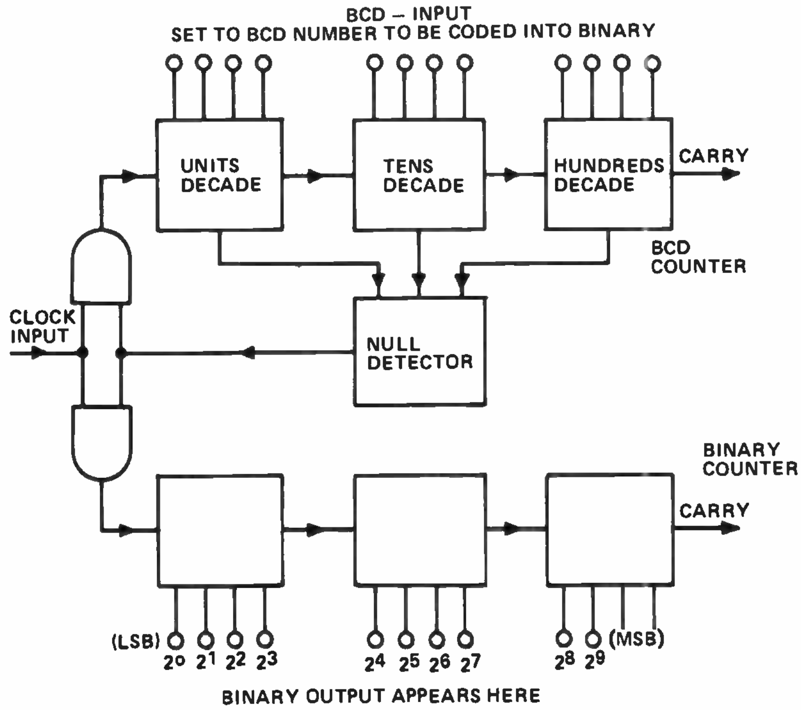


Fig.4. To convert a BCD number to its binary equivalent the same circuit as Fig.3 is used but the BCD number is now the one pre-loaded.

parallel method works well for BCD to decimal and other cases but requires innumerable connections when set to convert decimal or BCD back to binary. It is little used in this reverse mode.

BINARY CODED DECIMAL TO DECIMAL AND OTHERS

Each BCD stage stores its decimal number as some form of binary code using four bits. The 1-2-4-8 weighting is the most usual form used but other codes such as the 'excess three' and the 'Aiken' variations, are also used. Thus, each of the digit values 0 to 9 (in decimal) is represented by four lines, each having a '0' or a '1' state. This is demonstrated by studying the truth table for equivalent BCD and decimal states given in Fig. 5.

When the output must finally appear as decimal indication, it is necessary to energise the display or character printer segments appropriately. Displays, such as the neon tube or the columnar style — see previous part — require one output for each of the 0 — 9 numbers. From the truth-table of Fig. 5 it can be seen that to energise, say, a decimal '4' output we must set up a logic gate that provides an output when the BCD state is 0100. For '8' we need a BCD state of 1000. It is not possible to totally economise by using only '1', as the logical indications for this leads to ambiguities between numbers. On the other hand there is no need to arrange for all code sequences and bit combinations as that introduces redundancies using up extra unnecessary gates.

By careful design, and the use of inverters to invert '0' to '1's, it is possible to find a minimum number of AND gates and interconnections that will produce the 10 decimal states (0 to 9) as distinct outputs from the four-line (A B C D) outputs of the BCD stage. One such scheme is given in Fig. 6. Thus, by the use of logic gates alone we can provide a parallel code conversion from BCD to decimal.

Getting from BCD to a format suitable to drive a seven-segment display requires more gates, see Fig. 7, but the technique is basically the same. A decoder suited for the BCD to decimal requirement of a neon tube is quite unsuited to drive a seven-segment display. As both these and other conversions are in great demand they are available as simple ICs. Further, in some options the decoding logic is integrated onto the same chip as the BCD counter stage.

In practice the need to understand the internal operation of the decoder arrangement rarely arises, for the ICs are clearly marked with the connections to be made — it is just a case of making correct connections between the counter-stage chip, the decoder chip, and the display.

THE NEED FOR DISPLAY DRIVER STAGES

The power levels available from decoder stages are rarely adequate for direct drive of display units. A buffer stage which raises the power level is normally required. Again, these are generally incorporated into the decoder IC stage. Such integrated units are known as decoder/drivers. Different displays, even of the same format, require differing power needs so it is important to select decoder/driver stages suited to the display being used.

The buffer stage of a decoder/driver obtains current (or voltage gain) by the use of a transistor stage such as a Darlington pair or an emitter-follower circuit. A method recommended for driving seven-segment fluorescent displays is shown in Fig. 8 — these displays require high voltage drives.

Sometimes the need arises to drive displays from special-purpose one-off decoding circuits. In such cases a suitable driver stage is obtained by using standard IC inverter chips. (Discussed in Part 23).

THE ASSEMBLED BASIC COUNTER WITH DISPLAY

An illustration of the actual construction of a complete counting stage is to be found inside the digital clock shown in Fig. 9a. The display — neon tubes in this case — is arranged to appear where required by using end-connected tubes which plug into the main printed-circuit board as shown in Fig. 9b. Immediately behind each neon tube is the decoder/driver IC which, in turn, is driven by the counter IC located behind that again. On the circuit diagram these appear as shown in Fig. 9c and on the component overlay of the PC board as in Fig. 9d.

The Texas Instruments TIL 306 LSI is an example of an IC unit that incorporates the counter, decoder, driver, and display in one package. No doubt this will be the trend as it provides reduced assembly costs and smaller packaging. It should not be unrealistic to expect complete single-IC, multi-stage counter units to be in general use before long.

LATCHES

Direct coupling of the display to the counter stage results in a continuously changing display value. If the input is sufficiently dynamic it is awkward, if not impossible, to read values. Addition of a latch overcomes this by sampling and storing the count to be displayed for fixed intervals whilst the counter continues to cycle.

This is achieved using a memory stage between the counter and the decoder/driver stage as shown in Fig. 10. This system, the digital end of a digital voltmeter, displays a steady value for a short period by transferring the instantaneous value of the divider stage (the counter) into a buffer-store stage. The transfer or updating process is initiated by a common display timing line which is actuated at appropriate intervals. Such latches are invariably placed between the counter and decoder stages.

Internally a latch is a bi-stable designed specifically for the purpose of storing and transferring the value of a digital bit. Integrated circuit units provide four such latches in a dual-in-line package — see Fig. 11, thus allowing the four line data from a BCD counter to be sampled and stored by a single IC.

B.C.D. Inputs				Outputs										Decimal equivalent	
A	B	C	D	0	1	2	3	4	5	6	7	8	9		
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	Valid state of encoding
1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	
0	1	0	0	0	0	1	0	0	0	0	0	0	0	2	
1	1	0	0	0	0	0	1	0	0	0	0	0	0	3	
0	0	1	0	0	0	0	0	1	0	0	0	0	0	4	
1	0	1	0	0	0	0	0	0	1	0	0	0	0	5	
0	1	1	0	0	0	0	0	0	0	1	0	0	0	6	
1	1	1	0	0	0	0	0	0	0	0	1	0	0	7	
0	0	0	1	0	0	0	0	0	0	0	0	1	0	8	
1	0	0	1	0	0	0	0	0	0	0	0	0	1	9	
0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	Illegal states that should not occur with BCD code.
1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	
0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	
1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	
0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	

Fig.5. Truth table relating four-line BCD with its decimal equivalents.

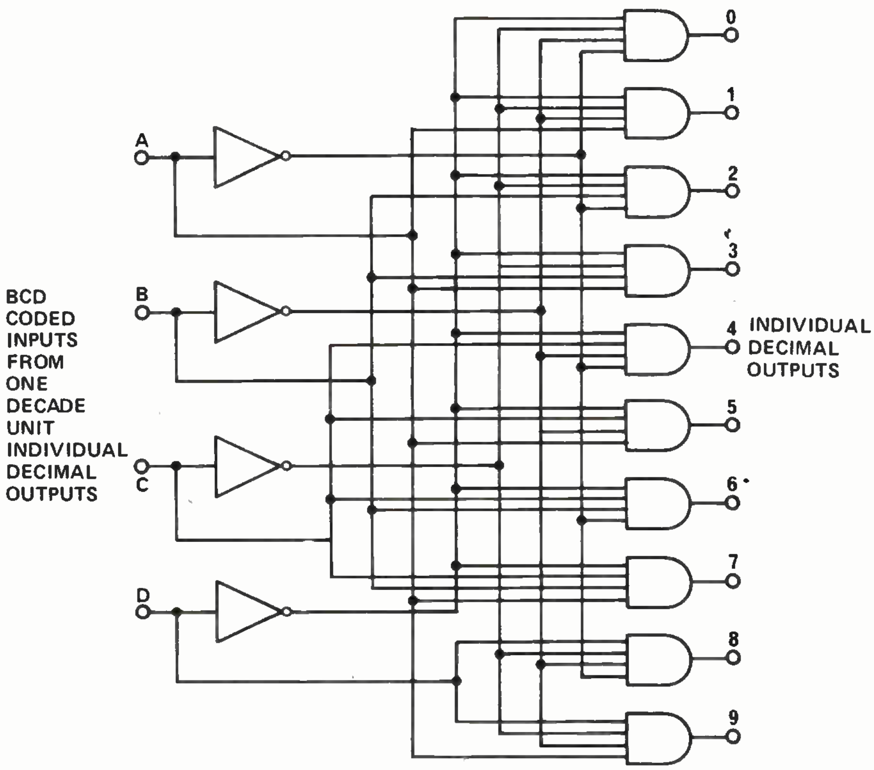


Fig.6. Logic arrangement for decoding BCD units into one-of-ten outputs.

DECIMAL POINT

Facilities are usually provided in all displays to enable an input to energise a left-hand or right-hand point at each digit position. Obviously specific circuitry is required to energise just one of the total available in a multi-digit display in order to present the correct decimal number. The simplest arrangement is when the range switch of, say, a multi-range digital voltmeter decides the point to use. In autoranging voltmeters (etc) and in many calculators, solid-state switching is used to select the correct point position.

BLANKING

In normal writing practice we do not

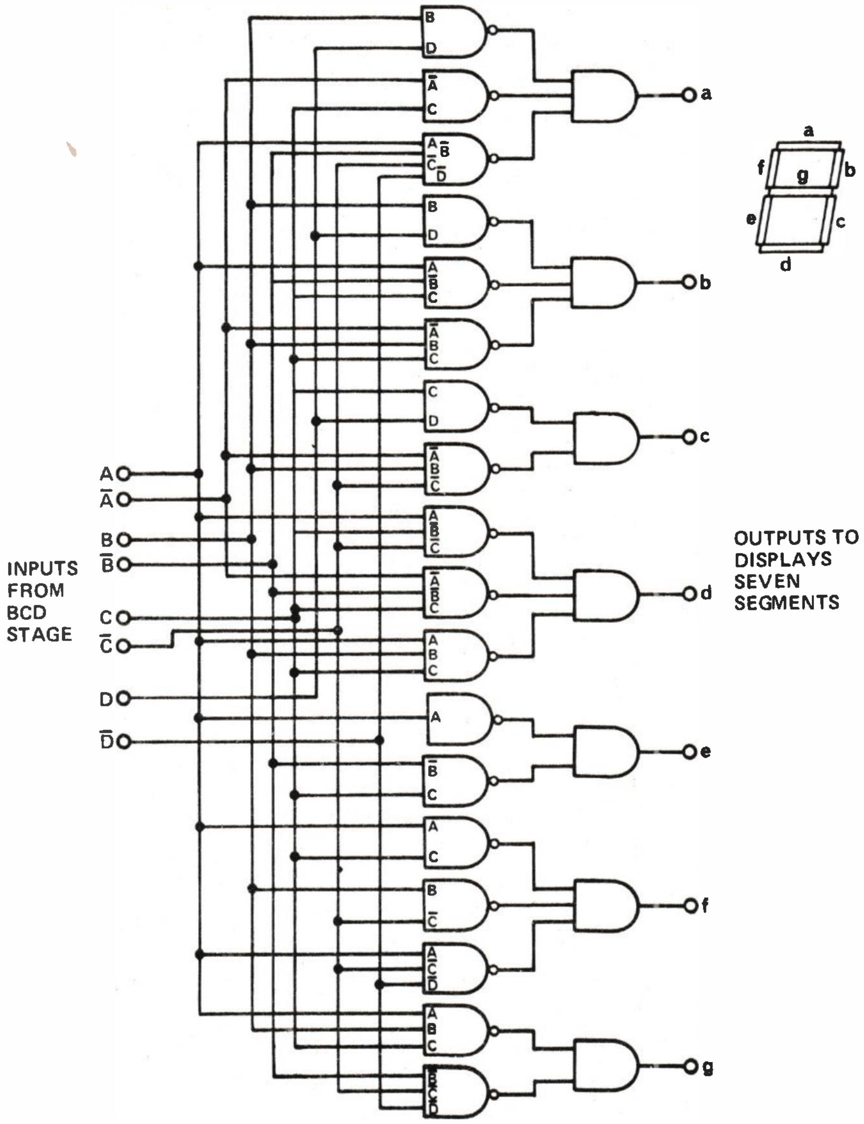


Fig. 7. Logic for converting BCD to seven-segment display format.

write the '0's that appear at either end of a number, for example, 0001357.0 as could be held in an eight digit display, is better presented as 1357 or as 1357.0. A facility is sometimes provided in display-counter systems that blanks unnecessary zeros. Leading zero suppression is performed within the decoder stages of Fairchild seven-segment decoders by connection of the ripple blank output RBO (ripple because each stage connects to the next) of the decoder stage to the ripple blank input RBI of the next lower decoder stage. Blanking of least-significant zeros is not usually included. The actual arrangement for blanking control varies from maker to maker. Fig. 12 shows a method using ripple blanking.

The blanking facility can also serve other purposes. It can, in certain applications, be used to blank-out illegal display values resulting from incorrect codes. The RBO output also provides a detection output indicating when the decoder stage is at the BCD zero state.

Blanking is also valuable as a way to save display power for it can be used to hold all displays off until there is something to display.

When no blanking input is provided it is also possible to blank the system by applying the spare BCD code states that result in no drive to the display. Yet another procedure is to disconnect the supply from the display itself.

INTENSITY CONTROL

Displays are usually manufactured to supply one value of output brightness. When brightness is to be tailored to

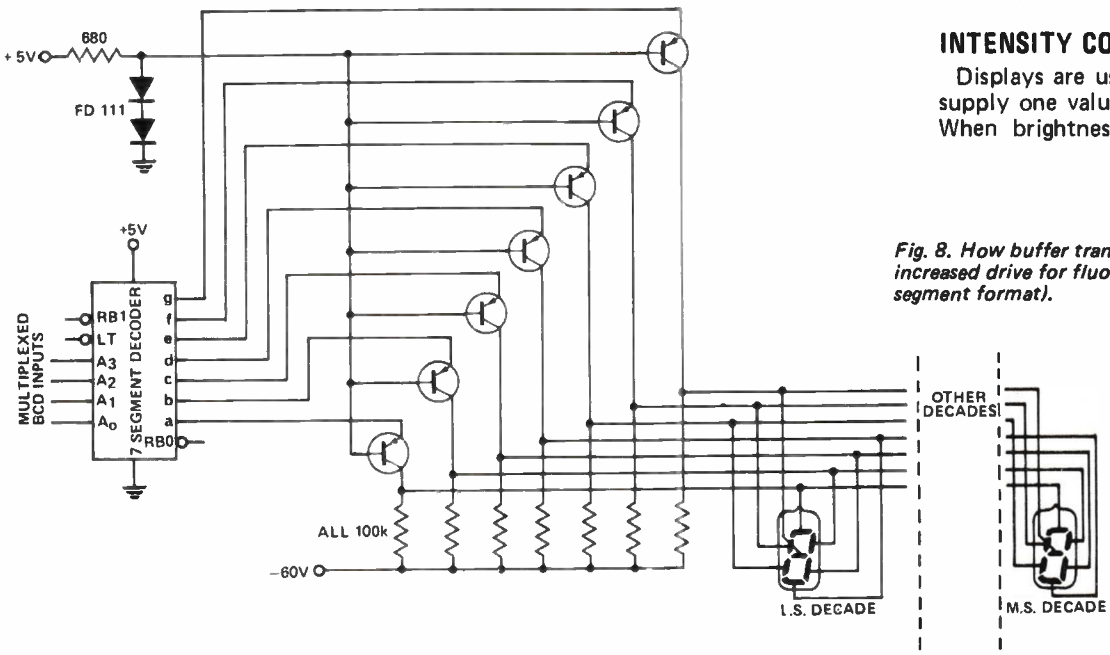
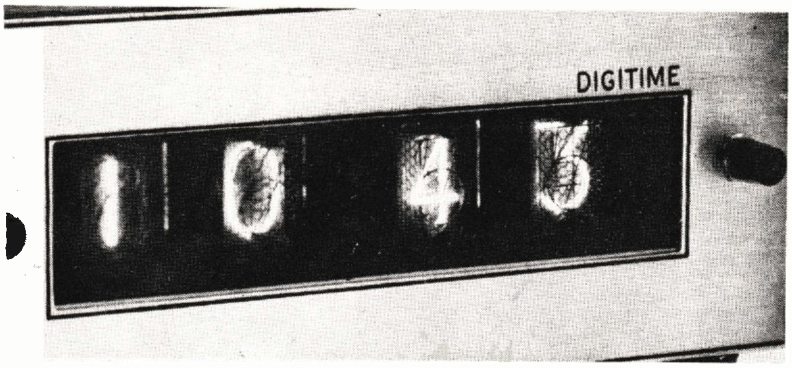


Fig. 8. How buffer transistors are used to obtain increased drive for fluorescent displays (seven-segment format).



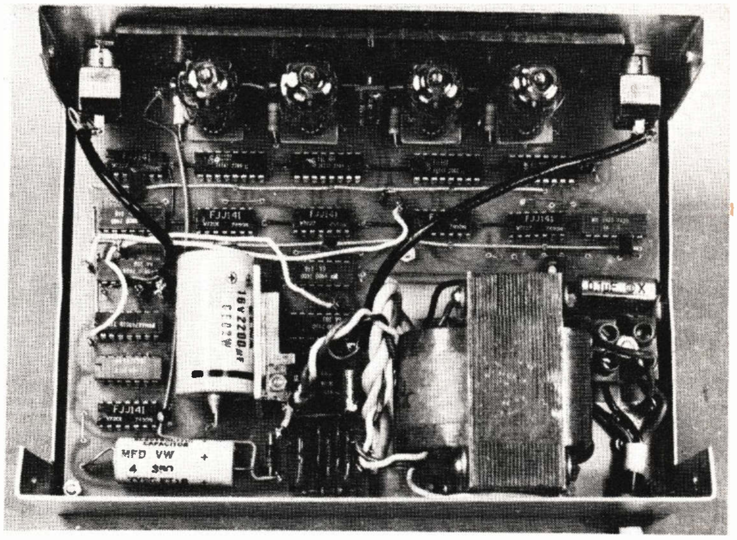
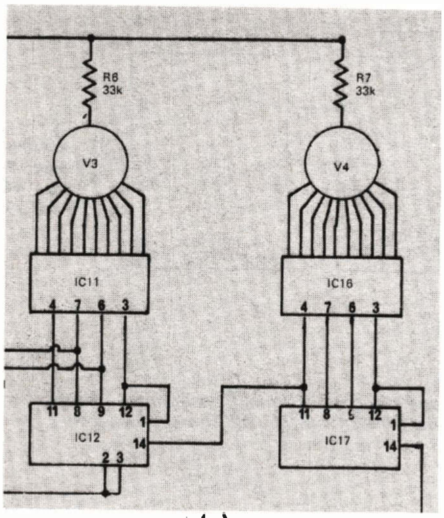
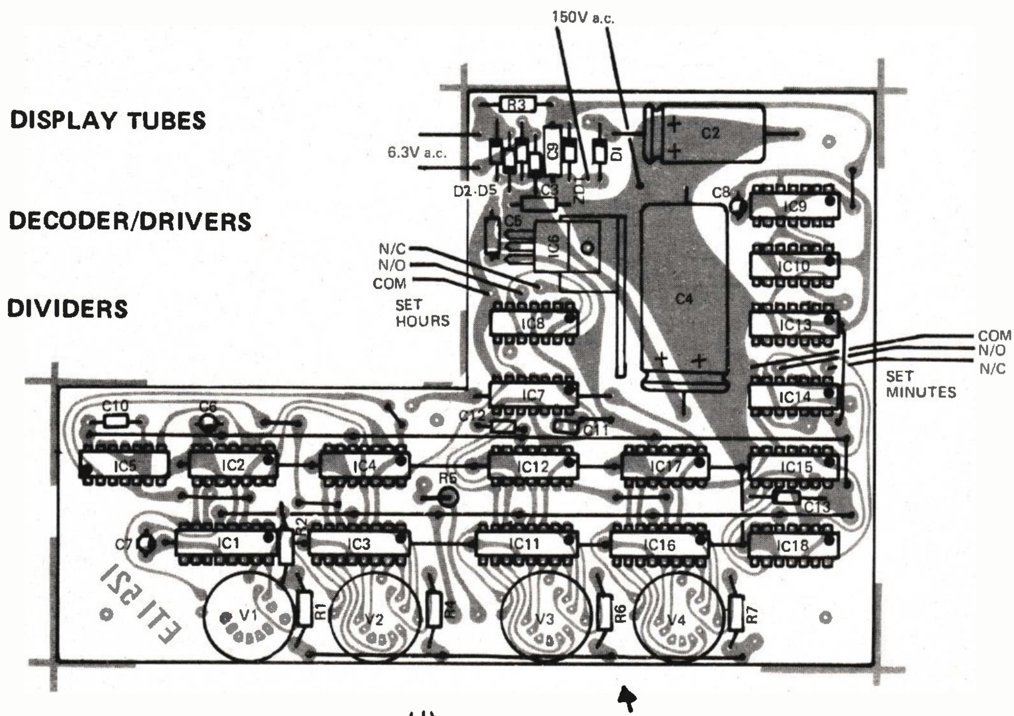


Fig.9. This digital clock illustrates use of counter stage subsystems.
(a) The frontal appearance of the Nixie display.
(b) Top view of component assembly.
(c) Circuit diagram of counter to display section.
(d) Component overlay. The V1 to V4 positions are tha sockets for the Nixie tubes, behind are the decoder/drivers which have the dividers behind those again.



(c)



(d)

particular ambient light conditions an appropriate kind of display can be selected that provides the desired luminance level. This however, does not always lead to a satisfactory choice when other considerations are taken into account.

Intensity of any display, however, can be controlled in a digital manner (that most desirable in digital systems) by turning the display on and off with an appropriate duty cycle (ratio on to off period). This is called pulse-duration intensity modulation. Provided the repetition rate exceeds 100 Hz the eye cannot detect that the radiation source is being modulated. Modulation may be achieved with any of the blanking methods given above.

The schematic of Fig. 12 includes an intensity modulation facility.

With LED displays, intensity modulation can actually increase the apparent brightness. The human eye has a characteristic response to radiation that has greater sensitivity to the peak value of modulated light, rather the average or rms power. LEDs can be pulsed at high frequency with high peak currents because of their nanosecond response time. The net result is apparently higher brightness for a given amount of power.

STROBING OR SCANNING

Displays which generate characters in the 7 x 5 dot matrix or seven-segment formats require decoding logic which energises the correct dots or segments. If each character has its own decoder we would need 7 lines for each digit of a seven-segment display. And 35 lines for each digit of a 7 x 5 dot-matrix display!

Obviously a method is needed to reduce the number of lines and circuitry required for multi-digit displays.

One such method is called strobing where lines of dots or segments are illuminated sequentially. The 7 x 5 array can be either strobed as lines horizontally or as rows vertically as illustrated in Fig. 13. Each row is selected one by one in sequence and the appropriate diodes in the row energised. Provided each row is

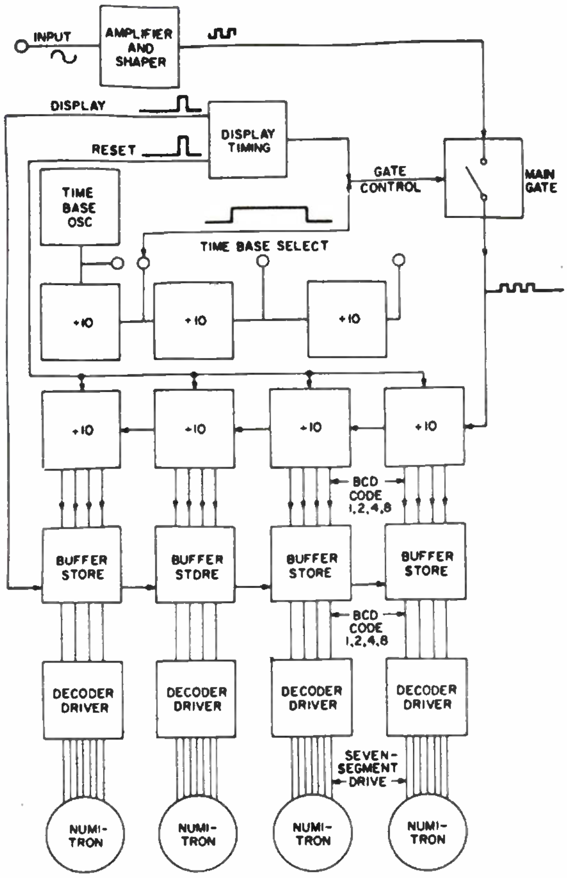


Fig. 10. Buffer stores are used to latch the display causing it to remain steady for selected periods. (circuit shown is a counter/timer using RCA incandescent displays).

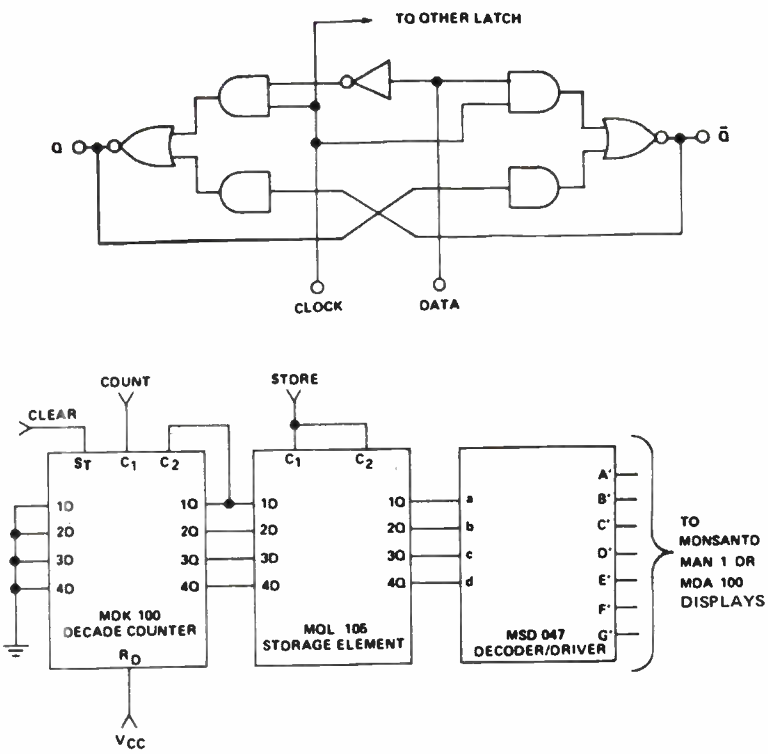


Fig. 11. Schematic (a) and pin connections (b) of counter, latch decoder system using the Monsanto MQL 105 four-bit bistable latch.

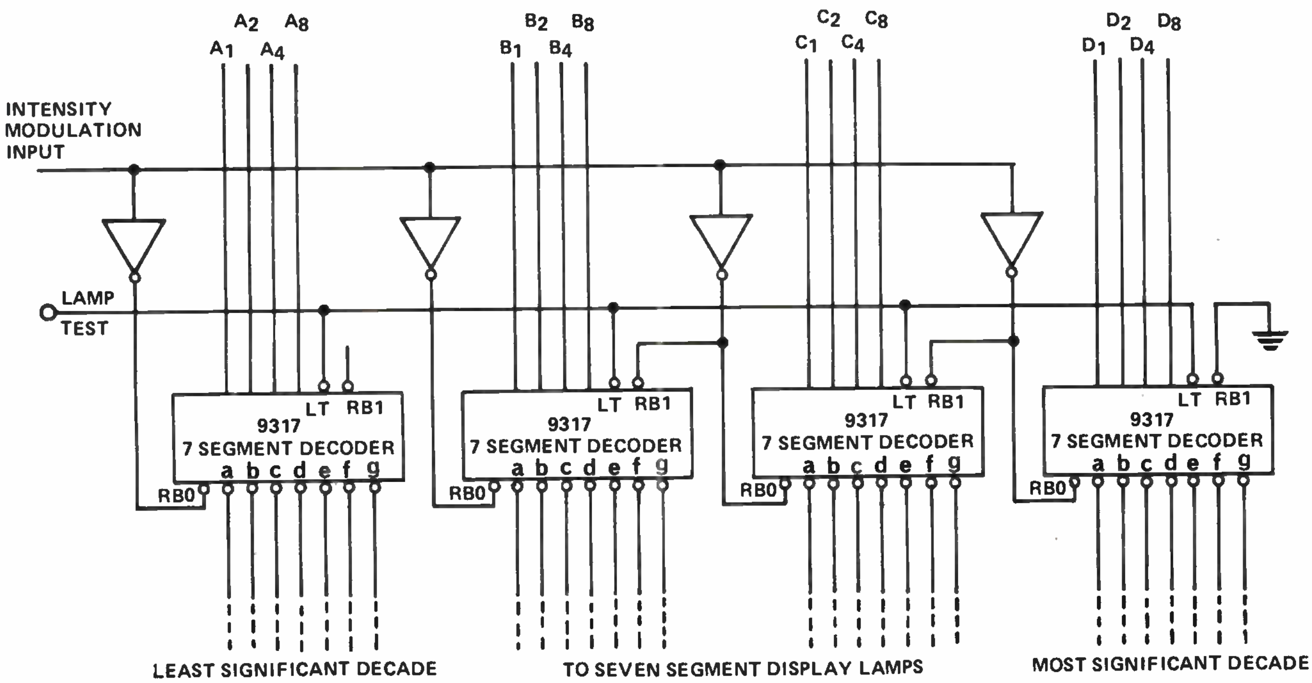


Fig. 12. Connections for ripple blanking in a four-decade display system. (RBD ripple blank output, RBI ripple blank input).

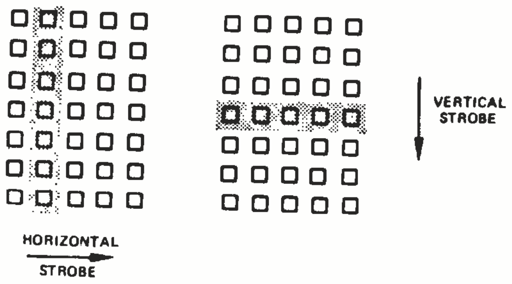


Fig. 13. Horizontal and vertical strobing of a 7 x 5 dot matrix display.

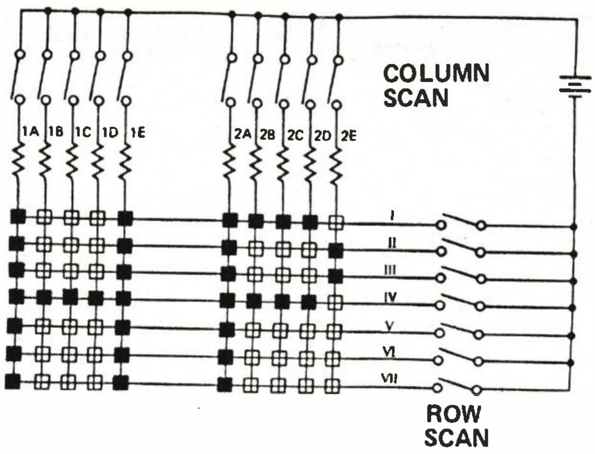


Fig. 14. Schematic of switches needed to address a 7 x 5 dot matrix.

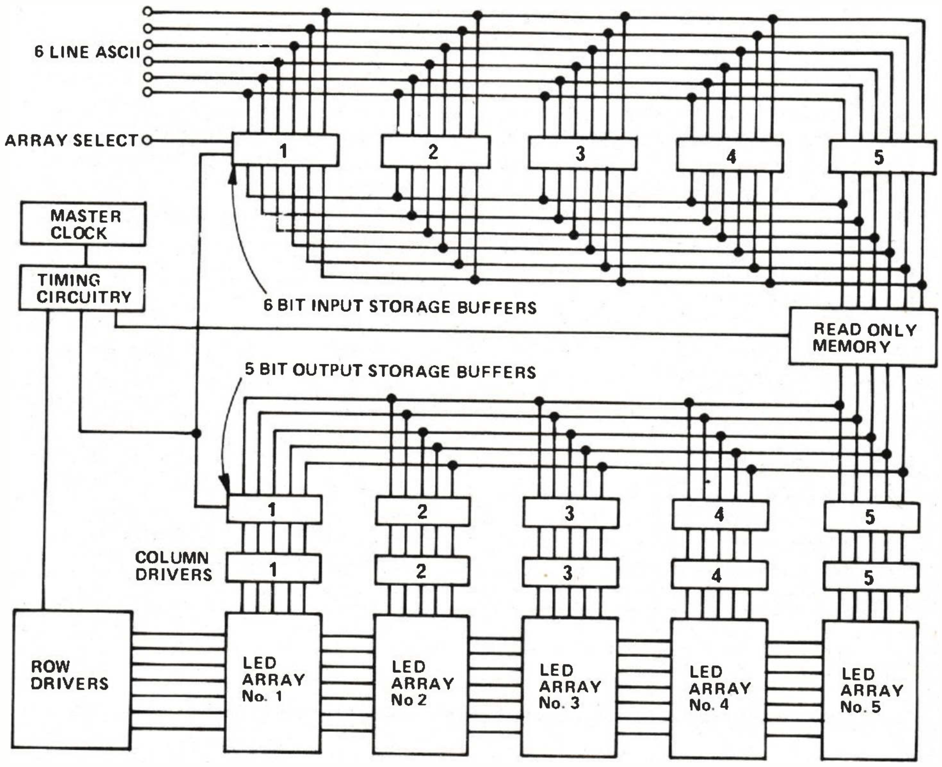


Fig. 15. Basic block diagram of a vertically strobed display using 7 x 5 dot-matrix devices.

returned to at no greater than 10 ms intervals the characters will be flicker free.

A diagrammatic illustration of how specific diodes are selected in a row is given in Fig. 14. The row switches are scanned in turn to cause a vertical scan. Simultaneous excitation of the other switch sets decides which diodes in the row are to be illuminated.

A strobing system requires a procedure to sequence the scanning action and a method of setting the selection switches that corresponds to the characters needed. The whole is controlled by a clock and timing generator. Storage buffers are also required to store the sequentially generated information. The task of creating the appropriate character timing codes is performed by a read-only-memory ROM. Clearly this method adds up to a complex system . . . really beyond this course's purpose. A schematic block diagram of a vertically-strobed five-digit LED display is given in Fig. 15. Although of apparently great complication this method is less expensive to employ than direct actuation through fixed gates. (Considerably more detail is to be found in the suggested reading list).

Another scanning method scans the matrix as a raster — across a row, one by one, and then to the next row. Strobing obtains its advantages by time-sharing common elements in a time-multiplexed manner.

MULTIPLEXING

When the input data to be displayed appears in serial form or when large numbers of displays (over four digits) are involved, multiplexing (selection of complete digits sequentially) becomes advantageous for driving seven segment and one-of-ten displays. The basic multiplexing system requires the main system units shown in Fig. 16. An upper limit to the number of digits is around 12 and higher for LEDs. There are disadvantages; namely, a higher voltage is required in the display to achieve the same brightness (LEDs are not so critical as other forms of display); the scan frequency must be at least 100 Hz to prevent flicker; transients must be carefully decoupled; and a clock failure (which stops the scan) may produce partial display failure because of excessive dissipation brought about by the increased voltage applied. (It is usual to include a failsafe protection circuit).

Again, the complexity appears great but in practice the multiplexed system

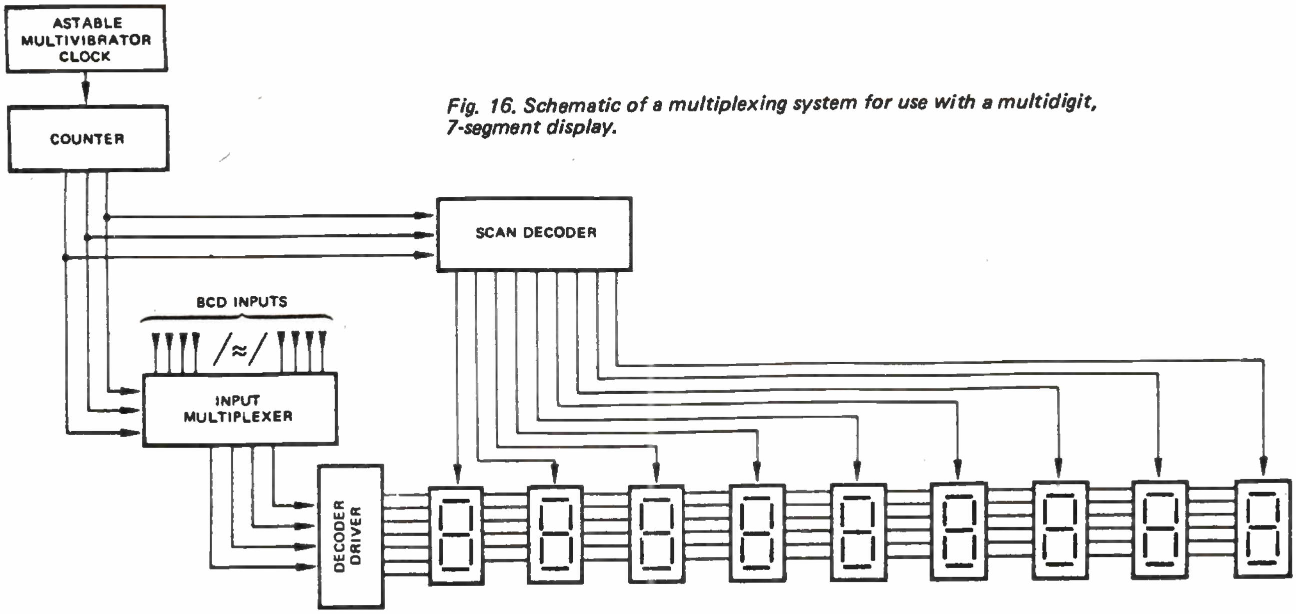


Fig. 16. Schematic of a multiplexing system for use with a multidigit, 7-segment display.

is simpler to build. For example, a multiplexed, seven-segment display, with storage for eight digits, involves around 10 dual-in-line packages and a few discretes which compares with about 16 ICs for a non-time shared system.

To further reduce the connections that must be made upon assembly, manufacturers offer multi-digit displays in which the anodes and cathodes of the LEDs are internally connected ready for multiplexed operation.

OTHER CONVERTERS

Apart from digital-code converters other converters are required in instrumentation: for example, when interfacing different systems of logic, eg TTL to CMOS, it is necessary to alter the dc levels of signals so that the output of one system provides the logic levels required by that following. This may require amplification or attenuation or shifting of a level. However specific ICs are marketed to suit various interfacing requirements. Other converters ,are needed for sending digital signals through standard transmission lines in communication links, for receiving signals from lines, for increasing the logic level differences to increase noise immunity (again for transmission), and units that drive peripheral devices such as relays and indicators. Signal inversion may also be necessary — we have already dealt with the inverter block earlier in the course.

Another class of converter is needed for converting digital signals to analogue voltages (D to A) and analogue voltages (and currents) into digital form (A to D). Such converters will be dealt with in the next section.

Further Reading:

"Digital Display Systems" referred to in the previous part deals with blanking and multiplexing.

"Solid State Alphanumeric Display Decoder/Driver Circuitry" — Hewlett Packard application note 931 gives details of scanning methods used with 7 x 5 displays.

"Mullard TTL Integrated Circuits — Applications" includes a chapter devoted to various kinds of code converter gating layouts. ●

AUDIO FACTS

SUB WOOFERS

There is a growing trend towards the use of sub-woofers to augment the very low end of the audio spectrum.

Because low bass is essentially non-directional only one speaker enclosure is required. This is connected to the existing system via its own amplifier and active crossover network together with circuitry which actively sums the bass output from the normal two stereo channels.

Our editor reminds us that Electronics Today International published full constructional details of precisely such a system way back in December 1971. He says that it was not then a popular project despite its extraordinary effectiveness — it may have been ahead of its time.

MOVING COIL CARTRIDGES

Most hi-fi enthusiasts have mixed feelings about moving coil cartridges. Some claim that they outperform all other types. But the general feeling has been that their inherently low output and corresponding tendency to pick up hum and other forms of noise outweighs any possible advantages.

Now however several amplifier manufacturers have included very high sensitivity inputs to cater for the inherently low output moving coil cartridges. Sony and Yamaha have included such inputs on their latest products and Dynaco's new PAT-5 kitset amplifier can be alternatively wired to provide the required 6 dB or so more gain.

Current manufacturers of moving coil cartridges include Ortofon, Supex, Fidelity Research and Denon.

REEL TO REEL RECORDER USES DOLBY AT ALL SPEEDS

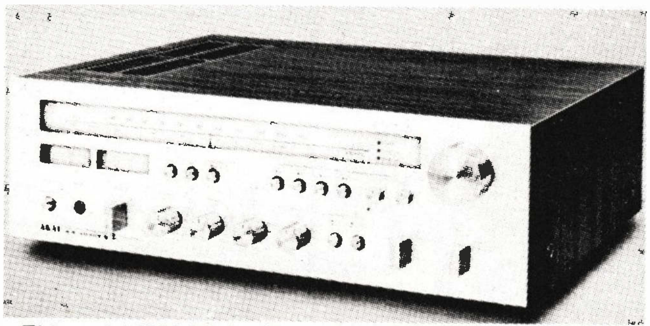
Dolby noise reduction circuitry has become a standard feature on almost all high performance cassette recorders.

However Dolby have until recently refused to grant licences to allow their circuitry to be incorporated in reel-to-reel machines capable of running at 15 inches per second. Even Revox were we understand unable to persuade Dolby to relax their attitude.

Tandberg must be more persuasive or something for the company has just released their new model 10XD semi-professional machine which incorporates Dolby circuitry usable at all tape speeds *including 15 ips.*

Tandberg's 10XD machine accepts 10½" NAB centred spools. It has three motors and four heads and incorporates most of the features of previous Tandberg machines including remote control. An additional feature though is an external control device which enables tape speed to be varied over a small range (i.e. between the major steps).

NEW AKAI EQUIPMENT



This model 1020 DB Am/Fm receiver is part of AKAI's extensive new range of equipment.

AKAI Australia have just released details of a wide range of new equipment.

The range includes eight new AM/FM receivers varying in price from $320 to $945. Several of the models are of particular technical interest in that they incorporate Dolby noise reduction circuitry anticipating the probable use of Dolbized FM radio transmissions.

Also in the new range is a medium-low priced turntable Model AP 001 (without cartridge) AP 002 (with cartridge) which features an interesting non-mechanical auto-stop mechanism. The belt drive machine is equipped with an oil damped tone arm lifting mechanism.

HI-FI AT LOWER COST

An Australian hi-fi equipment manufacturer has developed a speaker system which employs many features normally only available in more expensive units.

Researched and developed by acoustic engineers of the components division of Plessey Australia Pty. Ltd., the company's C12PW Woofer incorporates a roll surround, CFL cone, heavy duty magnetic assembly and an epoxy voice coil with aluminium former.

Combining high compliance and high efficiency with adequate power handling capabilities, the speaker is ideally suited for use in fully sealed enclosures. Coupled with the roll surround, the sealed system creates an air cushion which supports the speaker cone, enriching the quality of bass reproduction, according to Plessey.

Based on this concept, Plessey have developed a four-way/four-speaker system designated the PE 1200.

A departure from the traditional range of Plessey loudspeakers, the C12PW and the PE 1200 are the results of increasing interest in the field of high-fidelity systems for home entertainment.

With a fundamental resonance of 30 Hz and a conservative power handling capacity of 30 watts rms, Plessey claims that the locally produced speaker compares more than favourably in quality and performance with its imported competitors.

ADVERTISERS INDEX

Adcola 61
Akai 4
Amateur Astronomer 87
Ampex 26
Applied Technology 24
Audio Engineers 36
Autotronics 90
AWV 38
Bail Electronics 87
Bright Star 44
British Merchandising 68
BWD 37
Cema Dist. 69
Challenge Hi-Fi 54
Convoy 20,27
Dick Smith 39
Douglas Hi-Fi 78
Edge Electrix 58
Electro Technics 46
Electronic Disposals 88
Electronic Mailbox 25
Esalin 88
Ferguson Transformers 90
George Hawthorn 46
Haco .... IFC
Ham Radio 43,90
Harmon 8
ICS 68
International Dynamics 13,95
International Electronics Unlimited .92
Jacoby Mitchell 12
John Carr 88
Kent Hi-Fi 16
Kitsets Aust 72
Lafayette 90
Linear Technics 88
Logan Brae 68
Mod-amp 60
MS Components 53
Parameters 87
Pioneer 19
Rank .... OBC
Royston 52
Sabtronics 46
STC 67
Stotts Technical College 44
Thomson Radio Service 68
Trident TV 89
Video Hi-Fi 35
Warburton Franki 51
Wardrope & Carrol 90
Wedderspoon, W.C. 45
Wallin & Merrell 52,86

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