JANUARY 1982

RADIO & ELECTRONICS WORLD

70p

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Receivers FRG7700/R1000
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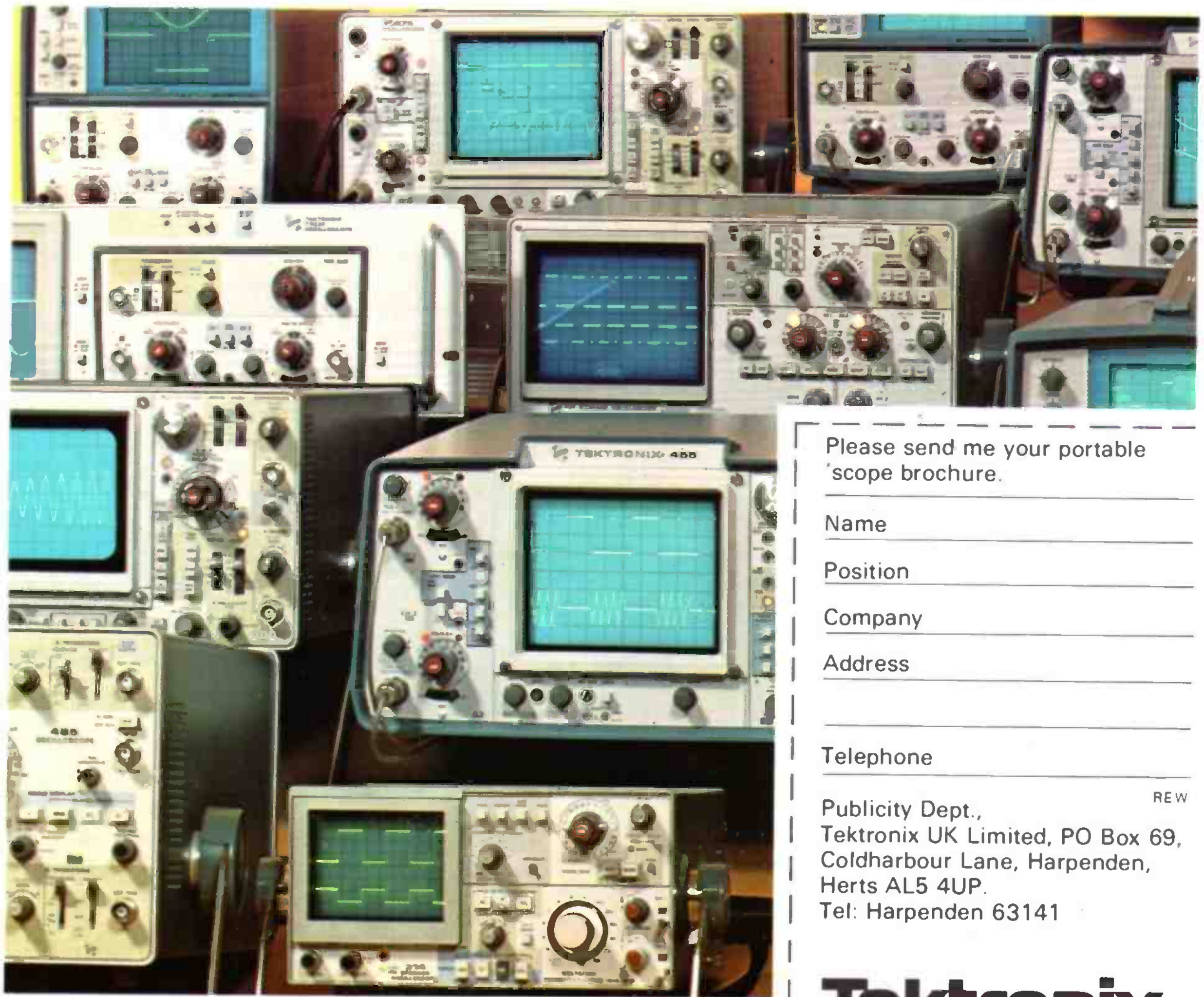

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Projects

Reviews

News

Features

Information

BACK ISSUES: Don't forget, back issues of **R&EW** can be obtained from our subscription department at 95p each, inc postage. Use the reply paid card/order form or send a cheque/PO.

FOOTNOTES:

1. The front cover of the December edition announced NEW ANALOGUE SWITCH ICs which (due to a last-minute hiccup) did not in fact appear in that issue We apologise to any readers who may have been inconvenienced.
2. We are rather disappointed with the number of entries received for the Transistor Design Competition and the 'Caption' contest (October issue) and for the November DMM Competition. Consequently, we are shifting the closing dates for all these events to December 21st, '81. The final results will be announced in the March '82 issue.
3. Due to pressures on space, a number of intended features have been dropped from the present issue (see also the Editorial page). We apologise to any readers who may be disappointed. To alleviate any future 'pressures' we shall, as from the March '82 issue, be increasing the number of pages in R&EW.

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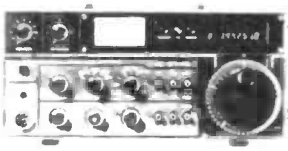

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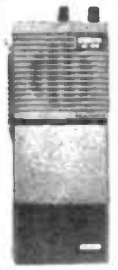

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EDITORIAL

Concepts

R&EW is published BY electronics people, FOR electronics people. We've set out to produce the kind of magazine that we, as practical electronics engineers/enthusiasts, have always wanted to see. That is, a magazine that is jammed solid with absolutely top-rate features, news, projects and product reviews, with not a single page wasted.

From the 'Features' point of view this means that, unlike many other magazines, we will not be wasting page space on material with titles like 'Famous People', 'How to Solder', 'Beginner's guide to Electronics', etc., or on similar 'book-type' material.

From the 'Projects' point of view it means that we intend publishing projects purely on merit, rather than to meet an arbitrary project quota. In other words, we are NOT in the business of publishing novice-designed metronomes, reaction timers or LED flashers, etc., just so that we can boast that we have 'X' number of projects in an issue. We ARE in the business of publishing professionally engineered projects that are highly innovative, or have great technical merit, or which satisfy a known and significant demand amongst our readers.

Of course, all of this sounds very fine and noble, but is far easier said than done. Consider the 'projects' angle, for example....

An On-going Scene

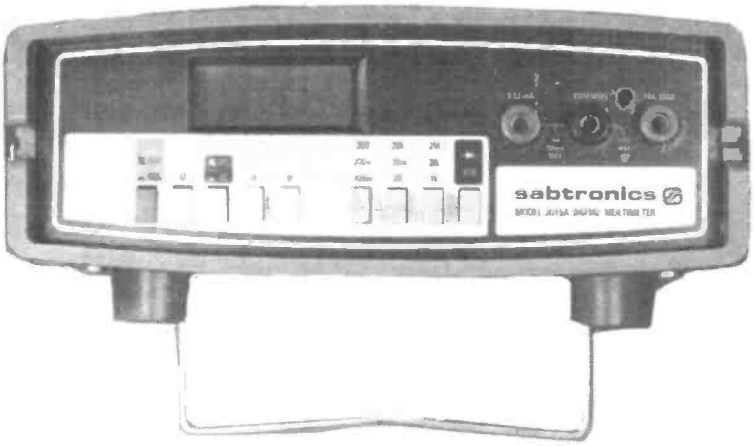
We at **R&EW** are keen to produce professionally designed projects that can easily be built by most of our readers and which actually LOOK professional when they've been built. We like all of our projects to be fully engineered and made available to our readers in complete kit form.

In some projects, 'engineering' simply means that we design a special PCB, using our in-house computer-aided design facility. In other instances, it may mean that we invest large amounts of money (up to several thousand pounds) in producing special injection-moulded cabinets, ironmongery and miscellaneous hardware, etc., to ensure that the final project is fully supported.

Providing this 'engineering' service, places a large burden on **R&EW**'s financial and physical resources. To help ease this burden and give our readers an even better service, we've recently started to arrange tie-ups with well known electronics engineering/design companies, with a view to pooling our research and manufacturing resources.

The immediate effects of our present tie-ups is that our own five-man £70 000 development laboratory is now backed up by additional research facilities to the value of £200 000, and our mechanical engineering facilities have been expanded by an order of magnitude. As a direct result we will, within the next couple of months, be publishing the UK's first FULL SPEC 40-channel DIY CB rig and Europe's most sophisticated low-cost microprocessor development system, with a host of other goodies to follow.

In the present issue you can see the first fruits of our tie-up with Sabtronics, the instrumentation specialists, in the form of the 3½ digit LCD DMM project. This particular unit is taken directly from Sabtronics' existing test gear range and was designed and engineered by that company. Some of our future test gear projects will actually be designed by **R&EW** but engineered and supported by Sabtronics.



The unusual editorial approach to the rather complex Sabtronics project is worth a brief note. We feel that most readers will find the circuit and description of the project interesting but only a few hundred readers will actually want to build the DMM. Consequently, we've omitted the usual copious (and space consuming) 'construction' notes from the article, but have ensured that they are adequately supplied with the complete project kit. Those readers who do not want to buy the kit can build the project directly from the circuit diagram given in the article.

Space - Space

You can gather from the last paragraph that we're trying very hard to save magazine space wherever we can, so that we can cram in as many extra features as possible. We've even reduced the print size on some more of the 'News' pages. Even so, space in this issue is not sufficient to present all the things that we would like, and we've very reluctantly had to drop the 'Amateur Radio' and 'In Your Workshop' features in favour of alternative material. 'Workshop' fans need not despair, however, as Dick and Smithy will (we hope) be re-appearing in a new magazine some time in '82. We'll keep you informed.

Ray Marston.

NEW PRODUCTS

voltage regulator with 150mA output, low drop-out voltage and low quiescent current, from National Semiconductor

National Semiconductor Corp, the industry leader in the design, manufacture and sale of voltage regulators and linear integrated circuits, has added the LM2931 to its LM2930 family of low input/output differential voltage regulators. The LM2930 and LM2931 are the first voltage regulators to feature an output current of 150mA with an extremely low input/output differential voltage of less than 0.4V. This low dropout voltage is the result of a PNP instead of an NPN pass transistor.

The LM2931 is available in two versions: a 5V version, and an adjustable version for output voltages from 3V to 24V. The adjustable version is the first voltage regulator to provide a digital on/off switch capability.

The LM2931 features a low quiescent current (IQ) of only 400 microamps with load currents not less than 10mA. As a result, it is ideal for "memory-keep-alive" and battery back-up applications as well as other low power processor systems. It is also useful in portable instrumentation and toys and games, where low currents are needed in standby mode, and higher currents are required during normal system operation.

The lower quiescent current of the LM2931 (400 microamps versus 60 to 8mA for other regulators) results in longer battery life in portable equipment applications. The useful life of the battery is extended still further since the LM2931-5 can be powered by batteries discharged down to 5.4V. Other 5V NPN regulators have always needed at least 7V to operate.

Available from National Semiconductor, Bedford.

121 for further details

Switch mode power supplies, from Delpak

A new range of switching regulator power supplies is now available. Designated Series 30, the new range will initially be imported from the Japanese manufacturers Inaba.

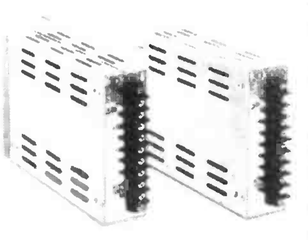
However, it is intended eventually to manufacture the range, under licence, in the UK.

Using a customised integrated circuit the Series 30 will have versions with single, double, triple and four-way outputs. Output capacity range from 30 watts to 150 watts.

The units feature built-in over-voltage and over-current protection, in-rush current suppression and remote sensing and control.

Available from Delpak (Electronics) Ltd, Luton.

122 for further details



Digital multimeter offers very high accuracy, from Thurlby

The new Thurlby 1503 HA is a low cost multimeter offering a very high level of accuracy and resolution. Developed from the standard 1503, the new instrument has an improved specification particularly on DC voltage, and is intended for applications where highest possible accuracy is of major importance.

A DC voltage accuracy of +/—(0.03% reading + 0.005% scale) is combined with a 4.75 digital scale length to improve overall accuracy by reducing resolution error.

Thirty-two ranges are provided covering the normal functions of AC and DC voltage, AC and DC current, and resistance, plus accurate diode test and frequency measurement functions. Maximum sensitivity is 0 microvolts, 10 milliohms, or 1 nanoamp, and current can be measured up to 25 amps short term, or 10 amps continuously.

The 1503 HA can operate from either disposable batteries or AC line, and a rechargeable battery option is available. It is designed and built in the UK and the price is £165 plus VAT.

The standard version with a basic accuracy of 0.05% is also available at £149.

Available from Thurlby Electronics Ltd, Huntingdon, Cambs.

129 for further details

New 'true RMS' digital multimeter from Bach-Simpson (UK) Limited.

Bach-Simpson (UK) Limited of Wadebridge, Cornwall, Manufacturer of panel meters, multimeters and test instruments, have introduced a new digital multimeter that reads true RMS on AC voltage and AC current and has a high frequency response up to 50 kHz.

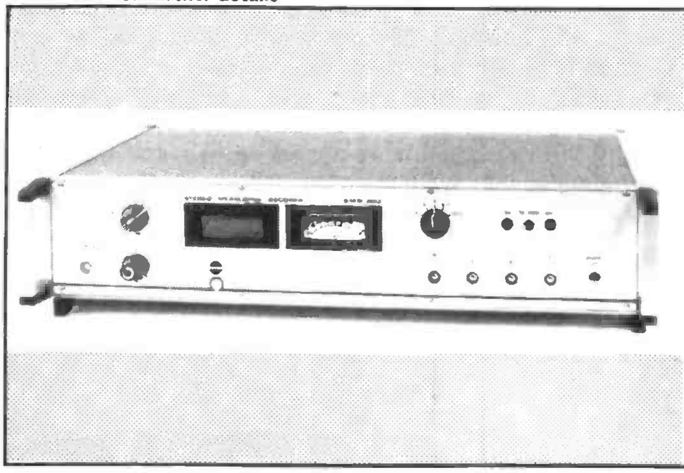
The Model 461-2R also features twenty six AC/DC current, voltage and resistance ranges with overload protection up to 250 V - a facility that is useful for service application. AC voltage measurement capability is up to 750 V and basic accuracy is to 0.1%.

Other technical features include: High voltage transient protection (6 kV, 100 uS); Extended AC voltage frequency response up to 50 kHz; Nickel cadmium rechargeable batteries supplied with AC charger/adapter. Standard design features include:-

1) Large, bright 3.5 digit LED display.
2) Safety designed to meet UL-1244 requirements.
3) Double fusing system.
4) Wide range of accessories available.
5) Portable, compact, only 2 x 5.63 x 4.6"; weight only 1.5 lb with nickel cadmuim batteries.
6) A full 8 hour day's operation on a single charge. May be AC line operated while batteries are being charged.

Further information on the new 461-2R is available on request from Bach-Simpson (UK) Limited, Trenant Estate, Wadebridge, Cornwall.

123 for further details



Stereo measuring decoder SMD-203, from Rood

Following the introduction of the SC-200 series digital stereo-generators with their striking performance (guaranteed 60dB channel separation, 0.01% (typical) harmonic distortion and a 95dB (typical) signal-to-noise ratio) and urgent need was felt for a stereo-decoder able to measure the performance of the SC-200 series stereo-generators.

FCC encoded stereo multiplex signals are very sensitive to distortion in transmission systems. Even minor changes in amplitude or phase characteristics will cause the channel separation to deteriorate. The specifications of the measuring equipment have to be of such quality that errors of the unit itself do not affect the results of the measurements. Because of its very low distortion and the high channel separation, even the smallet deteriorations in channel separation can be measured.

The new SMD-203 can be used for measuring stereo-generators, but also for measuring FM stereo transmitters and testing FM stereo relay receivers.

Available from C.N. Rood BV, The Netherlands

124 for further details

NEW PRODUCTS

New 20MHz dual trace oscilloscope from TRIO

CS1820 is an elegant solution to the problems of high speed waveform observations at a low cost. Featuring a high resolution display, usable to all four corners of its 140 mm rectangular, post accelerator type 16 kV CRT. A graduated inner face eliminates parallax errors and provides sharp bright pictures of high frequency and fast rising signals.

Trigger delay, for 'delayed sweep display', the key to observing complex waveforms, first used in the current and very successful CS 1830 is again employed in the CS 1820 to allow observation and analysis of any delayed section of a waveform. In addition, with B sweep not locked into the delayed sweep function any combination of A and B sweep may be selected. This system is extremely efficient in the detailed examination of high speed digital or video signals.

Fully guaranteed for 2 years, including pick up and return, the CS 1820 weighs 8.6 kg and measures 260 x 190 x 375 mm. Price £420 (excluding P & D and VAT). 100 MHz X1, X10 switchable probes are available with the oscilloscope at a special price of £7.00 each.

125 for further details

Portable noise level meter for broadcast circuits, from W & G Instruments

Program circuit noise meter type 4503 is a lightweight compact noise level meter designed to meet the latest European requirements for standardising the measurement of audio-frequency noise on sound programme circuits. It can be switched to measure quasi-peak noise in either a weighted or unweighted mode in accordance with CCIR recommendation 468-2. Level measuring range extends from +10dBm to —80dBm with a level accuracy of 0.1dB, and an unweighted frequency response flat to ±0.5dB from 32Hz to 16kHz.

Available from
W & G Instruments Ltd,
Greenford, Middx.

127 for further details

TG102 function generator, from Sinclair

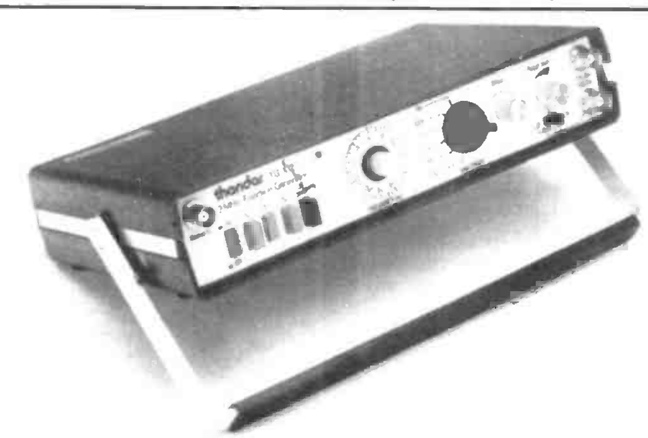
The TG102 function generator is the latest product complementing the Thandar range of test instruments. It is mains operated and has a frequency range of 0.2Hz to 2MHz producing sine, square and triangle waveforms plus DC from a variable amplitude 50 ohms output. TTL output is also provided. External sweep facility is available enabling greater than 1000:1 frequency change within a selected range.

The TG102 is housed in the proven Thandar case which combines ruggedness and portability.

The TG102 is designed and manufactured in England complete with mains lead and 1 year warranty and costs £145 plus VAT.

Available from Sinclair Electronics Ltd, Huntingdon, Cambs.

126 for further details



NEC MPU/Memory handbook

VSI now have stocks of a 700 page NEC handbook covering memories, MPUs, microcomputers and peripherals -including the new board products.

135 for further details

Babani book catalogue

The 1982 catalogue of Babani books is available FOC from the publishers. This 32 page booklet lists books of a substantially 'practical' theme covering topics ranging from transistor equivalents to DX TV, and computing.

B Babani (publishing) Ltd,
The Grampians,
Shepherds Bush Road,
London W6 7NF.

Ferranti VMOS Data Book

A 270 page data book covering a broad range of planar (i.e. no V or U grooves) power MOSFETs is available from Ferranti. The book contains a substantial cross reference of 'similar types', and lists the characteristics of each device. £2 each, post paid.

Ferranti Electronics, Fields New Road, Chadderton, Oldham OL9 8NP.

Dual-trace 20 MHz oscilloscope from Gould

Gould Instruments has introduced a new dual-trace 20 MHz general-purpose oscilloscope, the OS3000, which incorporates many facilities normally included in more expensive higher bandwidth oscilloscopes.

It features a bright 8 x 10cm rectangular display with a choice of a standard or long-persistence phosphors. The standard phosphor is a P43 (GY) type which has a characteristic similar to the normally used P31 (GH) phosphor but offers improved efficiency at a 2 kV accelerating potential. The —3dB bandwidth is from dc to 20 MHz, and the sensitivity can be adjusted continously via calibrated controls from 2 mV/cm to 25 V/cm to enable the screen to be scaled directly to different types of input parameters. The two input channels are identical in performance, with an accuracy of ±3%.

Several different display modes are available. Apart from the normal single and dual-trace modes, add and invert modes are included to aid baseline compensation and differential voltage measurements, and X-Y facilities are available for frequency and phase-shift measurement, using Lissajou figures. Enhancement of the display can be carried out using the Z-modulation input to obtain event markers, and this facility can also be used to remove flyback signals from X-Y traces. The timebase offers 18 speed settings, of 0.5 uS/cm to 0.2 sec/cm at an accuracy of ±3%, and an additional X10 pushbutton gives a maximum speed of 50 nS/cm. A variable sweep control also gives continously variable settings between 50 nS/cm and 0.5 sec/cm.

The OS300 is housed in a rugged case measuring 140 x 305 x 460mm and weighing 5.8 kg and is supplied with a fully adjustable handle. It has been designed on a modular basis for ease of maintenance, and is constructed using the latest automated production techniques at the Gould plant at Hainault, Essex. Cost is £295.00

128 for further details

NEW PRODUCTS

Higher current bench supply

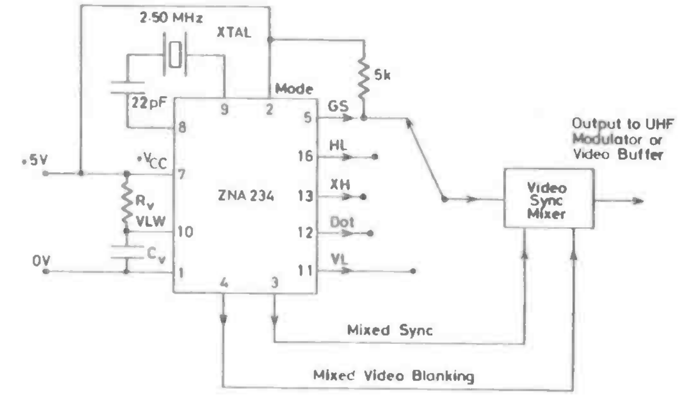
New from Thurlby is a 15 volt 4 amp version of the PL series of laboratory bench power supplies. Designated the PL154, the new supply operates in constant voltage or constant current modes from a few milliamps up to 4 amps continuous.

Twin digital meters give a highly accurate display of voltage and current levels to a resolution of 10 mV and 1 mA respectively. Remote sense terminals are provided to allow the precision to be maintained at high currents, and a separate DC output switch enables voltage and current levels to be set up before connecting the supply to the load.

A new feature is 'switchable current limit delay' which makes peak currents up to 7 amps available to circuits with fluctuating loads.

The PL154 is available from Thurlby Electronics Ltd. and their distributors. Price in the UK is £139.00 plus VAT.

130 for further details



TV Pattern generator IC from Ferranti

A comprehensive television pattern generator on a single IC has been developed by Ferranti Electronics and is now available from production. (Next months **R&EW** contains a feature based around this device).

Designated ZN234, the IC produces all the necessary test patterns for colour TV convergence alignment testing. It has a very high degree of accuracy and reliability, requiring only a 2.5 MHz crystal and the minimum of external components to provide a complete system ideally suited for the TV engineer or keen enthusiast.

ZN234, which is contained in a single 16-pin DIL package, provides all the waveforms necessary to produce crosshatch, dot and greyscale test patterns. There are separate outputs for these three functions, as well as separate vertical and horizontal line outputs and the mixed sync and mixed video blanking timing signals necessary for picture production. The IC is fully compatible with both European 625-line (CCIR) and American 525-line (EIA) operation. A 5 volt supply is required, and the outputs when mixed to give a composite video can be fed directly onto the video stages of the receiver or, via a modulator/oscillator through the TV aerial socket.

Full details of ZN234, including an Applications Note, are available from Ferranti Electronics, Fields New Road, Chadderton, Oldham, Lancashire, OL9 8NP.

132 for further details

New dual deck telephone answering machine.

A new quality low cost dual deck telephone answering machine code named ELGEM is now being manufactured by Hants based L.G.M. Electronics for Offices, Surgeries Factories and Homes etc. Using two international standard double-sided mini cassettes this machine has the facility for one cassette to be used for announcements whilst the other is used for recorded messages so abbreviating the need for constant announcement recording. Announcements are recorded through the built-in microphone and are played back through the loudspeaker.

This easy-to-use machine has indicator lamps to show 'power on', 'machine in use', 'callers message recorded' and 'tape run out'. Measuring only 6¾" x 12¼" x 2¾" and weighing 5¾ lbs it fits comfortably under the telephone. British designed and built, it is fully certified by the Post Office. It is provided with a standard Post Office plug and the mains lead is terminated with a 13 Amp plug. Included is a comprehensive 12 months Guarantee. The cost is £137.50 including VAT and Postage in the UK and Eire.

131 for further details

RFI suppression filters, from Eardley Electronics

A range of RFI power line suppression filters are available in various configurations of X-Y delta filters and LC types with current ratings from 0.5A to 40A.

Approved to VDE and ASEV for applications such as instrumentation, medical electronics, household appliances, business machines, power tools and power supplies etc. for protection from RFI and to reduce power line pollution.

Available from Eardley Electronics Ltd, Kensington, London.

134 for further details

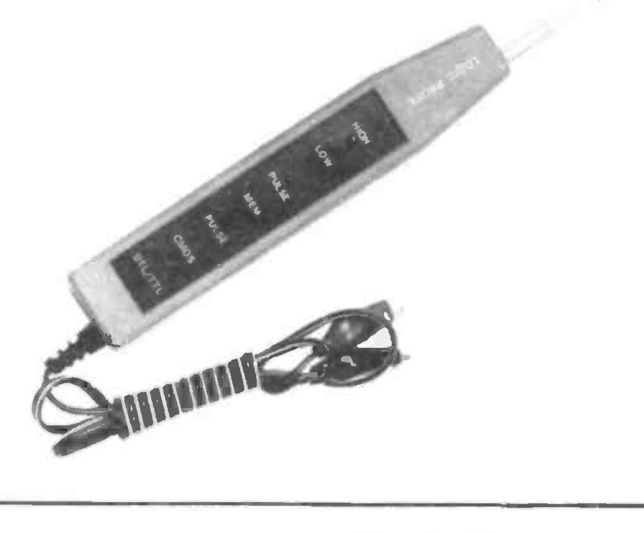
New low cost logic probe from Sabtronics.

Sabtronics announce the new LP-1 10 MHz Logic Probe for trouble-shooting logic circuits. The LP-1 has LED display for logic 0 and 1 with switch selectable thresholds to suit TTL or CMOS/MOS circuitry.

The probe also has the useful ability to either detect and hold pulses or 'glitches', or to stretch them. Power for the LP-1 can usually be taken from the Vcc line of the unit under test - connection is by mini crocodile clips, which are included.

Full interpretation instructions are printed on the reverse of the body of the LP-1, which costs £24.95 (+ VAT).

133 for further details



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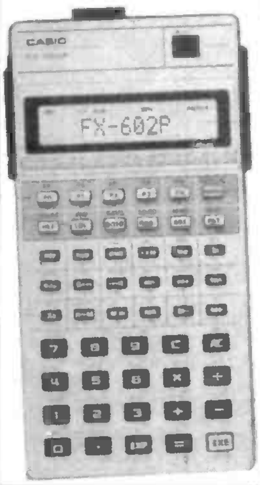

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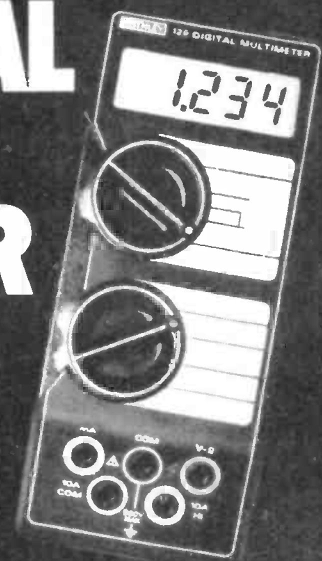

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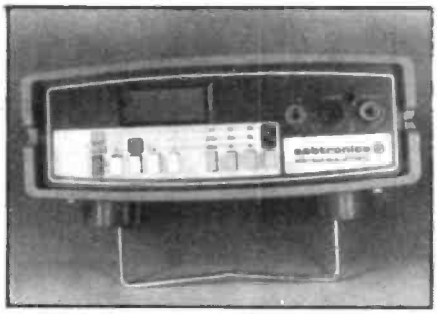
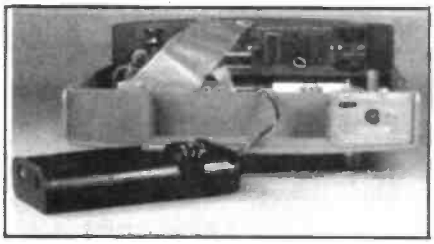
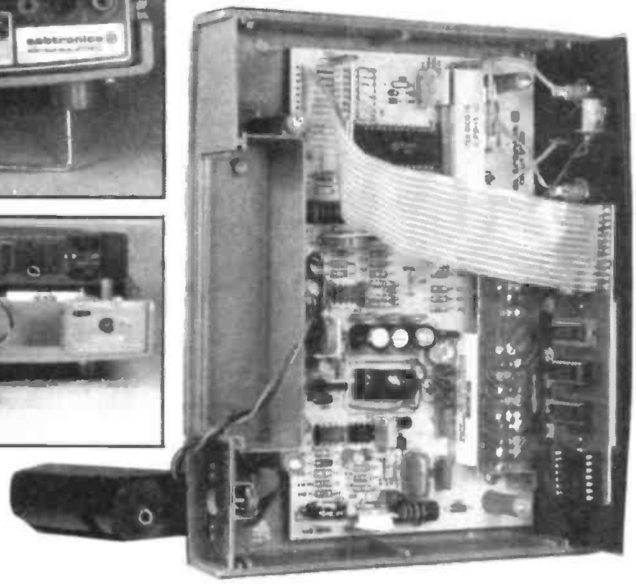
296 for further details.

3½ DIGIT LCD DMM. PROJECT

A fully-engineered 'professional spec' bench/portable digital multimeter for the advanced constructor, this unit has normal overload protection and a 'display freeze' facility. The unit is available in full kit form, backed up by a warranty. Project description by W.S. Poel.







THIS PROJECT IS THE FIRST to result from **R&EW's** 'on-going' design/engineering collaboration with Sabtronics Incorporated (see this month's Editorial). Full credits for this particular design go to Sabtronics, who market the instrument under the code number 2015 A. the 2015 A is a professional-specification instrument, with a total of 31 ranges covering six functions (AC/DC volts and current, plus ohms and 'diode test'). Measurement ranges span 100 uV to 1 kV peak on both voltage ranges, 0.1 uA to 10 A both current ranges, and OR 1 to 10 M on the resistance range. Basic accuracy varies from 0.1% on DC volts to 0.5% on AC current.

The 2015 A is battery powered (via four 'C' cells) and incorporates a low-battery (Lo Bat) warning indicator; mains power can be accepted via an external AC adaptor accessory. An unusual feature of the instrument is a Touch and Hold

SPECIFICATIONS
(@ 23°C ±5°C)

DC VOLTS

Range	Resolution	Accuracy of reading	Overvoltage protection
±200 mV	100 µV	± (0.1% + 1 l.s.d.)	1200V dc or peak ac
±2V	1 mV		
±20V	10 mV		
±200V	100 mV	± (0.2% + 1 l.s.d.)	
±1000V	1V	± (0.2% + 2.l.s.d.)	

INPUT IMPEDANCE	:	10 MΩ, all ranges
ROLLOVER ERROR	:	±2 1.s.d. max.
RESPONSE TIME	:	0.5 sec.
NMRR	:	>60 db at 50 and 60 Hz.
CMRR	:	>120 db at 50 and 60 Hz.

AC VOLTS (Sine wave)

Range	Accuracy of reading*	Frequency Response	Overvoltage Protection
200 mV	± (0.5% + 1 l.s.d.)	40 Hz to 40 kHz	250V dc or peak ac
2V			
20V			
200V	± (0.7% + 2 l.s.d.)	40 Hz to 2 kHz	1200V dc or peak ac
1000V	± (1.0% + 5 l.s.d.)	40 Hz to 400 Hz	

RESOLUTION	: same as DC Volts
INPUT IMPEDANCE	: 10 MΩ in parallel with 100 pF, all ranges
DC OFFSET REJECTION	: 25% of full range selected
CMRR	: >60 dB at 50 and 60 Hz.
RESPONSE TIME	: 5 sec. max. to within 5 digits

*Accuracy at 50/60 Hz.

DC CURRENT

Range	Resolution	Accuracy	Burden Voltage
±200 µA	0.1 µA	± (0.1% + 1 l.s.d.)	1 mV per µA
±2 mA	1 µA		1V per mA
±20 mA	10 µA	± (0.3% + 3 l.s.d.)	10 mV per mA
±200 mA	100 µA		10 mV per mA
±2A	1 mA	± (1% + 6 l.s.d.)	100 mV per Amp
±10A	10 mA		100 mV per Amp

OVERLOAD PROTECTION: 200 µ A to 200 mA ranges - 250 mA at 250V dc or ac peak. 2A and 10A ranges - 12A max. (unfused)

AC CURRENT (Sine wave)

Range	Accuracy @ 50/60 Hz	Frequency Response
200 µA	± (0.5% + 1 l.s.d.)	40 Hz to 1 kHz
2 mA		
20 mA		
200 mA		
2A	(1.5% + 2 l.s.d.)	
10A		

RESOLUTION
BURDEN VOLTAGE
OVERLOAD PROTECTION
} Same as dc current

3½ DIGIT LCD DMM.

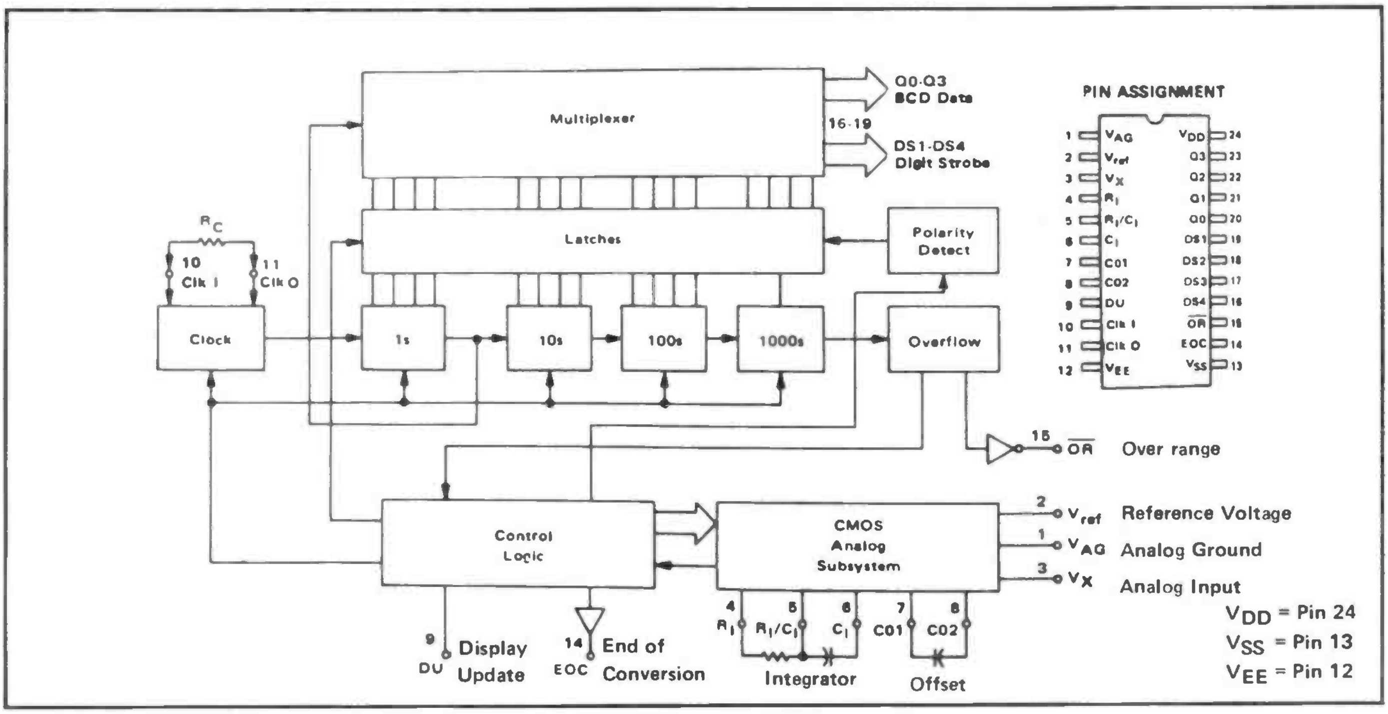


Figure 1: Block diagram of the basic DMM circuitry, together with pin assignments of the MC14433 A/D converter.

RESISTANCE

Range	Hi/ Lo	Resolution	Accuracy of reading	Measuring Current	Overload Protection
200 Ω	Lo	0.1Ω	±(0.1% + 1 l.s.d.)	1 mA	250V, 1/4A fuse
2 kΩ	Hi	1Ω			
20 kΩ	Lo	10Ω		10 µA	250V dc or peak ac
200 kΩ	Hi	100Ω			
2 MΩ	Lo	1 kΩ	(0.2% + 2 l.s.d.)	100 nA	500V dc or peak ac
20 MΩ	Hi	10 kΩ			

OPEN CIRCUIT VOLTAGE: 12V max (leads open)
FULL SCALE VOLTAGE (1999 reading): Lo Ω: 199.9 mV
Hi Ω: 1.999V
RESPONSE TIME: 200 Ω, 2 kΩ, ranges - 0.5 sec.
20 kΩ, 200 kΩ, ranges - 2.5 sec.
2 MΩ, 20 MΩ, ranges - 5 sec.

DIODE TEST

Range	Test Current	Switches Engaged (IN)
2 kΩ	1 mA	Ω, 200, X10
200 kΩ	10 µA	Ω, 20k, X10
20 MΩ	100 nA	Ω, 2M, X10

ENVIRONMENTAL:

OPERATING TEMPERATURE: 0°C to +55°C
STORAGE TEMPERATURE: -40°C to +70°C (without batteries)
RELATIVE HUMIDITY: 0 to 80%
TEMPERATURE COEFF: 0.02%/°C

GENERAL:

READING RATE: 3 times/sec.
POWER REQUIREMENT: 4.4 to 6.5V dc @ 120 mA nominal, or optional Sabtronics Model AC-115 or AC-230 Battery Eliminator/Charger.
DISPLAY: 3-1/2 digit (1999 max. reading) 7-segment LED 9.2mm character
SIZE: 7.62 cm x 20.32 cm x 16.38 cm (excluding protruding parts)
WEIGHT: 0.68 kg. (without batteries)

facility (available via a special ready-built accessory probe, not included in the price of the basic kit) which enables the user to temporarily store or 'freeze' readings when he is probing into delicate parts of circuitry.

Construction.

This DMM is emphatically NOT a beginner or novices project (see photo's), nor is it suitable for construction on home made PCBs. Consequently, we are not describing PCB layouts/drawings in this particular feature.

In view of the expense of the project, we are only going to recommend the use of complete Sabtronics kits, which carry a limited warranty: This warranty does not extend to non-recommended forms of construction. **R&EW** have managed to negotiate a worthwhile kit-price saving for readers.

For the benefits of those readers who INSIST on building the project direct from the circuit diagram, using their own forms of construction, we have persuaded Sabtronics to separately supply the plastic cases (complete with battery compartment) and a blank front panel.

The Sabtronics kits come complete with a set of notes that concisely but adequately cover all pertinent details of construction and setting up of the DMM. A major defect of the notes is that they give no circuit description or analysis to assist those constructors who have an interest in such matters. **R&EW** have set out to repair this defect, by presenting a set of 'Circuit Description' notes in the present article.

Circuit Description: The DMM

The Block Diagram (Figure 1)

Contrary to popular belief, the world of 3½ digit LCD DMMs does not revolve entirely around the seemingly ubiquitous ICL7106 DMM IC, and our particular instrument provides a useful illustration of some valid techniques that have been overshadowed in the 'one-chip' approach.

Figure 1 illustrates the 'block' approach to the design of the bench DMM. The main A/D converter device (MC14433) is also depicted in block form - and you will see one of the major features of this approach is that the DVM IC presents data in multiplexed BCD format, rather than direct LCD drive.

This allows the data to be transferred quite readily to an MPU input, and also

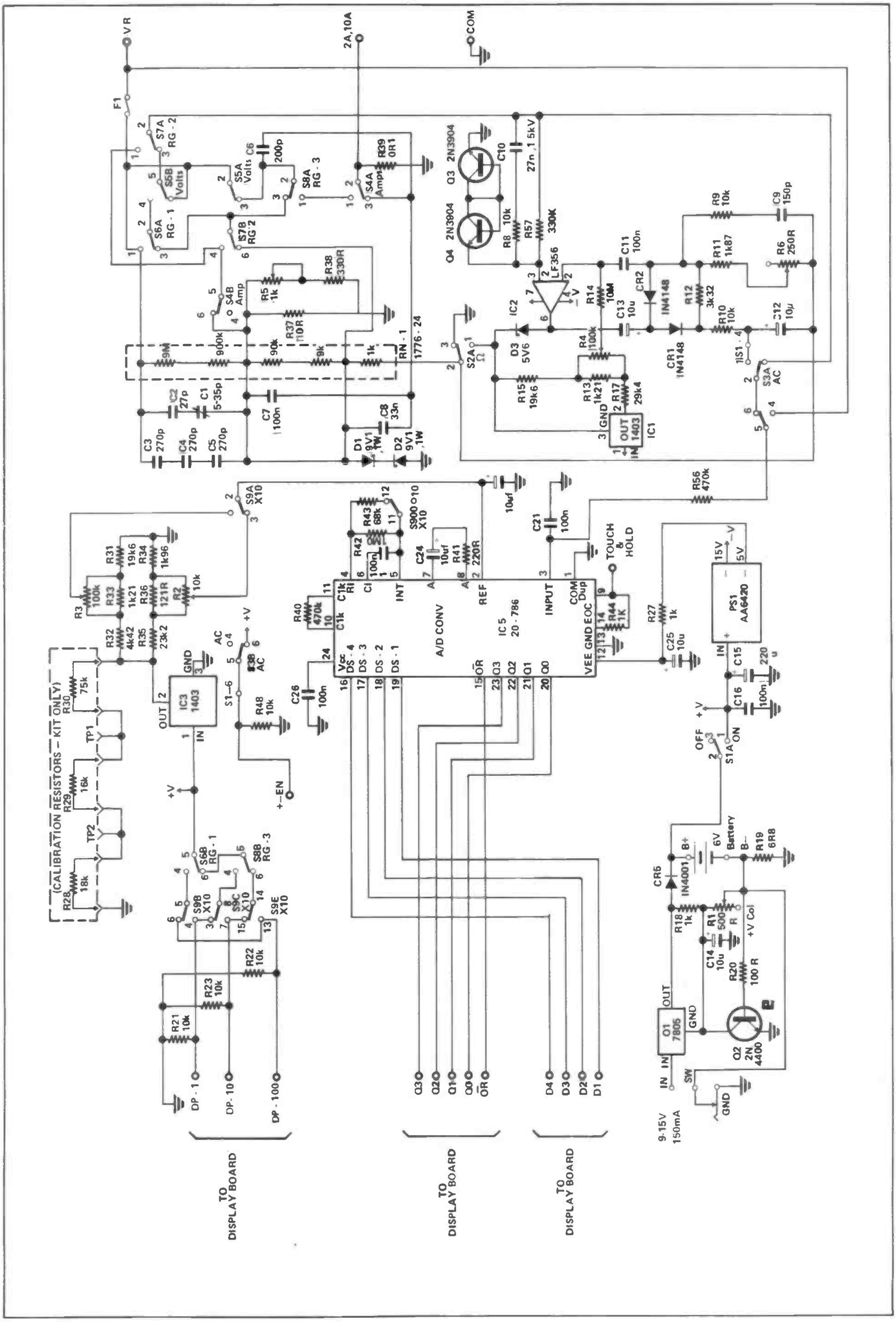


Figure 2: Circuit diagram of the main board of the 2015A DMM.

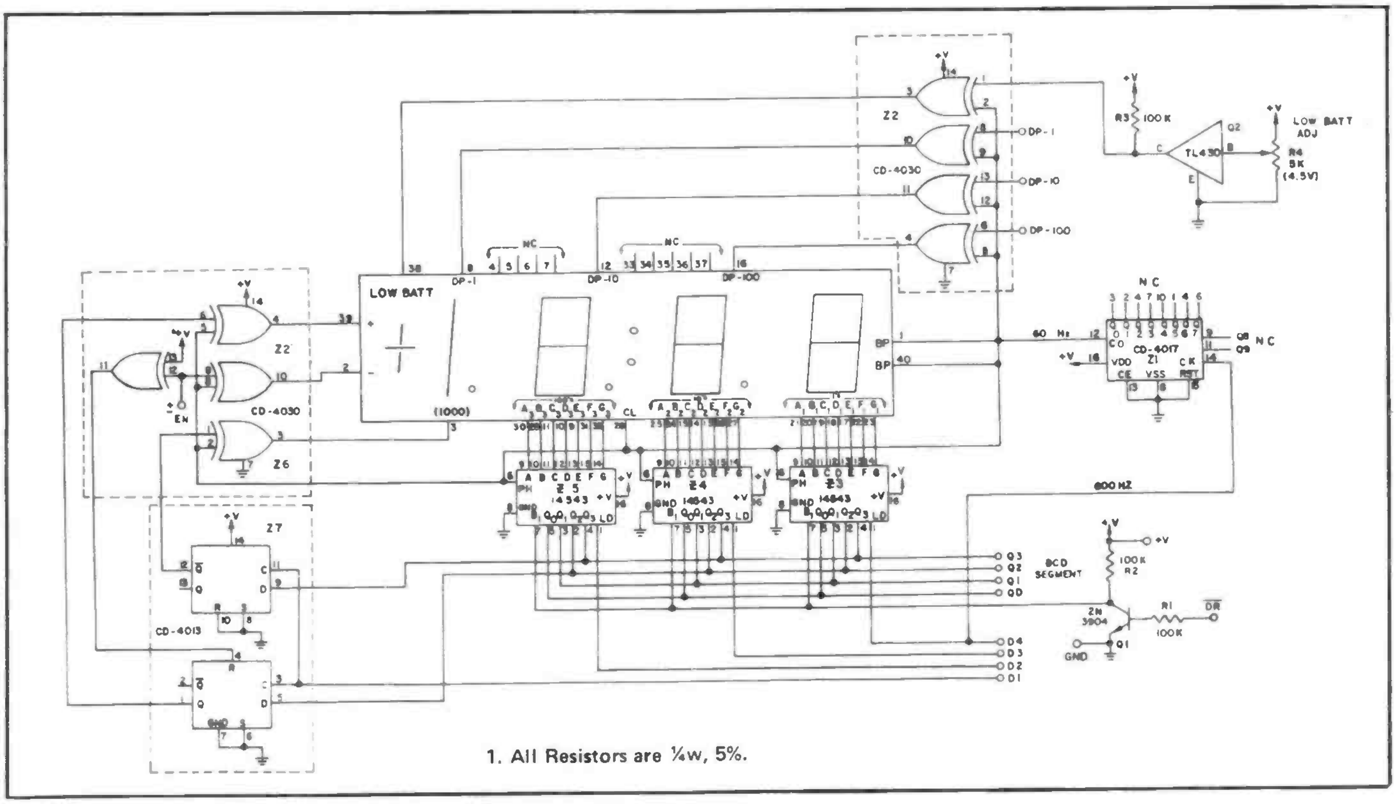


Figure 3: Circuit diagram of the display board of the 2015A DMM.

allows the display system to be 'bussed' so that one display unit can be fed from a variety of data inputs. It is also possible to use either LED or LC displays, the choice being determined by the display interface. These features are not fully implemented in the basic DMM, but they exist for those of you wishing to exploit them further. (The manufacturer's data for the MC14433 is comprehensive and contains several applications circuits that provide a good background to the design and theory of the system. A copy of the data can be obtained for 35p from **R&EW** Readers Services.)

In a straight fight between the ICL7106 and this approach, the major diadvantage here is the need for a differential power supply source - and the only solution in a battery instrument is to use a thirsty DC/DC converter. But the MC14433 fights back with a useful 'x10' multiplier facility, whereby the basic A/D can be switched between 1.999 V and 199.9 mV FSD, thereby doubling the number of ranges available for a given switch array. For a detailed description of the A/D function, see the separate 'boxed' circuit description.

The Circuit (Figure 2)

The major features determining the precision of any DMM are the accuracy of the reference voltages, and the accuracy of the attenuator network. CMOS A/D converter ICs all have a very high input impedance that provide minimal loading to the input circuits. High value, close tolerance resistors are not the easiest of animals to locate, and Messrs. Caddock Inc seem to have the DMM input attenuator market to themselves. In this design, the intermediate steps in the network are not required since the x10 facility takes care of unnecessary range switching.

Voltage References.

The voltage references are provided by MC1403 ICs, precision band-gap voltage reference sources with a temperature coefficient of 10ppm/°C. With a 2.000 V reference at pin 2 of the A/D (derived from IC 3), the device operates by determining the ratio of the input voltage to the reference voltage -where a ratio of '1:1' implies the maximum count of 1.999 V. Thus a 200 mV reference at the same point relates to a maximum 'in range' input of 199.9 mV. Since the accuracy of the reading depends on the accuracy of the reference, considerable care is taken to ensure that the reference voltage is correctly established.

IC2 drives a true RMS AC detector which provides reliable results to 10kHz. C1 is used to trim the frequency compensation of the network, and it should be borne in mind that any high impedance measurements at frequencies above a few kHz tend to become misleading as a result of lead capacitance and other 'stray' effects.

The ohms range uses the input attenuator array to establish an accurate reference for the circuit around IC2 to perform a ratiometric comparison with the unknown resistance. The ratio of the known/unknown resistance is the same as the ratio of the voltages across these two resistors - so once the instrument has been calibrated to provide a 'known' voltage across the reference resistance, it follows that the voltage across the unknown may be measured as an accurate representation of the resistance value -directly in ohms.

Display Considerations (Figure 3)

The decimal point switching is derived from the input switching circuitry, and overrange indication is supplied via pin 15 of the A/D, which goes low when overdriven - thereby blanking the display with Q 1.

Many readers will be rather rusty on the basics of LCD driving, since so many LSI systems perform all the necessary thinking for the designer. Not so here, you get good old-fashioned multiplexed BCD, and whilst it is quite possible to take a cowardly way out and use a combined decoder/driver/display module such as the **WR&E** DM 180 or similar, the 'designer's' solution is to use 4000 series CMOS. And in any case, the DM 180 does not provide the 'lo bat' indicator in the display format - but don't forget it, in case you want to use the solution in a slaved 'remote' display application.

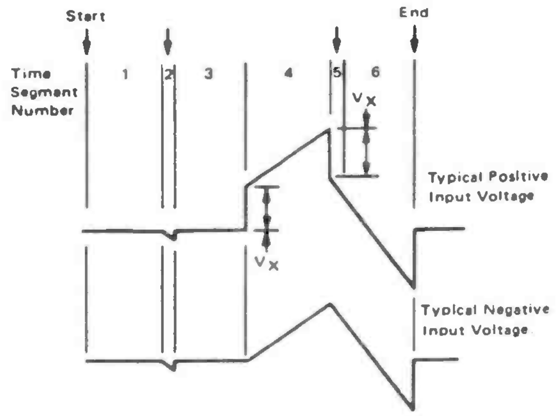


Figure 4: Integrator waveforms at Pin 6.

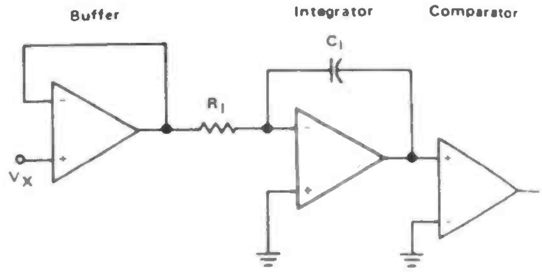


Figure 5: Equivalent circuit diagrams of the analogue section.

CIRCUIT DESCRIPTION: THE A/D CONVERTER

The MC14433 CMOS integrated circuit, together with a minimum number of external components, forms a modified dual ramp A/D converter. The device contains the customary CMOS digital logic providing counters, latches, and multiplexing circuitry as well as the CMOS analog circuitry providing operational amplifiers and comparators required to implement a complete single chip A/D. Autozero, high input impedances, and autopolarity are features of this system. Using CMOS technology, an A/D with a wide range of power supply voltage and low power consumption is now available with the MC14433.

During each conversion, the offset voltages of the internal amplifiers and comparators are compensated for by the system's autozero operation. Also each conversion 'ratiometrically' measures the unknown input voltage. In other words, the output reading is the ratio of the unknown voltage to the reference voltage with a ratio of 1 equal to the maximum count 1999. The entire conversion cycle requires slightly more than 16000 clock periods and may be divided into six different segments. The waveforms showing the conversion cycle with a positive input and a negative input are shown in *Fig 4*. The six segments of these waveforms are described below.

Segment 1 - The offset capacitor (C_0), which compensates for the input offset voltages of the buffer and integrator amplifiers, is charged during this period. Also, the integrator capacitor is shorted. This segment requires 4000 clock periods.

Segment 2 - The integrator output decreases to the comparator threshold voltage. At this time a number of counts equivalent to the input offset voltage of the comparator is stored in the offset latches for later use in the autozero process. The time for this segment is variable, and less than 800 clock periods.

Segment 3 - This segment of the conversion cycle is the same as Segment 1.

Segment 4 - Segment 4 is an upgoing ramp cycle with the unknown input voltage (V_X) as the input to the integrator. *Fig 5* shows the equivalent configuration of the analog section of the MC14433. The actual configuration of the analog section is dependent upon the polarity of the input voltage during the previous conversion cycle.

Segment 5 - This segment is a down-going ramp period with the reference voltage as the input to the integrator. Segment 5 of the conversion cycle has a time equal to the number of counts stored in the offset storage latches during Segment 2. As a result, the system zeros automatically.

Segment 6 - This is an extension of Segment 5. The time period for this portion is 4000 clock periods. The results of the A/D conversion cycle are determined in this portion of the conversion cycle.

The backplane signals for the LCD are taken from the multiplexed outputs of the A/D device. The 600Hz strobe signal at D 4 digit driver output is divided by 10 in IC 1 to provide a 60 Hz backplane signal. The truth table for the special functions contained in the D 1 'frame' (shown in *Table One*) is separated and decoded in IC 6 and IC 7.

Coded Condition of MSD	Q3	Q2	Q1	Q0	BCD to 7 Segment Decoding	
+0	1	1	1	0	Blank	
−0	1	0	1	0	Blank	
+0 UR	1	1	1	1	Blank	
−0 UR	1	0	1	1	Blank	
+1	0	1	0	0	4 → 1	Hook up only seg b and c to MSD
−1	0	0	0	0	0 → 1	
+1 OR	0	1	1	1	7 → 1	
−1 OR	0	0	1	1	3 → 1	

Table 1: Truth Table

The very useful display freeze function is achieved by clamping the display update pin of IC 5 to ground. This simply holds the data in the output latches, instead of enabling new data to be loaded when the 'end of conversion' (EOC) signal appears at pin 14.

The rest of the circuit concerns the internal/external power switching and regulation. The way in which the circuit accommodates the battery eliminator-cum-charger is an ingenious concept where R 1 is used as a Vbe multiplier to establish the reference voltage at the 'ground' terminal of IC 1. Whatever voltage occurs at the collector of Q 2 is added to the 5 V of the basic regulator, resulting in a nominal output of 5 V 7 across the battery terminals with the power 'on' (6 V 1 off load). The charging current is set to 100 mA, as a result of the 680 mV potential developed across R 19 (V= 100mA x 6 R 8) acting to stabilize the collector voltage of Q 2 by turning Q 2 on when its Vbe is exceeded if excess charging current is being drawn. ■ R & EW

R&EW KIT PRICES:

DMM Project Pack £73 + VAT

Touch and Hold Probe £13 + VAT

Your Reactions.........	Circle No.
Immediately Applicable	136
Useful & Informative	137
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Sinclair ZX81 Personal Comp[uter] the heart of a system that grows with you.

1980 saw a genuine breakthrough – the Sinclair ZX80, world's first complete personal computer for under £100. Not surprisingly, over 50,000 were sold.

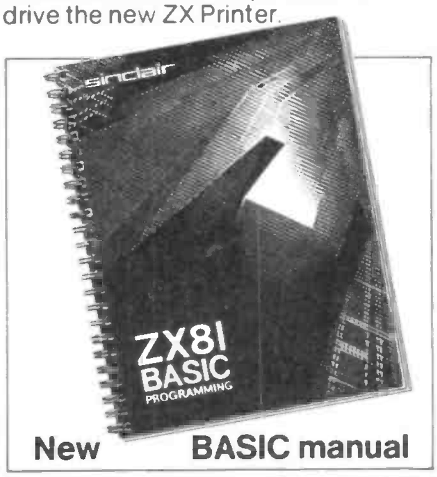
In March 1981, the Sinclair lead increased dramatically. For just £69.95 the Sinclair ZX81 offers even more advanced facilities at an even lower price. Initially, even we were surprised by the demand – over 50,000 in the first 3 months!

Today, the Sinclair ZX81 is the heart of a computer system. You can add 16-times more memory with the ZX RAM pack. The ZX Printer offers an unbeatable combination of performance and price. And the ZX Software library is growing every day.

Lower price: higher capability
With the ZX81, it's still very simple to teach yourself computing, but the ZX81 packs even greater working capability than the ZX80.

It uses the same micro-processor, but incorporates a new, more powerful 8K BASIC ROM – the 'trained intelligence' of the computer. This chip works in decimals, handles logs and trig, allows you to plot graphs, and builds up animated displays.

And the ZX81 incorporates other operation refinements – the facility to load and save named programs on cassette, for example, *and* to drive the new ZX Printer.



Every ZX81 comes with a comprehensive, specially-written manual – a complete course in BASIC programming, from first principles to complex programs.

Kit: £49.95

Higher specification, lower price – how's it done?
Quite simply, by design. The ZX80 reduced the chips in a working computer from 40 or so, to 21. The ZX81 reduces the 21 to 4!

The secret lies in a totally new master chip. Designed by Sinclair and custom-built in Britain, this unique chip replaces 18 chips from the ZX80!

New, improved specification
- Z80A micro-processor – new faster version of the famous Z80 chip, widely recognised as the best ever made.
- Unique 'one-touch' key word entry: the ZX81 eliminates a great deal of tiresome typing. Key words (RUN, LIST, PRINT, etc.) have their own single-key entry.
- Unique syntax-check and report codes identify programming errors immediately.
- Full range of mathematical and scientific functions accurate to eight decimal places.
- Graph-drawing and animated-display facilities.
- Multi-dimensional string and numerical arrays.
- Up to 26 FOR/NEXT loops.
- Randomise function – useful for games as well as serious applications.
- Cassette LOAD and SAVE with named programs.
- 1K-byte RAM expandable to 16K bytes with Sinclair RAM pack.
- Able to drive the new Sinclair printer.
- Advanced 4-chip design: micro-processor, ROM, RAM, plus master chip – unique, custom-built chip replacing 18 ZX80 chips.

Built: £69.95

Kit or built – it's up to you!
You'll be surprised how easy the ZX81 kit is to build: just four chips to assemble (plus, of course the other discrete components) – a few hours' work with a fine-tipped soldering iron. And you may already have a suitable mains adaptor – 600 mA at 9 V DC nominal unregulated (supplied with built version).

Kit and built versions come complete with all leads to connect to your TV (colour or black and white) and cassette recorder.

NEWS

The All Electric Aeroplane

Contrary to what most people believe, aircraft control systems use mainly mechanical and pneumatic control linkages. That is, all except a British Aerospace modified Jaguar, which claims to be the worlds first aircraft to fly solely with an all digital quadruplex 'fly-by-wire' control system made to production standards. Marconi Avionics supply the electronic technology to control servos made by Boulton Paul Ltd. of Wolverhampton.

This system replaces all mechanical linkages in the control system -autostabilisers, control rods and all control surface manipulation is now handled electronically by four high speed computers. These are linked to two further actuator drive and monitor computers, leading to a duo-triplex 'failure absorption' actuator.

The signals not only respond to direct pilot commands, but are also initiated automatically to correct uncommanded aircraft motion - whilst maintaining performance within the safe parameters of the airframe. All this now means that a basically unstable aircraft can be flown without excessive pilot fatigue.

A basically unstable aircraft may seem paradoxical, but the ugly equipment-laden fighters of the next decade can now compromise the principles of sound aerodynamics in their efforts to stow even bigger and better electronic warfare systems. The multiple control systems enable up to two failures in either the electrical or hydraulic systems, without a serious effect on system performance.

Pigs in Space

Nothing to do with Kermit & Co. Amateur satellite enthusiasts can get themselves a "Ham in Space" sweatshirt from AMSAT Box 27, Washington DC 20044 for around US$20. (the US

Pinstripes for Buzby

Telecom is planning to launch an electronic mail service based on the system developed and operated in the USA by Dialcom Inc. The services will be marketed from a computer bureau in the London area using Prime 750 computers in an extension of the Prestel concept.

The user sends 'correspondence' via a terminal to another user on the network, and the recipients terminal then stacks incoming 'mail' in order of arrival, taking into account priority signals. The same communications may be sent simultaneously to several destinations.

How long is a piece of fibre optic cable

201 km - or twice the distance from the end to the middle -according to a recent release from Telecom on the subject of their proposed new London to Birmingham optical link. Billing this as the longest in the world, BT chairman Sir George Jefferson promised "at least 100.000 km of fibre during the 1980s to create a network embracing all of Britain's major cities".

The link to Brum contains eight 125 micrometer fibres, with an initial two pairs offering 480 simultaneous phone conversions each. This could give a whole new dimension to the expression 'crossed line'.

Networking Viewdata

The Wembley Viewdata '81 conference saw the conclusion of several agreements for the network of European viewdata systems so that Prestel users in the UK, for example, can access the German PPT's Bildshirmtext service - and vice versa.

This is a further feature of a facility known as 'gateway', which is being
mit viewdata users to
ıon-viewdata systems.

Sun and Wind power TV

The IBA has just commissioned the first ecology conscious TV transmitter station at Bossiney in Cornwall for the benefit of the 300 local residents.

The occasion also marks developments in local 'community' relays for the small rural communities who to date have been saved from the dubious delights of the ITV's offerings. In case the locals' prayers are answered by calm, cloudy or foggy weather - 1000 Ah of lead acid accumulators are provided to keep the station's 150 watt power demand satiated when the 780 W solar array or 150 W wind generator are idle.

Radio Lincolnshire goes QRO

A new BBC Radio Lincolnshire transmitter on 1368 kHz was operational from October 1 st to extend coverage to virtually the entire county. The site of the 2 kW transmitter is just outside Lincoln city, and if you happen to live in Swan Pool, then 1368 kHz tuned traps can be made easily with around 200 uH and 200 pF variables.

A Thorny Point

In our Philips DMM competition on Page 71 of the November issue of **R&EW**, we inadvertently made reference to 'an AVO' - failing to take account of the fact that although this term has passed into common usage when referring to amp/volt/ohmmeters within the electronics trade, the trade mark of AVO is the property of AVO Ltd., who are anxious to discourage this type of usage.

In view of the fact that the AVO range now extends far beyond the classic 'AVO Mk8' most commonly associated with the name, we are pleased to be able to draw the attention of our readers to the current range of AVO instrumentation - which although technologically is a far cry from the simple ruggedness of the AVO Mk8, maintains the same image of sturdy reliability.

R&EW Data Brief LC7137

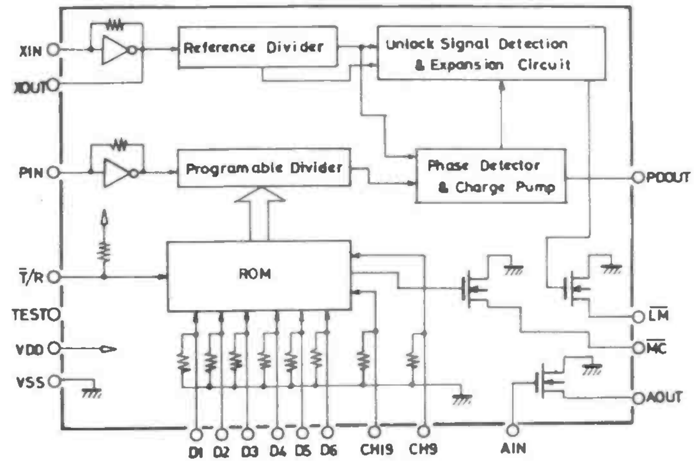
CB synthesisers for the UK channels.

This Databrief should coincide with the availability of the Sanyo LC7137 UK CB specification PLL device in the UK. As you can see, it is a great deal more straightforward than any solution that can be devised using other techniques, and will thus form the local oscillator section of the **R&EW** CB transceiver system that will be described starting next month.

The LC7137 is a single crystal PLL system, programmed via a standard 6 bit BCD switch. The receive local oscillator is generated directly with a 10.695 MHz offset (oscillator 'low'). The transmit frequency is generated at half the output frequency, since the maximum input frequency of the programmable divider is 20 MHz.

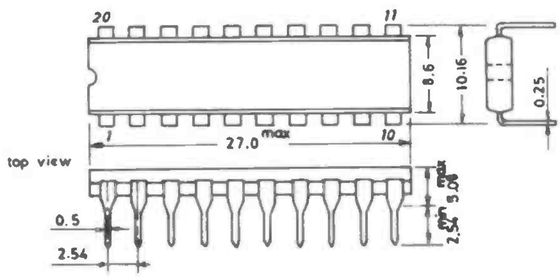
It is also easier to achieve linear FM by starting at half the output frequency - as in FM radio control systems. The existing LC7131 PLL device for the USA 40 channel specifications uses exactly the same external circuitry and pinout as the LC7137 - but despite this compatibility, it is NOT a straight swap. There is a difference in reference frequencies, and the 7131 family mix the VCO with 10.24 to achieve the TX output frequencies.

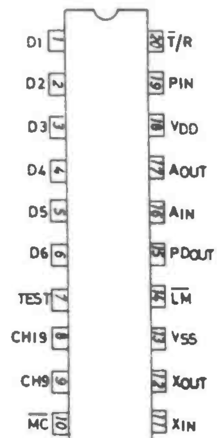
The device features *(Fig 1)* an on-board crystal oscillator, phase detector, programmable counter, reference divider, out-of-lock indication and an instant channel 9/19 call feature.



			min	typ	max	unit
ABSOLUTE MAXIMUM RATINGS at Ta = 25 C						
Maximum Supply Voltage	VDD		-0.3 to 8.0			V
Maximum Input Voltage	VIN	input pin	-0.3 to VDD+0.3			V
Maximum Output Voltage	VOUT(1)	PDOUT,XOUT	-0.3 to VDD+0.3			V
Maximum Output Votlage	VOUT(2)	LM,MC,AOUT	-0.3 to 10.0			V
Maximum Output Current	IOUT(1)	MC,LM	0 to 10.0			mA
Maximum Output Current	IOUT(2)	AOUT	0 to 2.5			mA
Operating Temperature	Topg		-30 to 70			C
Storage Temperature	Tstg		-40 to 125			C
OPERATING CONDITIONS at Ta = 25 C			min	typ	max	unit
Supply Voltage	VDD (PIN) (CONDITION)		5.0	6.0	7.0	V
Input 'H' Level Voltage	VIH D1—D6,T/R,CH9,19		VDD-0.8			V
Input 'L' Level Voltage	VIL —				0.8	V
Input Amplitude	VIN(1) XIN	fIN(1) = 10.25MHz sine wave, C-coupled	1.0		0.9VDD	Vp—
	VIN(2) PIN	fIN(2) = 20MHz sine wave, C-coupled	1.0		0.9VDD	Vp—
	(PIN)	(CONDITION)				
Input Frequency	fIN(1) XIN	VIN(1) = 1.0Vp-p sine wave, C-coupled	1.0		10.25	MHz
	fIN(2) PIN	VIN(2) = 1.0Vp-p sine wave, C-coupled	1.0		20	MHz
ELECTRICAL CHARACTERISTICS at Ta = 25 C,VDD = 6+- 1V						
Feedback Resistance	Rf	XIN,PIN		3.0		Monn
Pull Up/Down Resistance	RIN	D1-D6,T/R CH9,19		35		kohn
Input Floating Voltage	VIF(1)	D1-D6 VI opened CH9,19			0.2	V
	VIF(2)	T/R VI opened	VDD-0.2			V
Input Current	IIN	AIN VI = ½VDD		0.01		nA
3 States Off Leakage	IOFF(1)	PDOUT vo = ½VDD		0.01		nA
Output 'L' Level Voltage	VOL	Mc,LM Io = 10mA			1.1	V
Output Off Leak Current	IOFF(2)	MC,LM			5.0	uA
Dissipation Current	IDD	fIN(1) = 10.24MHz fIN(2) = 20MHz N = 3381 AIN = Vss,D1 = VDD other pins opened			20	mA

D1-D6 :Channel data Input [BCD (D1...LSB, D6...MSB)]
XIN,XOUT :Crystal oscillator amplifier
VDD,VSS :Power supply
MC :Mis-code indicating output
LM :Out-of-lock output [Lock: open ('1')]
PDOUT :Charge pump output
AIN,AOUT :Amplifier for low-pass filter
PIN :Programmable divider input
T/R :TX/RX (T/R = '0'...Tx,T/R = '1' (or open)...Rx)
CH19 :Ch-19 input
CH9 :Ch-9 input
TEST :TEST pin. TEST pin may be connected to VSS,VDD or open





Frequencies

Data in our possession does not give full details of the actual frequencies derived and employed in the LC7137, so we have had to extrapolate the solution from details of the output frequency and the programmable divider numbers.

In view of the odd frequencies required for the UK 27 MHz specification, the results cannot be obtained directly as with the exact 10 kHz spacing of other standards. To accommodate the 1.25 kHz 'offset' of the UK plan and yet maintain a relatively easy incremental 'N' number in the programmable divider (which is maximum of 4 decades), the device has to use a 5.000226 kHz reference frequency, derived by dividing by 2048 in the normal way, but with a 10.24046285 MHz crystal. In practise, a standard 10.240 MHz crystal can be pulled this far by a trimmer.

The receive frequencies are generated as oscillator low, with a 10.695 MHz offset; taking channel 1 as an example, 'N' + 3381, so Flo + 16.90576 MHz, corresponding to an RF frequency of 27.60076 MHz. Not exactly 27.60125, but 490 Hz lower. ON transmit, the 'N' is 2760, leading to 27.601249 MHz. Much closer, and well within the specification tolerance.

The results at the channel 40 are 27.99078 and 27.99126 - again well within tolerance of the UK specification on transmit, and well within the IF passband on receiver - especially when the fact that the second IF conversion from 10.695 to 455 kHz is also offset by 462 Hz (10.695-10.240462), thus making up the apparent receiver error at the second conversion.

In this way, the LC7137 has manoeuvred very cleverly around the pitfalls of the UK specification, which many pundits had forseen as a big problem. The programmable dividers are just 4 decades in the FCC system, (*27.125* MHz etc.), but 5 decades for the UK (27.*60125* MHz). As you can see the LC7137 has retained the 4 decade solution, and confounded those ill-informed observers who claimed the UK specification would lead to £300 sets!

Bells and whistles.

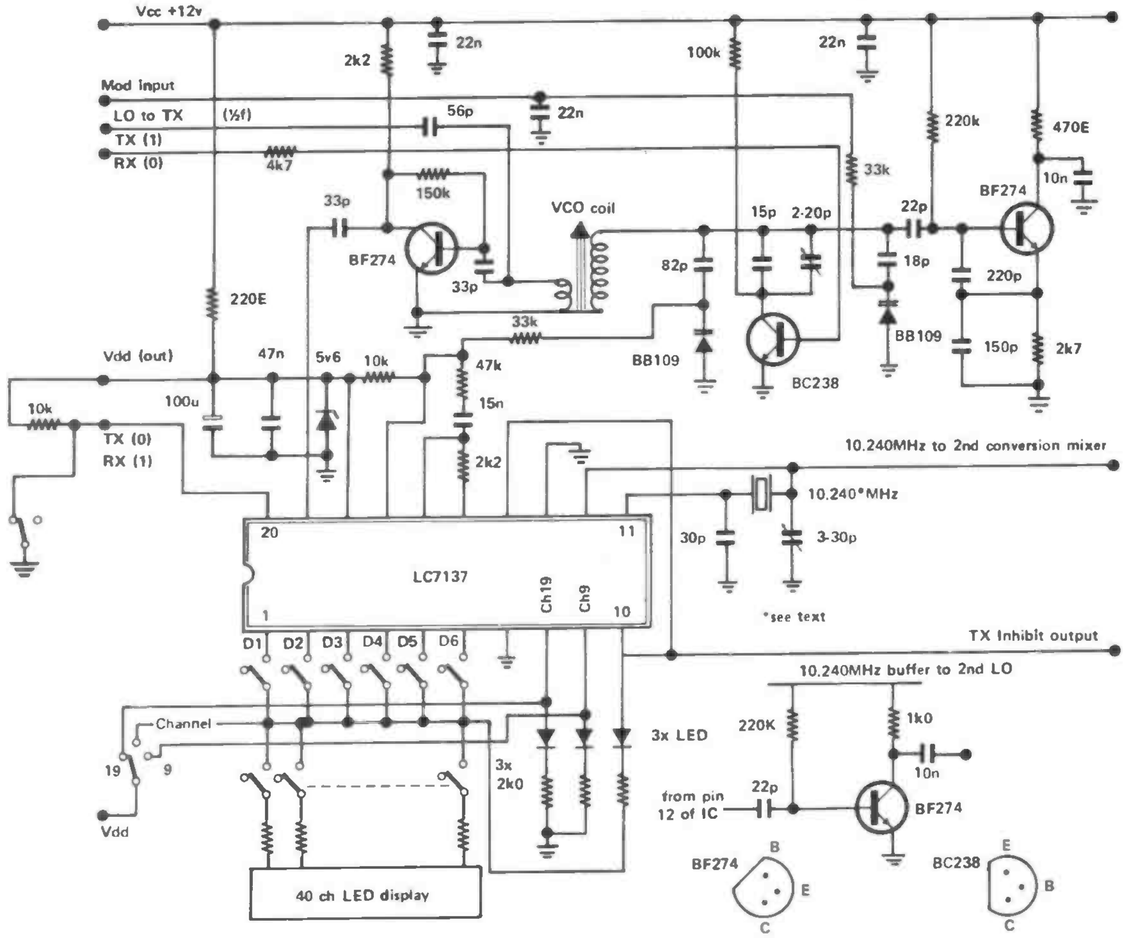
Apart from the basic function of providing the necessary frequencies for transmitting, and receiving with a low cost 455 kHz ceramic IF filter - all from a simple BCD switch - the LC7131 includes.

Priority channel 9 and channel 19 switching

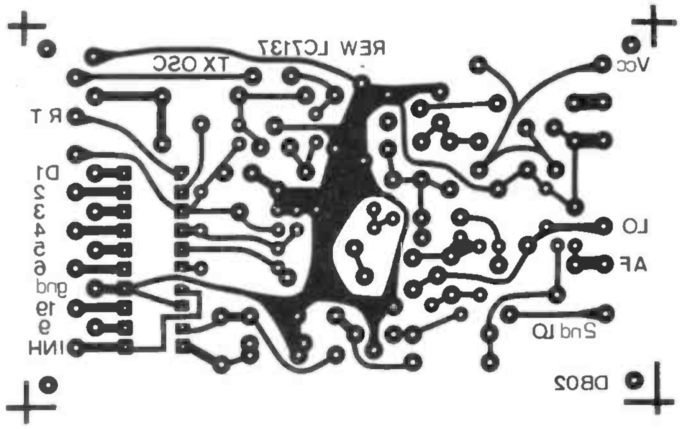
Miscode (MC) lockout, to prevent transmission out of band

Unlock detector

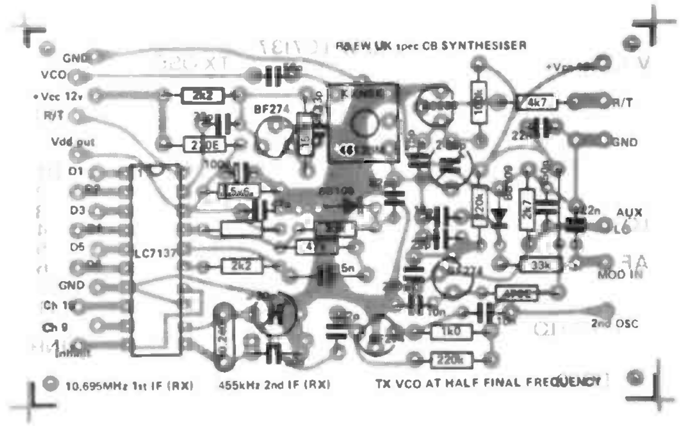
Under miscode conditions, the emergency channel 9 is selected by default in case the equipment has been damaged as a result of an accident etc., when its use is particularly vital.



Application Circuit



PCB Foil (Top) and overlay (below)



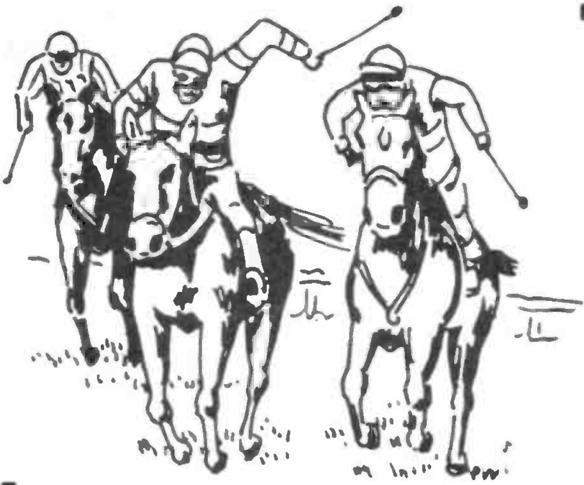
LC7136 PROGRAM DATA vs. DIVISOR RATIO

FREQUENCY	CH NO.	D1	D2	D3	D4	D5	D6	RX(T/R=1)	TX(T/R=0)
		PROGRAM CODE							
27.60125	1	1	0	0	0	0	0	3381	2760
27.61125	2	0	1	0	0	0	0	3383	2761
27.62125	3	1	1	0	0	0	0	3385	2762
27.63125	4	0	0	1	0	0	0	3387	2763
27.64125	5	1	0	1	0	0	0	3389	2764
27.65125	6	0	1	1	0	0	0	3391	2765
27.66125	7	1	1	1	0	0	0	3393	2766
27.67125	8	0	0	0	1	0	0	3395	2767
27.68125	9	1	0	0	1	0	0	3397	2768
27.69125	10	0	0	0	0	1	0	3399	2769
27.70125	11	1	0	0	0	1	0	3401	2770
27.71125	12	0	1	0	0	1	0	3403	2771
27.72125	13	1	1	0	0	1	0	3405	2772
27.73125	14	0	0	1	0	1	0	3407	2773
27.74125	15	1	0	1	0	1	0	3409	2774
27.75125	16	0	1	1	0	1	0	3411	2775
27.76125	17	1	1	1	0	1	0	3413	2776
27.77125	18	0	0	0	1	1	0	3415	2777
27.78125	19	1	0	0	1	1	0	3417	2778
27.79125	20	0	0	0	0	0	1	3419	2779
27.80125	21	1	0	0	0	0	1	3421	2780
27.81125	22	0	1	0	0	0	1	3423	2781
27.82125	23	1	1	0	0	0	1	3425	2782
27.83125	24	0	0	1	0	0	1	3427	2783
27.84125	25	1	0	1	0	0	1	3429	2784
27.85125	26	0	1	1	0	0	1	3431	2785
27.86125	27	1	1	1	0	0	1	3433	2786
27.87125	28	0	0	0	1	0	1	3435	2787
27.88125	29	1	0	0	1	0	1	3437	2788
27.89125	30	0	0	0	0	1	1	3439	2789
27.90125	31	1	0	0	0	1	1	3441	2790
27.91125	32	0	1	0	0	1	1	3443	2791
27.92125	33	1	1	0	0	1	1	3445	2792
27.93125	34	0	0	1	0	1	1	3447	2793
27.94125	35	1	0	1	0	1	1	3449	2794
27.95125	36	0	1	1	0	1	1	3451	2795
27.96125	37	1	1	1	0	1	1	3453	2796
27.97125	38	0	0	0	1	1	1	3455	2797
27.98125	39	1	0	0	1	1	1	3457	2798
27.99125	40	0	0	0	0	0	0	3459	2799

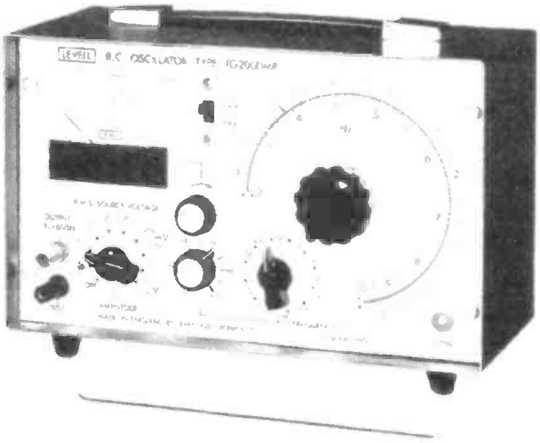
1: logical high level
0: logical low level

1

1: logical high level
0: logical low level

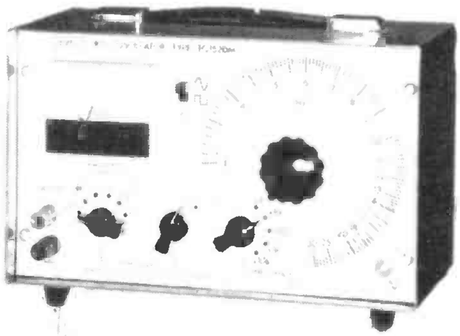


DON'T GAMBLE WITH PERFORMANCE BUY LEVELL OSCILLATORS



FREQUENCY	1Hz to 1MHz in 12 ranges. 0 to 1% fine control on TG200DMP.
ACCURACY	± 1.5% ± 0.01Hz up to 100kHz. ± 2% up to 1MHz.
SINE OUTPUT	7V r.m.s. down to < 200μV with Rs = 600Ω.
DISTORTION	<0.05% from 50Hz to 15kHz, <0.1% from 10Hz to 50kHz, <0.2% from 5Hz to 150kHz, <1% at 1Hz and 1MHz.
SQUARE OUTPUT	TG200D, DM & DMP only, 7V peak down to <200μV. Rise time <150nS.
SYNC OUTPUT	< IV r.m.s. sine in phase with output
SYNC INPUT	± 1% freq. lock range per volt r.m.s.
METER SCALES	TG200M, DM & DMP only. 0/2V 0/7V & −14/+6dBm.
SIZE & WEIGHT	260 × 130 × 180mm. 4.3kg with batteries.

TG200	TG200D	TG200M	TG200DM	TG200DMP
£99	**£108**	**£125**	**£130**	**£135**



FREQUENCY	3Hz to 300kHz in 5 decade ranges.
ACCURACY	± 2% ± 0.1Hz to 100kHz. Increasing to ± 3% at 300kHz.
SINE OUTPUT	2.5V r.m.s. down to <200μV
DISTORTION	<0.2% from 50Hz to 50kHz. <1% from 10Hz to 200kHz.
SQUARE OUTPUT	2.5V peak down to <200μV.
SYNC. OUTPUT	2.5V r.m.s. sine.
METER SCALES	0/2.5V & −10/+10dB on TG152DM.
SIZE & WEIGHT	260 × 130 × 180mm. 3.4kg with batteries.

TG152D Without meter **£80**

TG152DM With meter **£99**

FREQUENCY	0.2Hz to 1.22MHz on four decade controls.
ACCURACY	± 0.02Hz below 6Hz. ± 0.3% from 6Hz to 100kHz. ± 1% from 100kHz to 300kHz. ± 3% above, 300kHz.
SINE OUTPUT	5V r.m.s. down to 30μV with Rs = 600Ω.
DISTORTION	<0.15% from 15Hz to 15kHz. <0.5% at 1.5Hz and 150kHz.
METER SCALES	2 Expanded voltage and −2/+4dBm
SIZE & WEIGHT	260 × 180 × 180mm. 5.4kg.

TG66B Battery model **£265**

TG66A Mains & battery model **£280**

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SX14	150	½ watt Resistors 22 ohm-2m2 Mixed	£1
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*Quantities approximate, count by weight.

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SX18	100	Mixed Ceramics 1pf-56pf	£1
SX19	100	Mixed Ceramics 68pf-0.5mf	£1
SX20	100	Assorted Polyester/Polystyrene Capacitors	£1
SX21	60	Mixed C280 type capacitors metal foil	£1
SX22	100	Electrolytics, all sorts	£1
SX23	50	Quality Electrolytics 50-1000mf	£1
SX24	20	Tantalum Beads, mixed	£1

*Quantities approximate, count by weight

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- SX35 1 x Rocker Switch SPDT Miniature 240v 5A — 40p
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17 for further details

Data File No. 2

In this second edition of 'Data File', Ray Marston shows how to use transistors, op-amps and 555 timers to make a variety of square wave or 'clock' generator circuits.

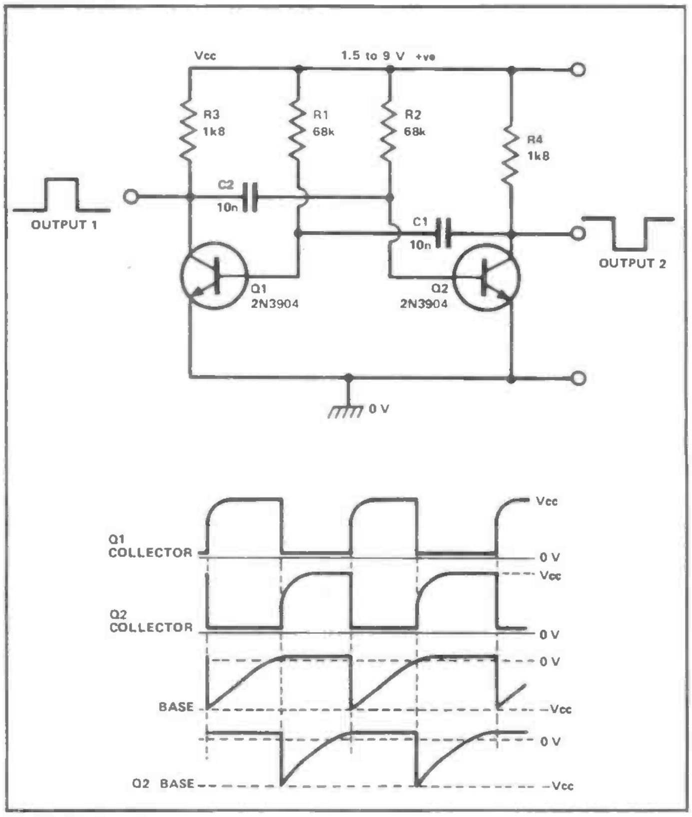

Figure 1: Circuit and waveforms of basic 1kHz transistor astable multivibrator.

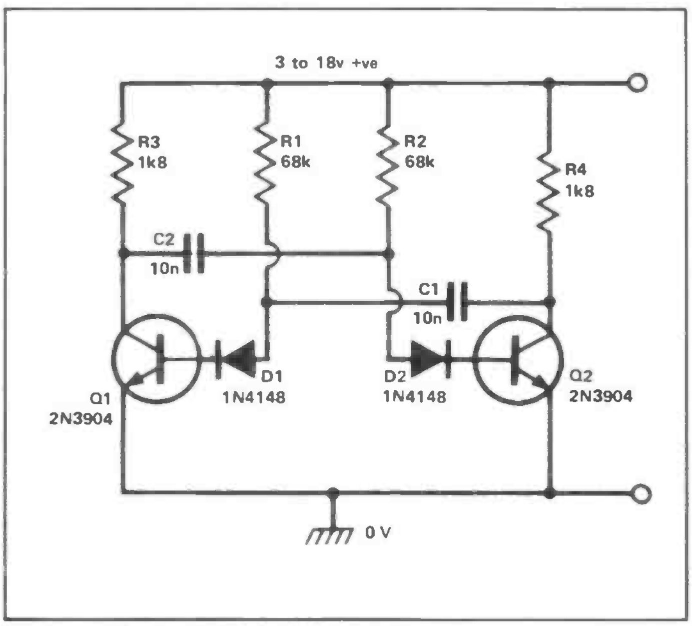

Figure 2: This version of the 1kHz astable has frequency correction applied via D1 and D2 and can be used with any supply voltage up to the breakdown limits of the transistors.

THE 'SQUARE WAVE' GENERATOR IS one of the most basic circuit blocks used in modern electronics. It can be used for 'flashing' LED indicators, for generating audio tones, or for 'clocking' logic or counter/divider circuitry, etc. The generators themselves may produce either symmetrical or non-symmetrical waveforms, and may be of either the free running or the 'gated' type.

Square wave generator circuits are quite easy to design and may be based on a wide range of semiconductor technologies, including the humble bipolar transistor, the op-amp, the 555 timer chip, or on CMOS logic elements, etc. In this month's edition of 'Data File' we'll confine our discussion to designs based on the transistor, the op-amp and the 555.

Next month, we'll continue the subject by showing 22 different CMOS based square wave generator circuits.

TRANSISTOR ASTABLE CIRCUITS

One of the easiest and cheapest ways of generating repetitive square and rectangular waveforms is to use the basic two-transistor astable multivibrator circuit shown in *Fig 1.* A major advantage of this rather old-fashioned transistor circuit is that it can quite happily operate from supply voltages as low as 1.5 volts or, with a slight modification, from supply voltages up to several tens of volts.

The *Fig 1* circuit acts essentially as a self-oscillating regenerative switch, in which the on and off periods of the circuit are controlled by the C1-R1 and C2-R2 time constants. If these time constants are equal (C1 equals C2 and R1 equals R2), the circuit acts as a square wave generator and operates at a frequency of approximately 1/(1.4 C1 R1). Thus, the frequency can be decreased by raising the values of C1-C2 or R1-R2, or vice versa. The frequency can be made variable by using twin gang variable resistors (in series with 10k limiting resistors) in place of R1 and R2. ▶

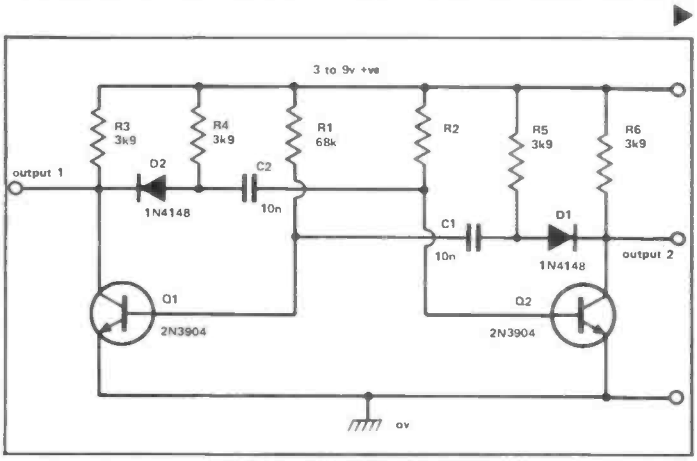

Figure 3: This version of the 1kHz astable has waveform correction applied via D1 and D2 and produces excellent square waves.

Data File No. 2

Outputs can be taken from either collector of the *Fig 1* circuit, and the two outputs are in antiphase. The operating frequency of the circuit is substantially independent of supply rail values in the range 1.5 to 9 volts. The upper supply voltage limit is set by the fact that, as the transistors switch regeneratively at the end of each half cycle, the base emitter junction of one transistor is reverse biased by an amount roughly equal to the supply voltage. Consequently, if the supply voltage exceeds the reverse base emitter breakdown voltage of the transistor (typically about 9 volts), the timing operation of the circuit will be upset. This snag can be overcome by using the circuit modification shown in *Fig 2*.

Here, a 1N4148 diode is wired in series with the base input terminal of each transistor and effectively raises the reverse base emitter breakdown voltage of each transistor to about 80 volts. The maximum supply voltage of the circuit is then limited only by the collector emitter breakdown characteristics of the transistors, and may be several tens of volts. In practice, the 'protected' circuit of *Fig 2* gives a frequency variation of only 2% when the supply voltage is varied from 6V to 18V.

The leading edges of the output waveforms of the *Fig 1 and 2*

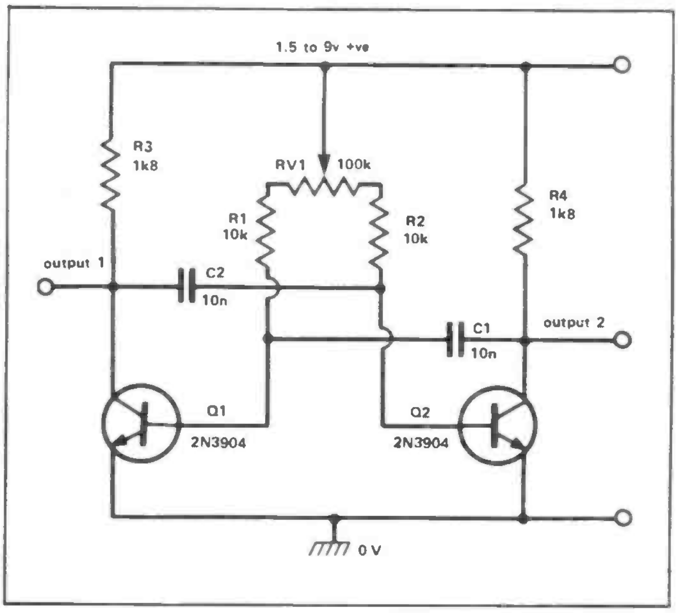

Figure 5a: Basic variable M/S ratio astable, operating at about 1100Hz.

circuits are slightly rounded. The lower the values of R1 and R2 become relative to collector resistors R3 and R4, the worse this rounding becomes. Conversely, the larger the values of R1 and R2 relative to R3 and R4, the better the waveshape will be. The maximum permissible values of R1 and R2 are equal to the products of transistor current gain (say 90) and the R3 (or R4) values (1k8 in this case), so the maximum possible values of R1 and R2 are 162k in the *Fig 1* and *2* circuits.

The rounding of the leading edges of the basic astable circuit occurs because the collector voltage of each transistor is prevented from rising immediately to the positive rail voltage as the transistor turns off, because of loading by its cross-coupled timing capacitor. This deficiency can be overcome, and excellent square waves obtained, by effectively disconnecting the capacitor from the collector of its transistor as it turns off, as in the 1kHz generator of *Fig 3*. Here, D1 and D2 are used to disconnect the timing capacitors at the moment of regenerative switching. The main time constants of the circuit are again determined by C1-R1 and C2-R2. The effective collector loads of Q1 and Q2 are equal to the parallel resistances of R3-R4 and R5-R6 respectively.

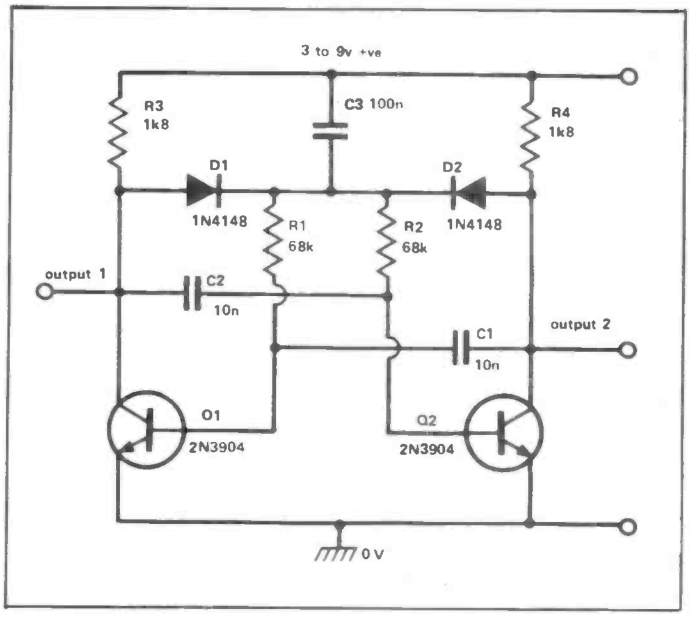

Figure 4: This 1kHz astable has a sure start facility.

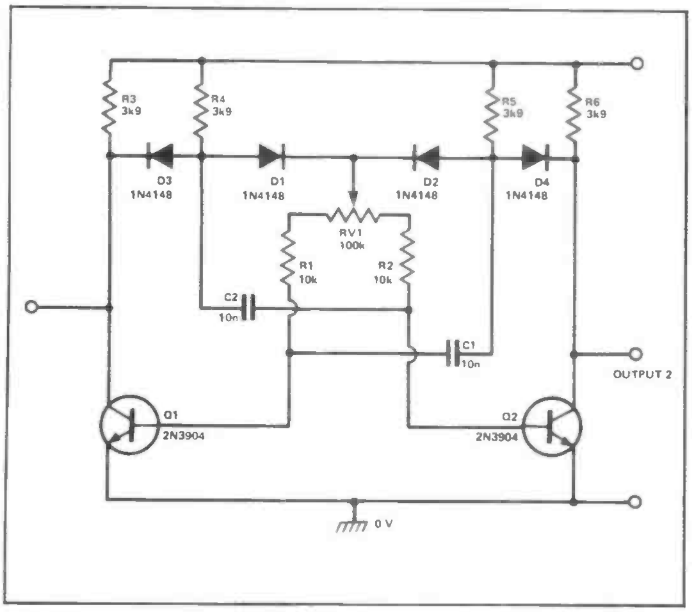

Figure 5b: This improved version of the variable M/S ratio astable has waveform correction and the sure start facility.

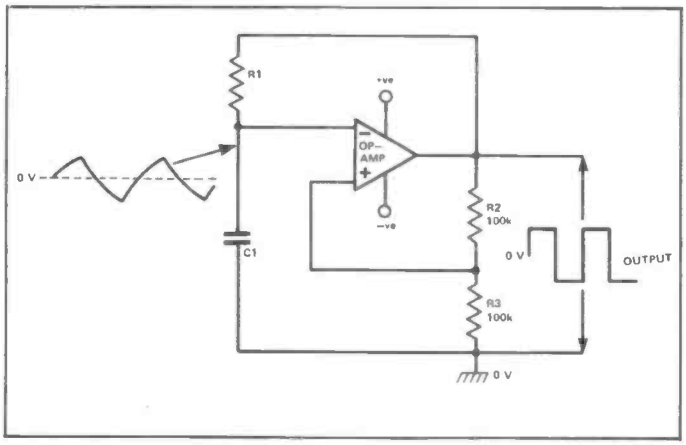

Figure 6: Basic op-amp relaxation oscillator circuit.

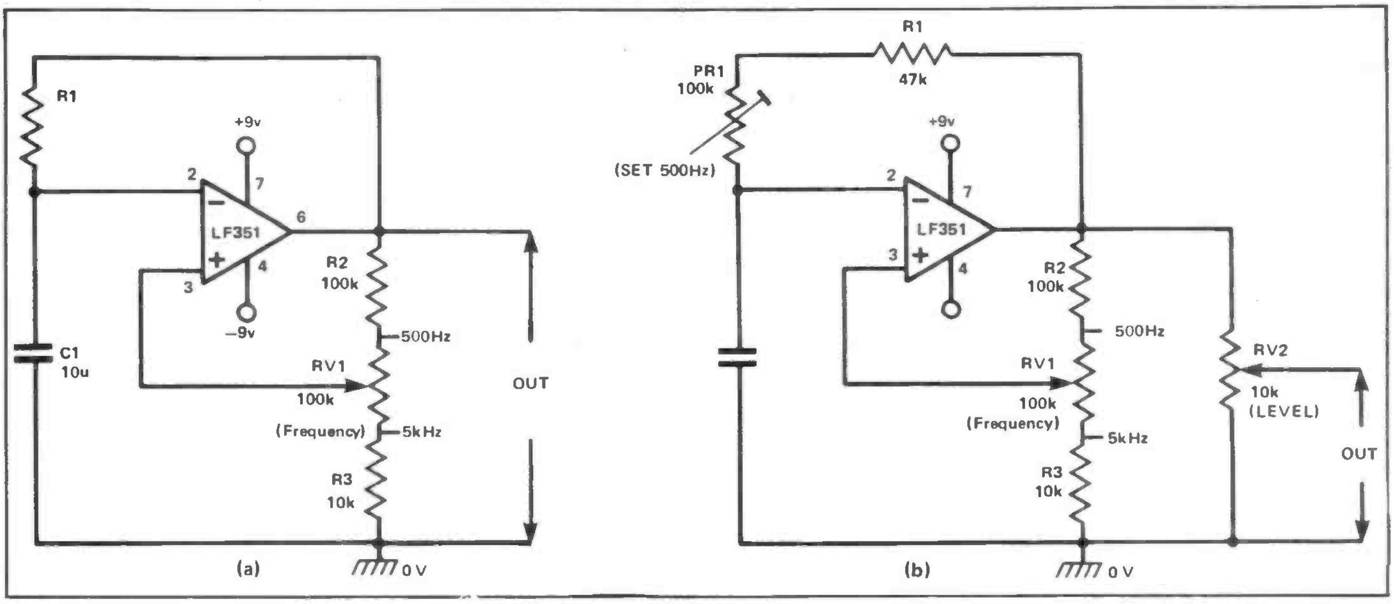

Figure 7a: Simple 500Hz to 5kHz square wave generator, and Figure 7b: an improved version of the circuit.

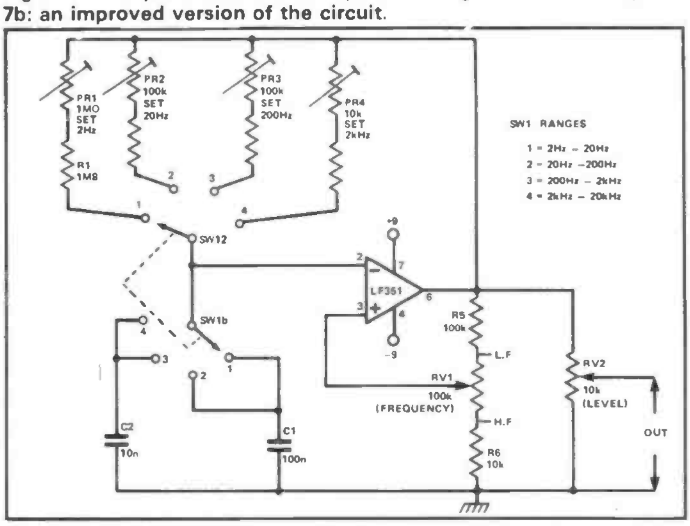

Figure 8: Four-decade (2Hz to 20kHz) square wave generator. The preset pots enable the circuit to use a single calibrated frequency scale.

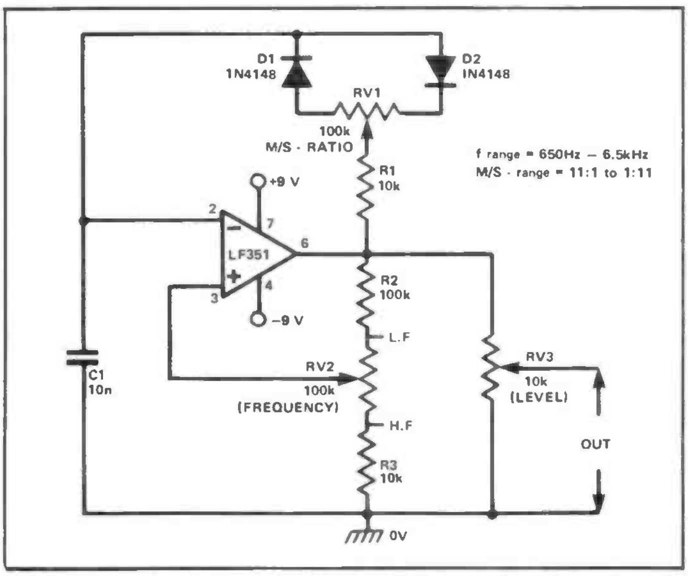

Figure 9: Variable frequency, variable mark/space ratio 'square wave' generator.

Operation of the basic astable multivibrator relies on slight imbalances of the transistor characteristics, so that one transistor turns on slightly faster than the other when power is first applied. If the voltage to the circuit is applied by slowly increasing it from zero volts, both transistors may turn on simultaneously, in which case oscillation will not occur. This snag can be overcome by using the sure start circuit of *Fig 4*,in which the timing resistors are connected to the transistor collectors in such a way that only one transistor can ever be turned on at a given moment.

The transistor astable circuits that we have looked at so far are designed to give a symmetrical output waveform, with a 1:1 mark/space ratio. A non-symmetrical waveform can be obtained by simply making one set of astable time constant components larger than the other. *Fig 5a* shows the connections for making a fixed frequency (about 1100Hz) variable mark/space ratio waveform generator, in which the ratio can be fully varied over the range 1:10 to 10:1.

The leading edges of the output waveforms of the above circuit may be objectionably rounded for some applications when the mark/space control is set to its extreme positions. Also, the circuit may be difficult to start if the supply voltage is applied to the circuit slowly. Both of these snags can be overcome by using the connections of *Fig 5b*, in which the circuit is fitted with sure start and waveform correction diodes.

OP-AMP SQUARE WAVE GENERATORS

Good square waves can be generated by using a fast op-amp, such as the LF351, in the basic relaxation oscillator configuration shown in *Fig 6*. This circuit requires the use of dual power supplies and, because of the slew-rate limitations of op-amps, it's output waveform rise and fall times are not as good as those obtained from transistor, 555, or CMOS astables. The op-amp circuit has, however, some distinct advantages over these alternative types of 'square wave' generator.

Specifically, it has excellent frequency stability and waveform symmetry, and it's operating frequency can be varied over a wide range by altering any one of it's four passive component values.

The basic operation of the *Fig 6* circuit is fairly easy to follow. In operation, the output of the op-amp alternately switches between the +ve or —ve 'reference' voltage to the non-inverting terminal of the op-amp, this reference voltage being a fixed fraction or ratio (determined by the R2-R3 ratios) of the supply voltage. Suppose initially that C1 is discharged and the op-amp output has just switched +ve. In this case C1 will charge positively via R1 until it's voltage reaches the +ve reference value on the non-inverting terminal of the op-amp, at which point ▶

Data File No. 2

the op-amp output voltage (and thus the reference voltage) will start to fall and thus initiate a regenerative switching action in which the output switches abruptly to the negative rail voltage.

C1 will then start to charge in a negative direction via R1 until it's voltage reaches the new (negative) reference value on the non-inverting terminal, at which point the op-amp output will again switch regeneratively high and initiate a new action in which the whole sequence repeats itself.

The action of the op-amp circuit is such that a symmetrical square wave is developed at the output of the op-amp, and a non-linear triangle waveform is developed across C1. Each waveform swings symmetrically about the zero-volts line. Note that the operating frequency is virtually independent of the supply rail voltages, but can be varied by altering the R1 or C1 values, or by altering the R2-R3 ratios.

Figure 7a shows the practical circuit of a simple 500Hz to 5kHz op-amp square wave generator, in which the frequency variation is obtained by altering the attenuation ratio of the R2-RV1-R3 potential divider, and *Fig 7b* shows how the circuit can be improved by using RPS1 to preset the frequency range of the RV1 frequency control to a precise minimum value, and by using RV2 as an output amplitude control.

Figure 8 shows how the above circuit can be modified to make a general purpose square wave generator that covers the range 2Hz to 20kHz in four switched decade ranges. Note that preset controls RPS1 to RPS4 are used to precisely set the minimum frequencies of the 2Hz-20Hz, 20Hz-200Hz, 200Hz-2kHz, and 2kHz-20kHz ranges respectively, without calling for the use of precision components.

Finally, *Fig 9* shows how the basic relaxation oscillator circuit can be modified so that it provides both a variable frequency and a variable mark/space ratio output. The M/S ratio is variable via RV1, and the circuit action is such that C1 alternately charges positively via R1-D1 and the left-hand side of RV1 and charges negatively via R1-D2 and the right-hand side of RV1. The M/S ratio is variable over the range 11:1 to 1:11, and the frequency is variable over the approximate range 650Hz to 6.5kHz via RV2. Varying the M/S ratio setting causes only slight interaction with the frequency control.

Note that the *Fig 6* to *9* circuits can be used with virtually any types of op-amps, but that the maximum usable frequency and the quality of the output rise and fall times depends on the slew rate of the op-amp that is used. The LF351, for example, gives a

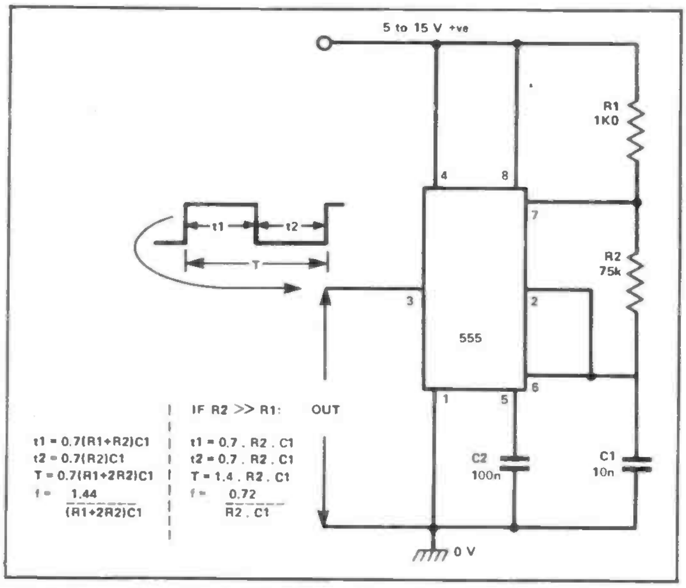

Figure 10a: Basic circuit of 1kHz '555' astable, with timing formulae.

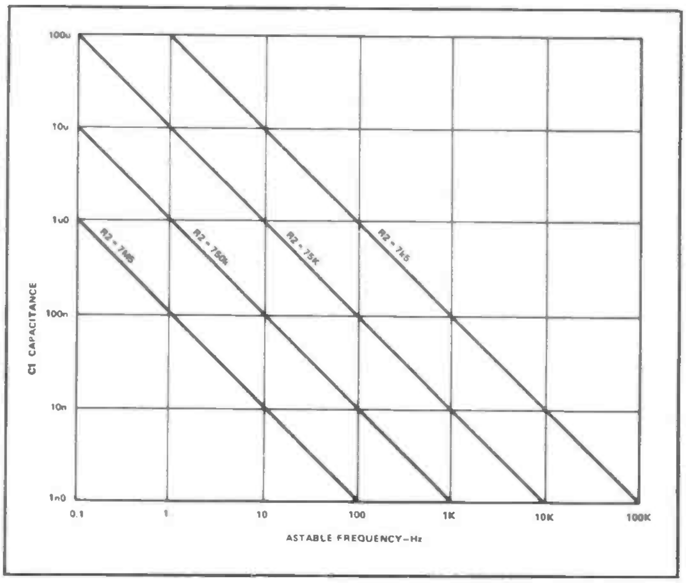

Figure 10b: Approximate relationship between C1, R2 and frequency of the 555 astable when R2 is large relative to R1.

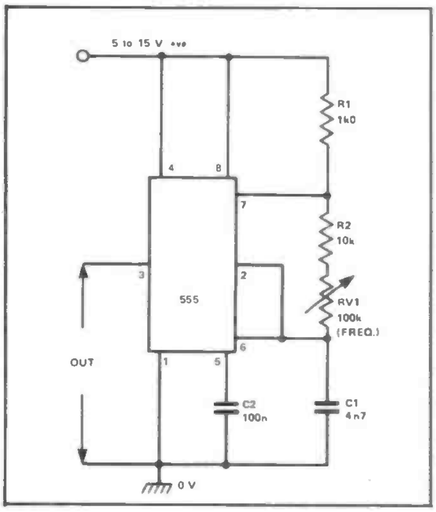

Figure 11: This variable frequency square wave generator covers the range 1.4kHz to 15kHz via RV1.

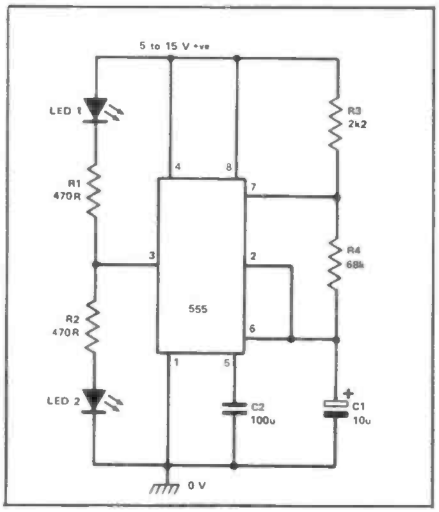

Figure 12: This 2-LED flasher operates at just under 1Hz. One LED turns on as the other turns off, and vice versa.

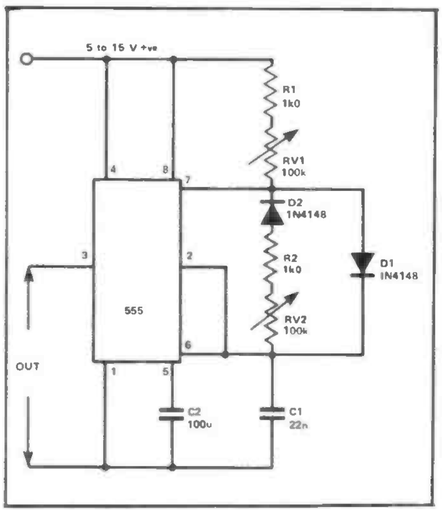

Figure 13: Astable with mark and space periods independently variable over the approximate range 15uS to 1.5mS.

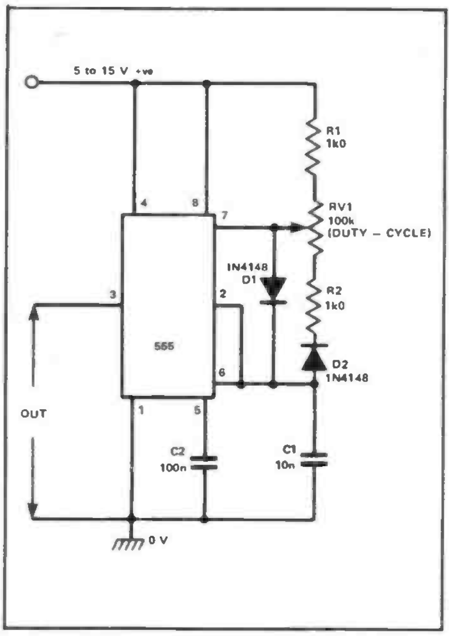

Figure 14: Astable with duty cycle variable from 1% to 99% via RV1. Frequency is almost constant at 1.2kHz.

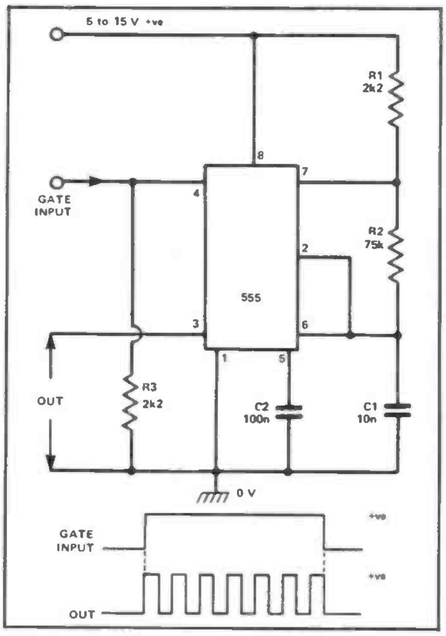

Figure 15: Electronically gated astable with gate signal applied to the pin 4 RESET terminal of the IC.

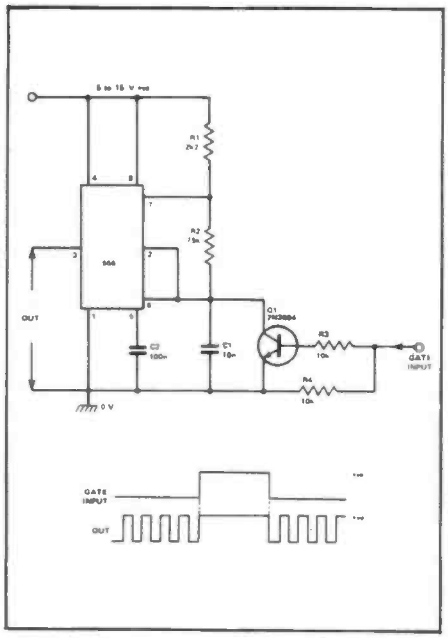

Figure 16: Electronically gated astable, with the gate signal applied to C1 via Q1.

performance that is about ten times better than the 741 in these respects. Also note that although we've shown the circuits as being powered from 9 volt split supplies, they can in fact be powered from any split supplies in the range 5 to 18V.

555 ASTABLE CIRCUITS

The IC known as the '555 timer' makes an excellent square wave generator when used in the astable mode. The device is readily available, inexpensive, and is housed in an 8 pin d.i.l. plastic package. It can be powered by any supply in the range 4.5 to 15 volts, has a low impedance output that can source (supply) or sink (absorb) load currents up to 200mA and, when used in the astable mode, generates output square waves with typical rise and fall times of about 100nS. The 555 astable has excellent frequency stability, can span the frequency range from near-zero to about 100kHz, and it's frequency and M/S ratio can be accurately controlled with two external resistors and one capacitor.

Figure 10a shows the practical circuit of a basic 1kHz '555' astable, together with the formulae that define the timing of the circuit. The circuit operation is such that C1 first charges exponentially via the series R1-R2 combination until eventually it's voltage rises to 2/3rds of the supply voltage, at which point a regenerative switching action takes place and C1 starts to discharge exponentially via R2 until eventually it's voltage falls to 1/3rd of the supply voltage, at which point a second regenerative switching action takes place and C1 starts to re-charge towards 2/3rds of the supply voltage via R1-R2, and the whole sequence repeats. C2 is used in this circuit (and those that follow) to decouple the internal circuitry of the 555 chip from the effects of supply line transients.

Note that the operating frequency of the above circuit is virtually independent of the supply voltage value, and that both the mark/space ratio and the frequency are determined by the R1-R2-C1 values. Also note that if R2 is large relative to R1, the operating frequency is determined mainly by the R2 and C1 values and that an almost symmetrical output waveform is generated. The graph of *Fig 10b* shows the approximate relationship between frequency and the C1-R2 values under the above condition. In practice, the R1 and R2 values can be varied from about 1k0 to 10M.

The basic *Fig 10a* circuit can be modified in a number of ways. *Fig 11,* for example, shows how it can be made into a variable frequency square wave generator by replacing R2 with a fixed and a variable resistor in series. With the component values shown, the frequency can be varied over the approximate range 1.4kHz to 15kHz via RV1.

Figure 12 shows how the circuit can be used as a 2-LED 'flasher' unit, in which one LED turns off as the other turns on, and vice versa. The circuit operates at a frequency of just under 1Hz.

Figure 13 shows how the circuit can be modified so that it's mark and space periods are independently variable over the approximate range 15uS to 1.5mS. Here, timing capacitor C1 alternately charges via R1-RV1-D1 and discharges via RV2-R2-D2.

Figure 14 shows how the circuit can be modified so that it acts as a fixed frequency 'square wave' generator with a mark/space ratio or duty cycle that is fully variable from 1% to 99% via RV1. Here, C1 alternately charges via R1 and the top half of RV1 and D1, and discharges via D2-R2 and the lower half of RV1. Note that the sum of these two timing periods is virtually constant, so the operating frequency is almost independent of the setting of RV1.

The 555 astable circuit can be gated on and off (enabled or disabled) either by applying a gate signal to pin 4, or by disabling or enabling the main timing capacitor via a transistor switch.

Figure 15 shows how the circuit can be gated via the pin 4 (reset) terminal. The characteristic of this terminal is such that, if the terminal is biased above a nominal 0.7 volts, the astable is enabled, but if it is biased below 0.7 volts by a current greater than 100uA (by taking pin 4 to ground via a resistance less than 7k0, for example) the astable is disabled and it's output is grounded. Thus, in the *Fig 15* circuit the astable can be turned on by applying a high or logic 1 signal to pin 4, or off by applying a zero or logic 0 signal to pin 4.

Finally, to complete this month's look at square wave generator circuits, *Fig 16* shows how the 555 astable can be gated on and off via a transistor wired across main timing capacitor C1. Here, with zero gate drive applied, Q1 is cut off and the astable is free to operate in the normal way, but when a high gate signal is applied Q1 is driven on and discharges C1, thus disabling the astable. Note that the output of this circuit is driven high when the astable is disabled in this way. ■ **R & EW**

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DFCM 500 PROJECT

In this concluding part of the series, A.L. Bailey describes the testing, final construction and calibration of our 8 Digit Frequency/Capacitance Meter project.

TESTING

Before dashing off and wiring all the pcb's into the case, it is strongly recommended that the following tests and checks are carried out to ascertain that the major functions are operating satisfactorily. It is easier to locate any faults with the pcb's on the bench when accessability is not a problem.

Double check each pcb for wrongly inserted components, reversed IC's, solder bridges etc. It is too late to do this after the power is applied.

First check the power supply. Connect mains power (carefully) to the input of the transformer, making sure that the earth lead is firmly soldered to the pcb underside before switching on. Rest the pcb on some insulating material while the tests are in progress to avoid accidents. Check with a multimeter that the output voltage is +5v ±0.2v. The off-load voltage at C34 +ve terminal should be around 20v.

Connect the multimeter on its 100mA current range between the charger output and earth. A reading of 45mA ±5mA should result. If too far out, the value of R58 can be changed to get nearer to 45mA. Do not continue with the tests unless the power supply is O.K.

.... the display

Plug the display pcb into the driver board. Referring to *Figure 17*, connect the +5v pin to the psu +5v output and solder an earth link between the underside of the 2 pcbs. Connect point B to point G. Connect one end of a wire to point A. Apply power and touch the other end of the free wire to points C, D, E, F and G, one after the other. The display should show .000000, .00000, .0000, .000 and .00 respectively, with the GATE led flashing at 1 second intervals. Change the wire from point B to G to B to F and connect the other wire to point F also. The GATE led should now flash at 10 second intervals, with .000 on the display. Reconnect point B to point G.

If any segments or digits of the display fail to illuminate, look for breaks in the pcb tracks or pins not soldered etc.

Connect a lead to the +5v supply and touch the other end to point Q, then R when the dc and ac led's should each light.

Now place the preamp/capacity measuring pcb alongside the driver pcb and connect an earth link to the underside of the 2 pcb's. Link point H-K on each together, point S to T, and +5v to each of the 2 connection pins marked +5v and +5v VHF. Link point M to +5v and points L, N & P to earth. Set VR's 1, 2, 3 and TC1 to mid travel.

.... the pre-amps

The preamplifiers can now be checked out. First the AF amplifier, by applying a signal within its range (to 1MHz approx) to point W. A reading directly in kHz should be obtained with the SIGNAL led illuminated, once sufficient signal is available to drive the counter. If no reading results, check that the voltage at the collector of TR10 changes when the signal is applied. If not, the fault is in the amplifier, otherwise in the control logic IC4 & 5.

Rewire point L to +5V and points M, N & P to earth (to select the control logic for the HF amplifier input). A signal applied to point X, in the range 1 to 50MHz should read on the display, although the decimal point will be incorrect for MHz at present. Again, if no reading results, check the voltage at the collector of TR6, and pin 2 of IC3 for changes with signal.

Rewire point N to +5v and point L, M & P to earth. Check the VHF input by applying a signal to point Y. Again, the decimal point will be incorrect but the reading should otherwise be correct. Pin 11/IC1 and pin 2/IC2 should vary with signal. If you want to achieve the highest possible frequency response from the counter, it is possible to remove the socket into which IC1 is plugged, and wire the IC directly into the pcb. This point has been left to this stage in case of a fault in IC1, as it could not be changed by the supplier if soldered, and it is a fairly expensive chip!

It only remains to check out the capacity measuring circuit. Reconnect P to +5v, and point L, M & N to earth. Connect point V to +5v. Apply power and a reading should be obtained on the display which is the residual circuit capacity. Check that by varying VR3 this reading can be set to zero. Connect a capacitor (preferably polystyrene or silver mica around 500-1000pF in value) between the Cx terminal and earth. The reading obtained should by adjustment of VR1 be capable of being set to the capacitor value. If no reading is obtained, short the Cx terminal to earth when a reading of around 1003.000 should result. If there is no reading the 1MHz oscillator (IC6/7) may not be functioning - this can be checked by connecting point H to pin 13 of IC8 when the same reading should result. If it does, the fault is in the circuit associated with IC9/10. An oscilloscope is really required to check this out, although judicious use of a multimeter will narrow the possibilities. Move the link currently connected to point V over to point U and connect a capacitor of value between 100-500uF from Cx to earth. This should be read but the value will depend on the capacitor tolerance and the setting of RV2, but should be in the right region.

If all this has checked out O.K. then the boards may be disconnected from all the links, and the case construction started.

CONSTRUCTION

The prototype was designed to fit into a Centurian instrument case type DX4 and the following assumes that this case will be used. It has the advantage of only requiring the front panel to be painted and lettered as the remainder is already finished in black vinyl. The kit suppliers can also supply the front panel already drilled, punched and screened with the

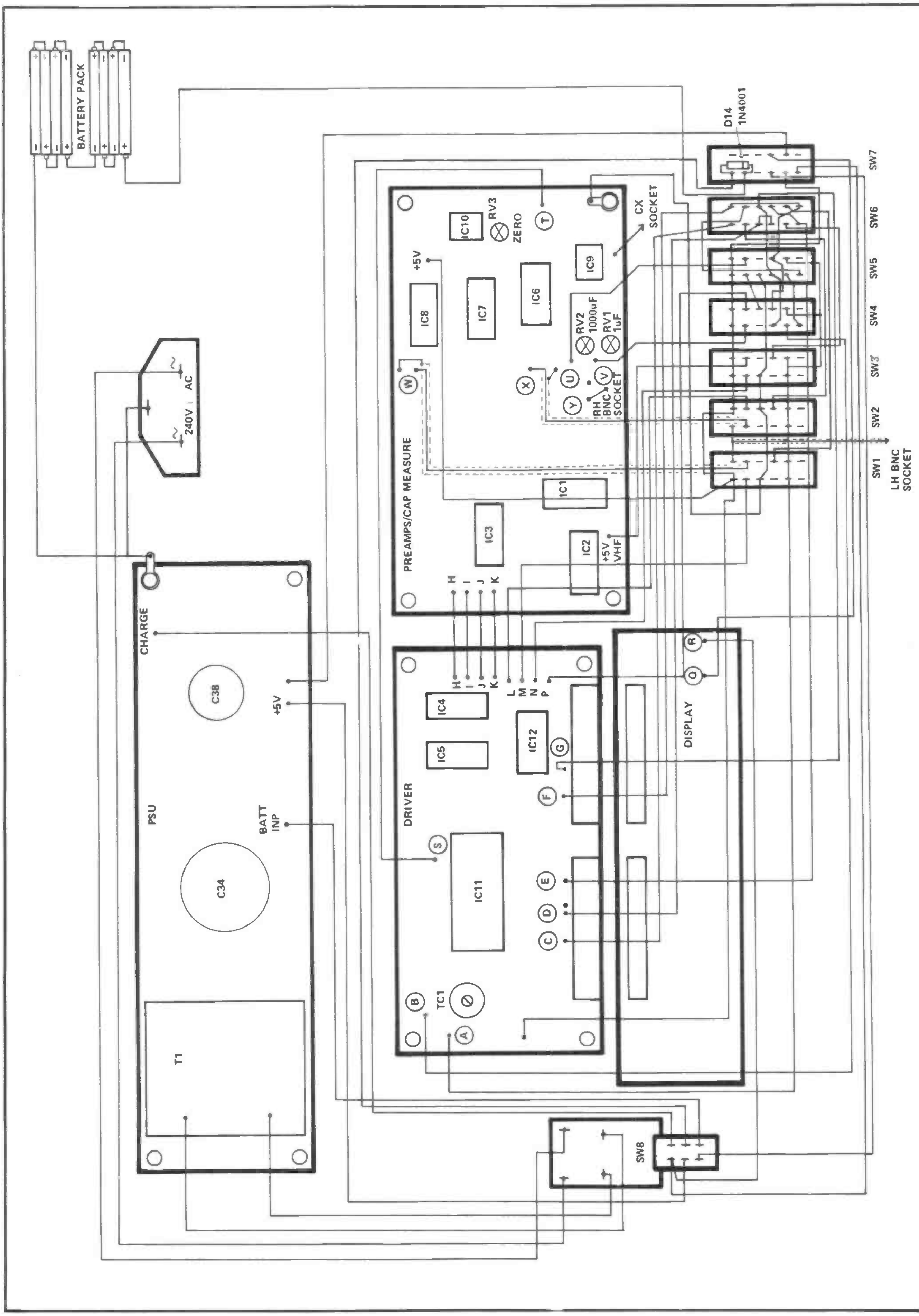


Figure 17: Main wiring diagram of the DFCM 500.

various legends if required. There is no reason why another type of case cannot be used if preferred, the only point to note is that the mains transformer should be kept as far away from the capacity measuring circuit as possible, as it can affect the readings due to pick up of mains hum.

.... the case

Figures 18 and 19, give the drilling plan for the base, rear and front panels. When all the holes and cut-outs are complete, the front panel can either be left unpainted and polished up before lettering and spraying with clear varnish, or primed and sprayed with car aerosol paint. The author used matt black paint and 'Joy' chromate primer for the prototype, and after applying the legends with Letraset, finished with a coat of Dupli-colour 'leveller' which is only a solvent, but fixes the legends in place without destroying the matt black finish.

Start the final construction by assembling the base panel, 2 lower angle strips and rear and side panels with their 4 fixing screws. Fix the mains socket into place on the rear panel. Referring to *Figure 17,* attach a 4 inch length of 2 core mains cable to the mains switch (on the tagged connector side) to the 2 terminals nearest the front of the switch, and a 12 inch length of the same cable to the other 2 terminals on the switch, again on the tag side. Clip off the 4 pins of these terminals on the other side of the switch. Connect the other end of the short lead to the two input connections to the transformer on the psu pcb, taking the cable through the holes with the insulation level with the pcb upper surface.

The psu pcb may now be bolted into place with a ¼ inch metal spacer between each hole and the lower panel, using 6BA us, bolts and lockwasher. A solder tag should be placed under the nut at the top right hand corner of the pcb.

Connect this tag to the upper tag on the mains connector. Bolt the mains switch into place with the leads on the underside, a .5 inch spacer between the back of the front panel and the front of the switch bracket, in each bolt position. Connect the other end of the long mains lead to the mains socket lower tags.

Insert the remaining 8 fixing bolts and nuts for the other two pcb's on the lower panel. Each consists of a .5 inch 6BA bolt inserted from the underside of the panel, then a lockwasher and 6BA full nut tightened down onto the lockwasher.

Before fixing the display/driver pcb into position, a piece of polarised red filter material should be glued into place behind the front panel for the displays -size 13 x 30mm. This is supplied with the kits. Now drop the display/driver pcb onto its mounting bolts and carefully locate into place holding the front panel slightly forward so that the LED's will go through the front panel in the holes provided. If, on straightening the panel up, the LED's project too far out from the panel, they should be resoldered slightly further back. Fix the pcb into position with a lockwasher and nut on each bolt.

Now mount the preamplifier/capacity measuring pcb into position, with IC1 at the front of the board attaching a solder tag to the front right hand corner of the pcb before fixing down. Mount the two BNC sockets on the front panel. Attach a short lead from the right hand BNC socket centre tag to the VHF input (point Y). Strip the insulation off each end of a 4 inch length of UR95 or similar miniature coaxial cable for .5 inch and separate the outer conductor into a pigtail and tin it. Strip 1/8th inch of insulation off the end of the centre conductor at each end, and solder one end to the left hand BNC centre conductor tag, and the braid to the earth tag on the socket.

Mount the two push clips in the two right hand holes on the front panel, and connect the right hand one direct to the earth tag on the preamplifier board and the left hand one to the Cx connection pin.

.... interwiring

Colour code the wires so that you know which is which, connect 3 inch lengths of wire to points U, V and +5v VHF connection pins, leaving the other ends free. Also strip another 4 inch length of coaxial cable, attaching the centre conductor of one end to point X, and the braid to the pin in front of Y. The switch unit may now be bolted into position (tag connectors uppermost) using .5 inch spacers between the front of the switch bracket and the front panel.

The remainder of the wiring can now be completed. Follow *Figure 17* **very** carefully, the best way being to mark each connection as you finish it with a red pen either on *Figure 17,* or a photocopy. Solder the various interswitch connections first, then complete those to the other modules. The three pigtails from the coaxial leads should be soldered together

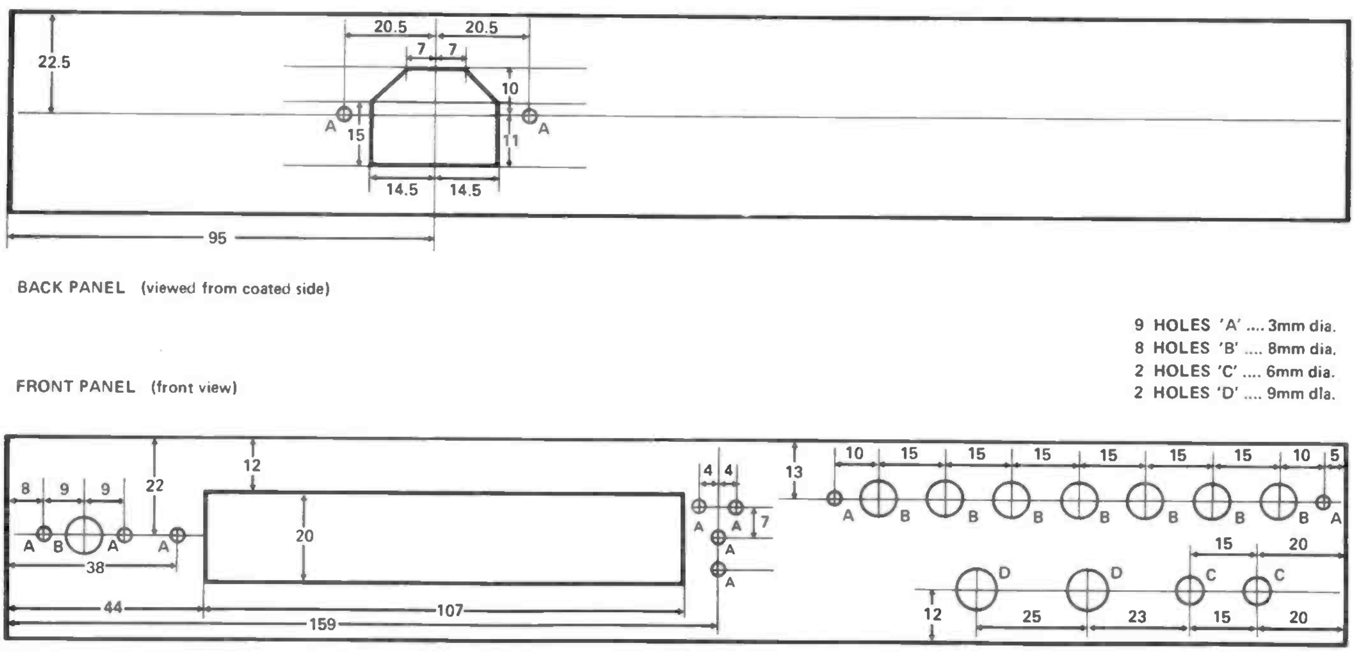


Figure 18: Constructional details of the front and rear panels.

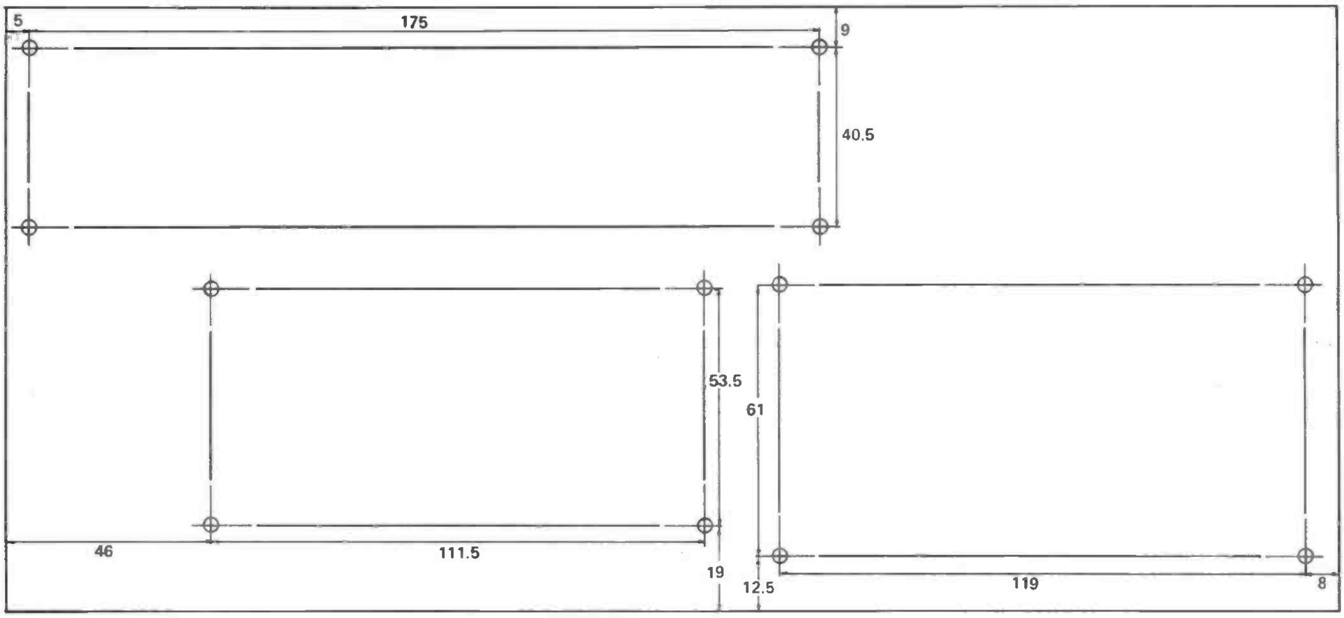


Figure 19: Constructional details of the bottom panel (viewed from the non-coated side).

behind the switch unit and insulated with tape or sleeving. The two sets of leads from the battery connectors must be soldered so that the 2 battery holders are in series, not parallel. Do not forget to solder D14 across the appropriate tags on SW7 - this diode is not shown on the circuit diagram but is an additional safeguard to prevent the battery discharging back into the charging circuit under certain switch combinations.

When connected, the two battery packs mount in the rear right hand corner of the chassis, as shown in the photographs and are secured to the bottom chassis plate with double sided adhesive tape.

The final piece of work is to make sure that there is no danger from touching the various points carrying mains voltages by insulating the top of the mains switch, and the tags on the mains connector. This can be done with insulating tape, or a rubber boot if available.

When all the wiring is complete, apply mains voltage from a properly terminated connector to the rear panel socket, and switch on. Check that the various inputs all function correctly, and that the decimal points are in the correct places. Depressing the x10 button should increase the gate time to 10 seconds from 1 second, and move the decimal point 1 place to the left for each range except capacitance which should be unaffected by either the x10 or 1/1000uF buttons. Any deviation will be due to wiring errors.

Depression of the mains and battery buttons should leave the display blank and both AC and DC LED's illuminated. As a final check remove FS2 from its holder and use a milliameter to make sure that the charging current is still 45mA or so when in this charge mode.

Selection of battery mode should work O.K. but the batteries are likely to have little charge and the display may fade out after a short while. The instrument should be left in full charge mode for at least 14-20 hours to get the batteries up to full charge. When used under portable conditions, the operating time available will vary greatly depending on the range and number of digits illuminated at any time, but can be expected to lie between 1 and 2/3 hours. Greatest consumption is on the VHF range due to IC1. This runs very hot to the touch, which is normal for ECL.

CALIBRATION

To set up the 10MHz crystal correctly requires the use of a radio tuned to 200kHz long wave. If the radio is held close to IC11, a very strong 1kHz heterodyne will be heard. Underneath this will be an underlying slow beat which can be nulled out with TC1, when the crystal will be on frequency. This may require several attempts to trim spot on.

Alternatively, another frequency counter could be used against which this could be calibrated, but this is almost certain to introduce errors.

The capacitance circuit can be calibrated by using a known close tolerance silver mica capacitor (100pF or near) and using VR1 to get the correct reading, after setting the display to zero with RV3. These settings interact to some extent so will need to be repeated. The 100uF range is more of a problem, as close tolerance capacitors of any appreciable value are virtually impossible to obtain. The best way is to measure a value just under 1uF on the 1uF range, then to set up the 1000uF range to read the same figure without removing the capacitor. Do no readjust the zero setting on the 1 uF range. Bear in mind that there is no overrange indication on capacity, and that the display will indicate the frequency of the 1MHz oscillator once values of greater than 1 or 1000uF are measured.

USING THE DFCM 500

The frequency measuring section of the DFCM 500 can be used to measure the frequency of virtually any oscillator providing sufficient drive is available for the instrument to operate correctly. One point to note is that if the VHF amplifier signal input is marginal, the display will tend to read twice the actual frequency but this should be obvious as the nominal frequency will usually be known.

Although the various amplifiers have isolated inputs, it is advisable to connect another capacitor of a voltage suitable for the circuit under test, especially if this is carrying high voltage, in series with the input. Connection to the circuit under test can be direct, or via a coupling loop of a few turns of wire if this is more suitable, say for inductors in oscillators. Transmitter output frequencies can usually be measured by plugging a small whip antenna into the appropriate input socket and placing the instrument nearby, with no direct connection to the transmitter under test. For very low power hand transmitter, a few turns of insulated wire wrapped around its antenna may be necessary for a reliable reading of the frequency. ■ R & EW

Using UARTs Part 2

Jonathan C Burchell describes the function of the UART, plus a universal 8 bit input/output port that is usable with any personal computer with serial input/output capability.

THE UART ITSELF

There are two main classes of UART; those designed as Logic subsystems for truly 'Stand-alone' operation, and those designed to interface directly to a microprocessor. This month we take a look at the second class, which primarily finds uses in interfaces designed to be placed remotely from the computer, and to talk to a UART of the first sort within the computer.

The UART derives it's timing from the baud rate clock, which is 16 times the desired bit rate. The two halves of a UART (receiver/transmitter) operate totally independently of each other, and it is convenient to study them that way, as follows:

THE RECEIVER LOGIC

Figure 1 shows a block diagram of the receiver logic of an AY-5-1012 UART. This device is typical of its class and is in fact pin for pin compatible with the following devices: AY-5-1013, TR1602, TR1604, TR1863 and IM6402, the only difference being the manufacturer, whether or not the device is 5 V only, (some members of this family need —12 volts to be supplied to pin 2) and the maximum operating speed of the device.

The receiver logic continually samples the SERIAL INPUT line, looking for a mark-to-space transition signalling the beginning of the first start bit. Once a transition has been detected, the receiver logic samples the line at every 8 + 16N clock periods. If the first sample is a mark, the receiver rejects the possibility of having detected a valid start bit and returns to the hunting mode. Assuming the first sample is still a space, the receiver enters the data entry mode and samples the line M times, where M is 5,6,7, or 8 writing the state of the receiver line into the next position in the receiver shift register each time. The input line is sampled for one clock period in the nominal centre of a bit period (see *Fig 2*): This technique is called window sampling and accounts for the great tolerance of speed variation and noise immunity of the UART receiver.

The receiver next checks the parity of the M data bits and compares this with the parity sense selected on Pin 39. If pin 35 NO-PARITY is enabled (high) no further action is taken and the parity error line (Pin 13) is held low, otherwise any difference from the computed and selected parity is latched into the parity error line.

The receiver next checks that the input line is still marking (e.g. a valid stop bit has been transmitted) and if it is not sets the framing error bit.

One clock cycle after the stop bit has been sampled, the receiver logic transfers the contents of the shift register to the holding register and thus to the receiver data register pins. The logic then sets the DATA AVAILABLE flag to indicate that a character has been received and is available at the output pins. If the DATA AVAILABLE flip/flop has not been cleared by the RESET DATA AVAILABLE line having been strobed low during the last character period, the logic sets the OVERRUN flip/flop to indicate that the last character in the register (which has not been read by the external logic) has just been overwritten:

THE TRANSMITTER LOGIC (Fig 3)

When in the idle state the TRANSMITTER OUTPUT line Pin 25 is held high. A high to low transition on the DATA STROBE line loads the transmitter holding register with the data on the transmitter input pins. As soon as the previous character has been transmitted the logic loads the transmitter shift register with the holding register contents, and brings TRANSMITTER BUFFER EMPTY high, to indicate that a new character may be loaded into the transmitter buffer.

After the SERIAL OUTPUT has been brought low for 16 clock periods (the start bit) the contents of the transmitter shift register are presented to the output line M times. Each 'bit' time remains at 16 clock periods. The transmitter logic next calculates

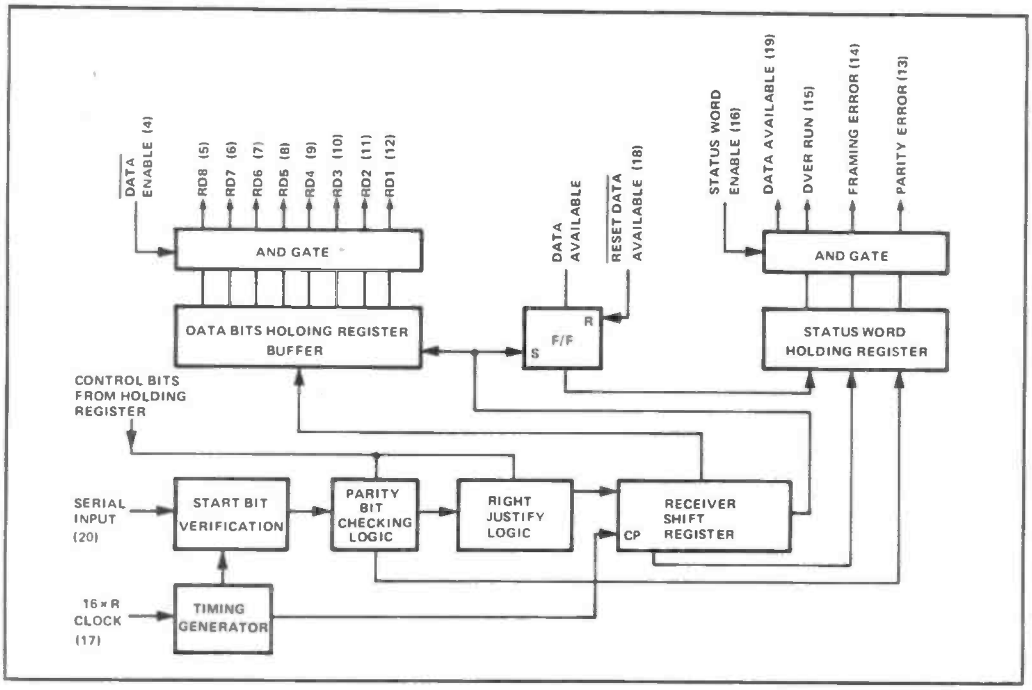


Figure 1: Block diagram of the receiver logic fo the AY-5-1012 UART.

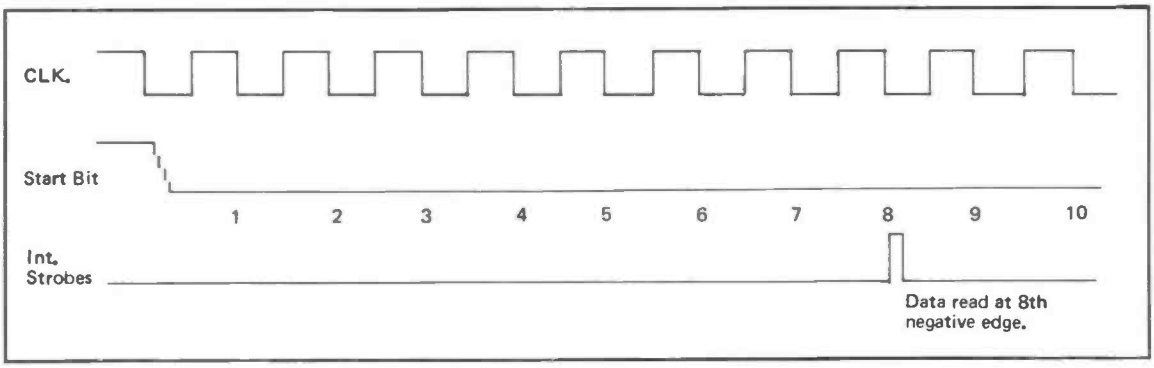


Figure 2: Waveforms demonstrating the receiver's window sampling technique.

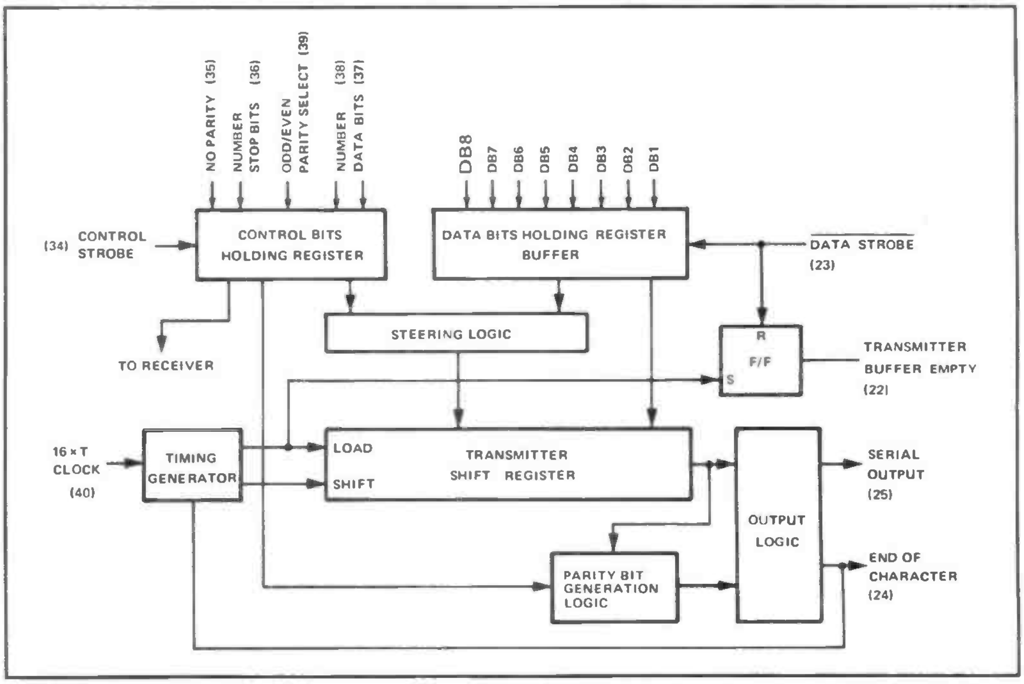


Figure 3: Block diagram of the UART transmitter.

I/O	High on I/P or O/P	Name	Pin No		Name	High on I/P or O/P	I/O
I		Vcc	01	40	TC	16x baudrate	I
I	−12V connection	Vgg	02	39	PS	ODD EVEN	I
I	Ground connection	Gnd	03	38	WS1	Word Length	I
I	Rd1-RD8 Tristated	DE	04	37	WS2	Word Length	I
O	MSB Rec. DATA out	RD8	05	36	NSB	Two stop bits	I
O	Bit 7	RD7	06	35	NP	No-polarity	I
O	Bit 6	RD6	07	34	CS	Load control reg	I
O	Bit 5	RD5	08	33	DB8	Bit 8 data MSB	I
O	Bit 4	RD4	09	32	DB7	Bit 7	I
O	Bit 3	RD3	10	31	DB6	Bit 6	I
O	Bit 2	RD2	11	30	DB5	Bit 5	I
O	LSB Rec DATA out	RD1	12	29	DB4	Bit 4	I
O	Parity error	PE	13	28	DB3	Bit 3	I
O	Framing error	FE	14	27	DB2	Bit 2	I
O	Overrun error	OE	15	26	DB1	Transmitter data LSB	I
I	Status Tristated	SWE	16	25	SO	Low during space	O
I	16x baud rate	RC	17	24	EOC	Low during character TX	O
I	Low resets DA	DAR	18	23	DS	Low loads TR	I
O	New character	DA	19	22	TBE	Holding register empty	O
I	Marking	SI	20	21	MR	Clears logic	I

Table 1

WS1	WS2	Word length
LOW	LOW	5 Bits
HIGH	LOW	6 Bits
LOW	HIGH	7 Bits
HIGH	LOW	8 Bits

Figure 4: Pin analysis of the UART functions.

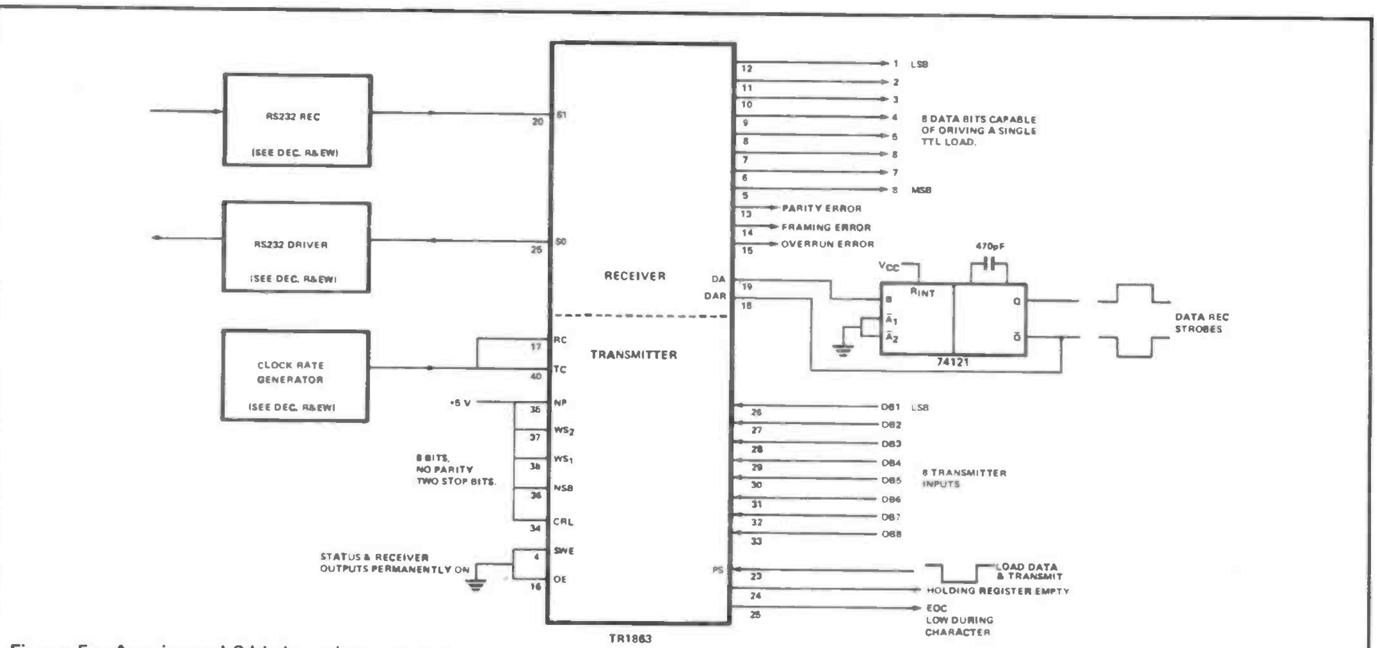


Figure 5a: A universal 8-bit input/output port.

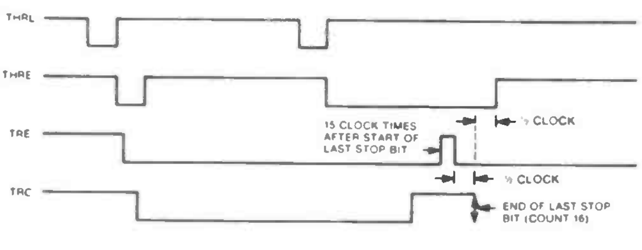
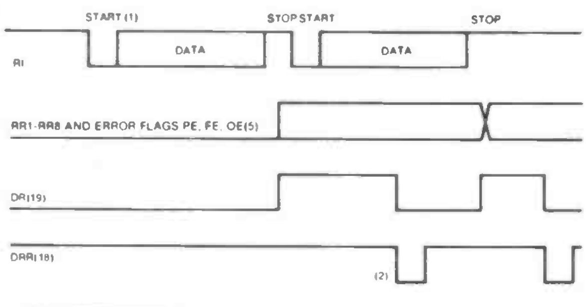


Figure 5b: The transmitter and receiver timing waveforms.



the parity according to the mode selected by the parity select input and, if NO-PARITY is not enabled, appends the parity bit to the last data bit. The stop bit, or bits are then appended to the last data or parity bit. The EOC flag (Pin 24) is held low all the time a character is being transmitted.

Both the transmitter and receiver are double buffered. During reception a second character can thus be being received before the first has been read, and during transmission a second character may be loaded into the holding register before the first has been transmitted. *Fig 4* provides a pin by pin analysis of the UART functions.

PUTTING IT ALL TOGETHER

Figure 5 shows a universal 8 bit input/output port which may be used to communicate with any personal computer with serial I/O capability. Each time a character is received, the DATA AVAILABLE flag triggers the monostable, which provides both positive and negative going strobes to the outside world as well as correctly resetting the DATA AVAILABLE flip/flop.

The receiver outputs can be used as a general purpose 8 bit output port, or to connect a Centronics parallel printer to a serial port (See November **R&EW**): This technique works best with a buffered, fairly fast printer, and a slow RS232 line, as no handshaking from printer to computer is provided for.

The transmitter is loaded each time DATA STROBE is brought low. If the maximum character rate can exceed 1.5 times the RS232 transmission rate, the external logic should be designed to check that the transmitter BUFFER EMPTY line is in the valid state before strobing DATA STROBE.

The transmitter input may, of course, be connected to virtually anything, including a standard parallel ASCII keyboard. The keyboard strobe will often connect direct to DATA STROBE.

Next month, in the final part of this series, we will look at the software aspect of the last class of UART's, namely those used to directly interface with a microprocessor.

Footnote: Last month's *Fig 8* was not included with the text. It is reproduced below. □ **R & EW**

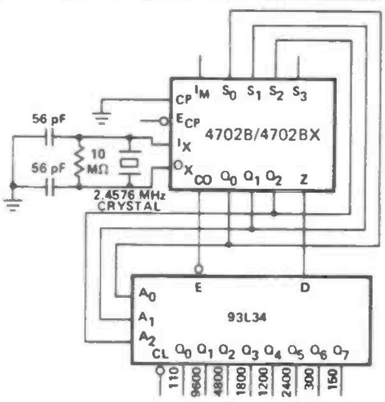


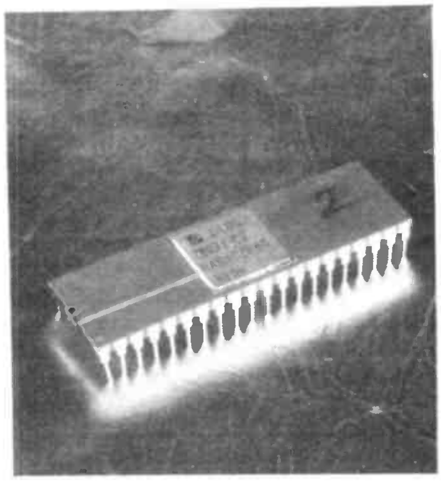
Figure 8: Bit-rate generator with 8 simultaneous frequencies (this diagram was omitted from last month's UART feature).

Your Reactions	Circle No.		Circle No.
Immediately Applicable	180	Not Applicable	182
Useful & Informative	181	Comments	183

FEBRUARY '82 ISSUE
ON SALE JANUARY 5th 1982

Next Month's R&EW presents PROJECT INNOVATIONS in

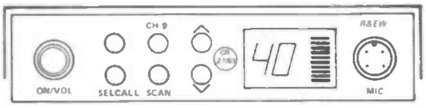
COMPUTING: Z-8 DEVELOPMENT SYSTEM



Europe's most advanced low-cost microprocessor development system, the Z-8 PDS. Designed and developed in R&EW's laboratory, this unique unit is programmable in Tiny Basic via almost any commercial/personal computer/terminal with a serial I/O capability. The Z-8 Programmable Development System features 8K-bytes of on-board RAM, 4K-bytes of EPROM, and a total of 16 input/output ports.

Specifically designed to facilitate the rapid development of 'dedicated' machine/process control systems and using a high level programming language, the Z-8 PDS can be used to give total microprocessor control of radios, test gear, domestic heating/lighting/security systems and industrial control/robotics systems. An absolute MUST project for all amateur and professional 'micro' engineers.

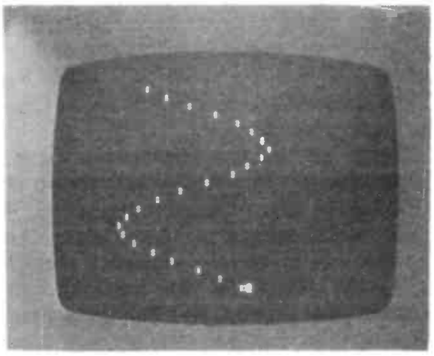
RADIO: 40-CHANNEL CB RIG



The UK's first **FULL SPEC** DIY 40-channel CB rig. Designed and fully kitted by R&EW, this unique project features fully synthesised tuning (with expansion to include channel scanning), 40-channel 'station' indication, 4 watts output power, etc., etc.

Fully engineered to R& EW's exacting standards, the rig is battery powered at 12 volts and suitable for either portable, mobile or 'shack' use.

TV: 'SINGLE CHIP' TV PATTERN GENERATOR



A state-of-the-art piece of test gear giving dot, cross hatch and gey scale, etc., outputs. Complete with built-in sound/vision modulator, this low-cost project gives a truly sophisticated performance.

PLUS a TV antenna-selector and lots, lots more.

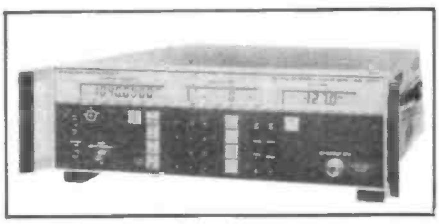
including,

REVIEWS OF:—

RADIO: Our now-famous reviews continue with the final part of the BIG MATCH between the FRG7700 and R1000 receivers.

and

FEATURES



TEST GEAR: In-depth looks at Marconi's fully synthesised TF2019 signal generator, and at the Thurlby 4¾ digit test meter.

plus the usual features,

including

DATA FILE (with 22 CMOS circuits), DATA BRIEF, and part 2 of FREQUENCY SYNTHESIS.

A POWER METER DUET

Roger Ray reflects on two directional RF Power Meters, the Rohde & Schwarz Naus 4 and the Telewave 44A.

Directional

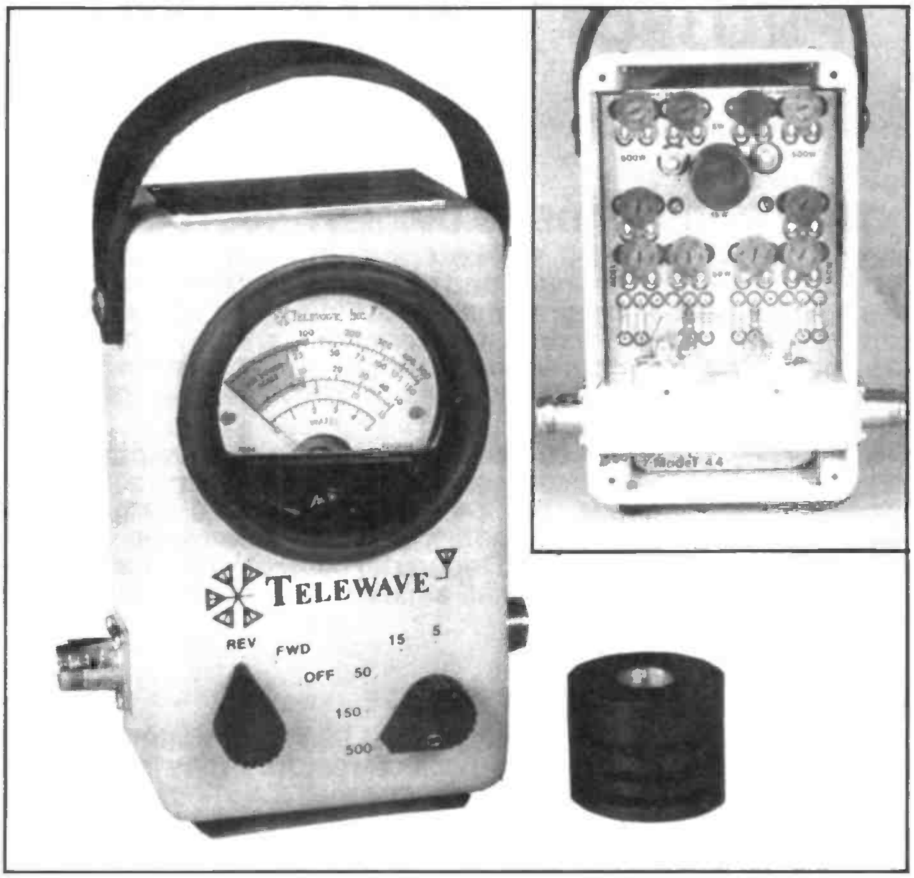
POWER METERS ARE general inserted between transmitter and aerial, and used to measure both power output from the transmitter and the match of the aerial. Transmitted power is that indicated in the FORWARD direction, while REVERSE power gives a measurement of the match of aerial or load. The degree of match or mis-match is usually quoted as a Voltage Standing Wave Radio (VSWR), and is calculated from the two powers measured.

Professional directional power meters are used to give both accurate power and VSWR measurements. Frequency range, direct power calibration, and accuracy set these instruments apart from the cheaper, commonly available SWR bridges. The Naus 4 and the 44A definitely fall into the professional category. These instruments use one or more directional couplers to sample the power in the line being measured. Forward and reverse powers in the directional coupler(s) are converted into DC voltages by rectifier diodes. The voltages are displayed separately on two meters in the case of the Naus 4 and on one switched meter in the 44A. All of the meters are calibrated in Watts and display average power.

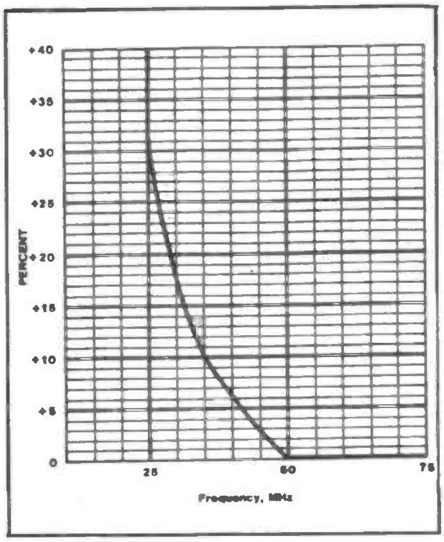
Both of the power meters reviewed have an upper frequency limit of 1 000 MHz. The lower limit on the Naus 4 is 25 MHz, while the 44A extends this down to 20 MHz. The drawback though with the Telewave 44A is that all measurements below 50 MHz are subject to a calibration factor (see accompanying chart). This is something that could easily be missed by someone unfamiliar with the instrument. An example of this is that if a 27 MHz CB transmitter is measured without taking into account the calibration factor, the measurement would be 20-25% low.

Ex World War II

The Telewave 44A is ruggedly constructed with a die-cast alloy case, heavy rubber meter protection and leather carrying strap. The meter itself would not look amiss in a piece of WWII surplus equipment. In the instrument reviewed the meter was set about 5 degrees out of square, which did not add to its asthetics. In practice though the meter is functional, and the five scales (one for each range)



Above: The Telewave 44A power meter.
Below: The Rohde and Schwarz Maus 4 power meter.



well spread out. Behind the scale is a good 20 uA taut-band movement, which is short-circuited for protective damping when the front panel FWD/REV switch is in the OFF position. Forward power is of course only forward power when the power meter is connected the right way round, and there is no marking on the case to indicate which way round is correct. In fairness, this is only a minor point, as the input is conventional being on the left-hand side. The overall appearance of the 44A is of a service instrument, that should well take the wear and tear of the service environment.

Laboratory Use

The R&S Naus 4 is housed in a pressed steel box, with an aluminium carrying handle. It differs from the 44A and indeed other power meters, in that the measuring head is remote from the main body of the instrument. The head is connected by means of a permanently wired flexible cable. This means that the measuring head can be used in awkward places, while the meters are left in the best place for them to be read. For convenience the measuring head can be clipped onto the back of the instrument, although this obscures the VSWR nomograph, and leaves the interconnecting cable dangling.

The whole unit is very heavy (about 9lbs) and this together with its rectangular construction implies laboratory rather than service use. The two separate meters for forward and reverse power, make aerial adjustments easier. The range on each meter is separately adjustable to allow very accurate measurements to be made.

Summary

The R&S Naus 4 definitely gives the impression of an accurate, well made power meter. The linear meter scales are easily read to an accuracy of the needle width. This power meter is battery operated, and the continuous operation battery life is almost a year.

In the laboratory it proved to be as accurate as anything we had to measure it with. The only minus point is its weight and size from a service point of view.

The Telewave 44A is robust and easy to use. As with the Naus 4 it gives correct upward indication on AM modulation -something that other instruments fall down on. The accuracy cannot be favourably compared with the Rhode & Schwartz unit, and the calibration factor below 50 MHz is decidedly tedious. Still at the price...

Footnote

The Naus 4 is available from Rohde & Schwarz UK Ltd, and the Telewave 44A from Racal-Dana Instruments Ltd.

■ R & EW

Your Reactions.........	Circle No.
Immediately Applicable	188
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Not Applicable	190
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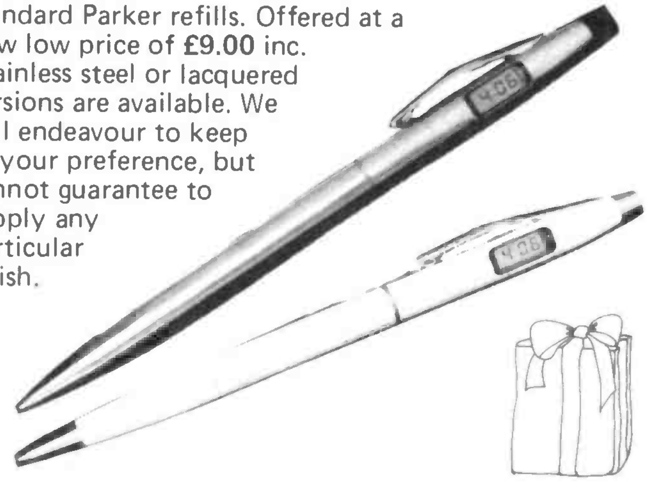
115 for further details.

christmas gift ideas



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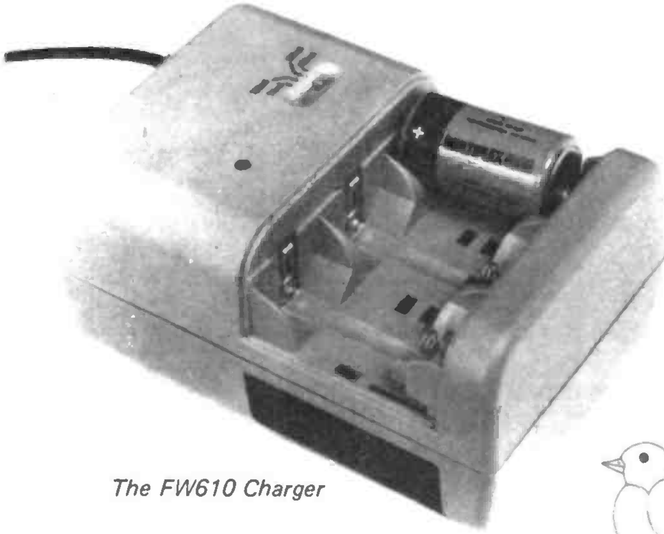
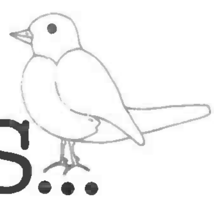


The FW610 Charger



CHRISTMAS GIFT IDEAS...

300 for further details

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TAKEDA RIKEN TR4122B

William Poel lusts after a superb value-for-money spectrum analyser from a not-so-well known Japanese manufacturer

The Other One

MOST COMMUNICATIONS ENGINEERS will by now be familiar with the test equipment offerings of Anritsu, but not so many perhaps will be familiar with the 'other' Japanese analyser manufacturer, Takeda Riken. As a result of a brief note in one of the News pages from our first issue, the UK representatives - Chase Electronics of Teddington - have made themselves known to us. We had hoped to get our hands on the TR4172 multi-function spectrum analyser which covers 50 Hz to 1800 MHz as a combined frequency/network analyser with 100 dB dynamic range.

However, it will take a few months for one of these tempting machines to be let out of Japan, so we are delighted to be able to start our acquaintance with the Takeda range with the TR4122B, which at around £ 7 500 must be easily the best value in its sector of the market.

The 'other' competition in this class of instrument has historically come from the US's big two - Tektronix and Hewlett Packard - who have quite plainly been finding life getting harder for them as a result of Anritsu and Takeda. Offerings from R&S, Ailtech, Polarad, Systron Donner and others do not seem to have been keeping pace with instruments emerging from Japan - but we invite comments from any manufacturer who would like to have their equipment considered in these pages.

First impressions

The first thing any reviewer does, is to draw mental comparisons with 'known ' reference points. In our case, these are a Tektronix 7 L 12 and HP 141 T system - and the 4122 B leaves both these 'classics' in the starting stalls. There are one or two small points (more later), but on the whole, the TR 4122 B is fitted with 'extras' that most other analysers class as costly options.

The main 'extra' is the built-in tracking generator. Any analyser without a tracking generator for swept filter response analysis measurements is rather like a car without reverse gear - and for easy quantitative operation, there is a digital frequency counter that works in conjunction with a spot marker.

The basic specifications (set out in table 1) compare more than favourably with anything in its class. The 80 dB dynamic range (with the 100 kHz IF filter) is 10 dB more than competitive offerings, making for useful IMD measurements in receiver front ends - Boltzman's constant and bandwidth/noise considerations do their usual bit to hamper measurement range in wider bandwidths - see **Fig 1**. The tailing off at the LF end is due to the fact that the IF bandwidth approaches the minimum frequency being viewed - i.e. you can't see a 500 kHz signal in a 1 MHz bandwidth, since the filter response goes through the zero point of the display anyway!

With the built-in tracking generator, a 90 dB range is guaranteed for filter analysis - a very useful feature indeed, and one we were able to use to verify some filter specifications we were previously obliged to the manufacturers' word for -or to try to measure by the tortuous technique of joining up different pictures to obtain the equivalent display range. The typical range appeared to delve as far as 95dB in a 0.5kHz bandwidth, which is more than just marginally better than Anritsu M 62 at around 80 dB.

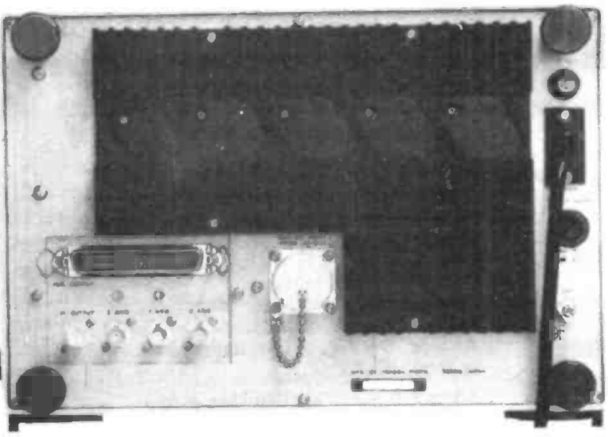
The Takeda Riken TR4122B

Portability

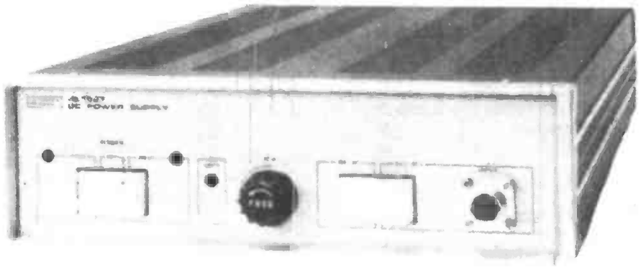
The versatility of the instrument is enhanced enormously by the availability of a rechargeable battery pack option - in TR 1927 *(PHOTO)*. Apart from mobile radio installations checks 'in situ', this enables remote field strength measurements to be made, and a scale calibrated in dBuV is available for this application. X,Y and Z outputs are available on the back panel *(PHOTO)*, and you might like to remember that since the 'X' output is basically the signal amplitude, and audio amplifier plugged in here will give a usable audio signal when the analyser is tuned into AM signals and set on 'zero scan' mode. FM can likewise be slope demodulated by tuning the signal to the side of the IF filter.The TR 4122 B provides a front panel 3.5 m jack for this purpose.

A crude 'AGC' is provided by the log amplifier, although when correctly tuned in, the linear 'Y' axis display mode provides excellent audio. This feature is particularly useful in field strength tests on broadcast equipment, since the station being viewed can be double checked by listening

The choice of 10.7 MHz as the final IF is a useful idea, since there are any number of IF modules that can be 'hung' on the IF output available on the back



Rear view of the TR4122B. Note the X,Y and Z output sockets.



The TR1927 rechargeable battery pack

panel to turn the TR 4122 into a complete communications receiver spanning 100 kHz to 150 MHz. (Zero span mode).

Counter Intelligence

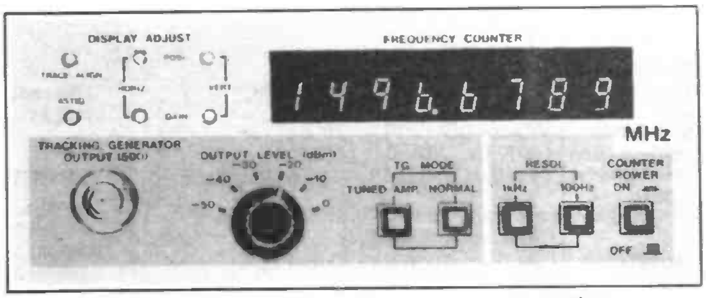
The use of the frequency counter is not simply for establishing the centre frequency on view - but like the display on the Marconi TF 2370, the TR 4122 has a manually tuned bright spot (the digital store on the TF 2370 uses a complete line). The clever part of the scheme is that the tracking generator can be configured as a tuned amplifier (see *PHOTO)*, centred on the 'spot' marker, whereby the counter reads the incoming signal directly against it's own timebase reference, without any of the errors of the analyser's own oscillators.

This feature enables easy measurement of sub-carrier frequencies in radio spectra - such as the 19 kHz on a stereo multiplex transmission, when a standard frequency counter would be incapable of reading anything other than the main carrier.

And now the 'bad' news

If you think our reviews tend to be a shade too sycophantic, maybe it's because we only choose to review basically good stuff. The TR 4122 has a couple of failings - no phase locking is one, and the wretched 'N' sockets is another. I suspect that most TR 4122s spend most of their life with 'N' to 'BNC' adapters screwed in. Set against the rest of the features, these are not serious.

The user of a spectrum analyser has to establish many parameters before use can commence, and there is nothing like an 'on screen' display of the various attenuator, span, timebase and level settings to make life easier. The next generation of analysers will make far greater use of digital storage, whereupon digital displays become a great deal easier. If a ZX81 can write on your TV for less than £70 - then spectrum analysers can establish the test parameters 'on screen' without adding enormously to the cost.



Close—up of the tracking generator/frequency counter section of the front panel.

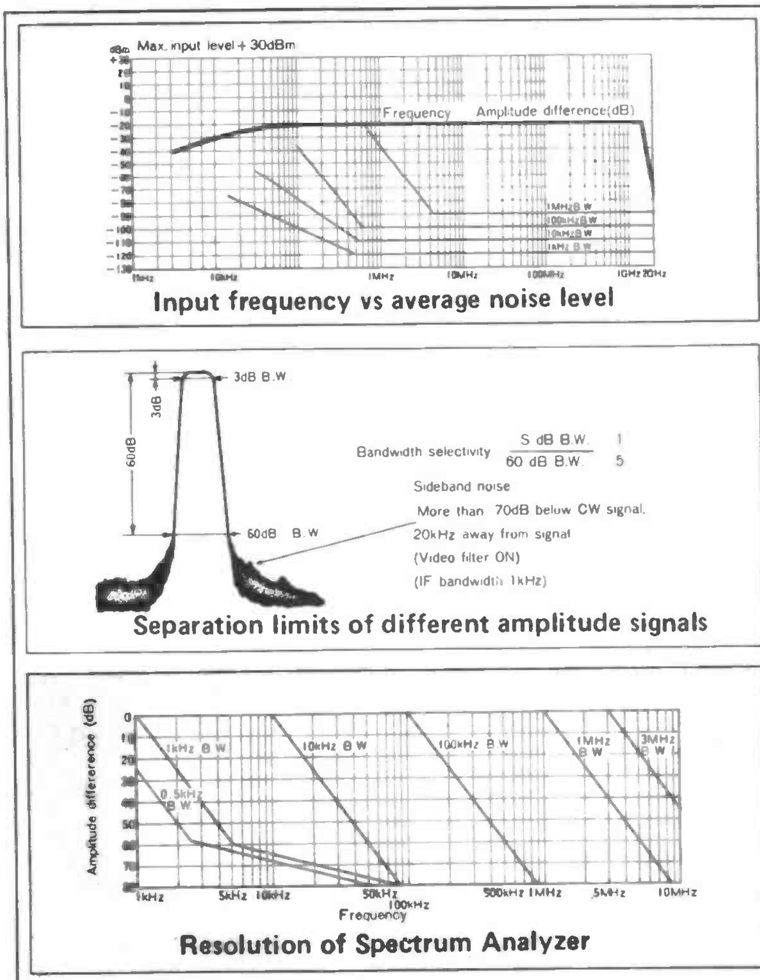


Figure 1: Performance graphs of the TR4122B.

TAKEDA RIKEN TR4122B

-TR-4122B SPECTRUM ANALYZER SPECIFICATIONS

SPECTRUM ANALYZER SECTION

Frequency Specifications

Measuring range : 100kHz ~ 1500MHz
Center frequency accuracy: Within ±10MHz
Scan width : 100MHz/div. ~ 2kHz/div., in a 1-2-5 sequence and zero scan with DISPERSION/DIV. switch, Becomes fixed tuned receiver at [0] position.
Scan linearity : Within ± 10%.
Stability:
Residual FM ; 1kHzp-p or less
Noise sideband ; more than 70dB below CW signal, 20kHz or more away from signal, with 1kHz IF Bandwidth, video filter ON
IF bandwidth : 500 Hz, 1, 10, 100kHz, 1, 3MHz
Bandwidth accuracy : ±20% of each resolution bandwidth
Bandwidth selectivity: 60dB/3dB IF B.W. ratio < 5 : 1
IF bandwidth switching accuracy: Within ±1dB (20°C ~ 30°C)

Amplitude Specifications

Ref. level : +50dBm ~ -62dBm, 10dB steps, 0 ~ -12dB
Ref. level accuracy : Within ±1dB (20°C ~ 30°C)
Y-axis scale selection: 10dB/div., 2dB/div., LINEAR
Level display accuracy: ±1dB or less/10dB, ±2dB or less/80dB
Dynamic range:
Average noise level; Less than −85dBm (at IF bandwidth 1MHz, video filter ON)
Spurious response ; Less than -70dB (at -30dBm input)
Residual response ; Less than -100dBm (at no input signal, input ATT 0dB)
CRT dynamic range; 90dB (10dB/div.), 20dB (2dB/div.)
Video filter : ON/OFF, Filter of 1/30 of IF B.W. at ON.
Frequency response : Input Mixer–within ±1dB (at 100kHz ~ 1500MHz)
Input Attenuator–within ±1dB (at 100kHz ~ 1500MHz)
Calibration output : Amplitude -30dBm ±0.5dB
Frequency 200MHz ±30kHz, crystal oscillator signal
Gain compression : -1dB or less at -10dBm input

Input Specifications

Input connector : Type N
Input impedance : 50Ω
V.S.W.R. 1.5 or less (at ATT. 10dB or greater)
Input attenuator : 0 ~ 50dB, 10dB steps
Maximum input sensitivity: -115dBm
Input destroyed level: Maximum input to input mixer (at input ATT. 0dB) +10dBm
Maximum input to input ATT. (at input ATT. 50dB) +20dBm, DC; ±50V

Scanning Specifications

Scan time : 0.2ms/div. ~ 10s/div., 1-2-5 steps and auto (Automatically controlled by DISPERSION, IF bandwidth, video filter setting)
Scan trigger modes : AUTO, LINE, VIDEO, SINGLE

General Specifications

CRT : Display area 10cm x 8cm (10div. x 10div.) P7 phosphor
Data input/output : DC voltage (+5V, -15V, +15V), lamp output (+6V ~ -6V), Blanking output (blanking at Lo), YIG drive output voltage, IF gain control signal, IF gain setting output, input ATT. setting output, external counter control signal
X-axis output : Approx. ±5V, output impedance approx. 1kΩ
Y-axis output : Approx. 0 ~ 5V, output impedance approx. 10kΩ
Z-axis output : Approx.0 ~ +15V, (Blanking at Lo)
Scan display : LED twinkle
Warning display : LED twinkle
Operating temperature: 0°C to +40°C
Power requirement : AC100V (120, 200, 220V) ±10%, 50/60Hz, approx. 100VA
DC operation possible, using accessory -TR-1927 battery pack
Dimensions : Approx. 300(W) x 200(H) x 500(D) mm
Weight : Approx. 18kg (basic)
: Approx. 20kg (with options)

TRACKING GENERATOR SECTION

Frequency range : 400kHz ~ 1500MHz
Output level : 0dBm ~ -50dBm, 10dB steps
Output level accuracy: ±1dB
Output S/N ratio : 30dB
Output Connector : N type
Output impedance : 50Ω
Frequency response : ±1dB
Stability : Conforms to Spectrum Analyzer stability
T.G. modes : TUNED AMP, NORMAL

FREQUENCY COUNTER SECTION

Frequency range : 400kHz ~ 1500MHz
Resolution : 1kHz, 100Hz
Display : Decimal 8 digits, LED display
Time base stability : Aging rate 5 x 10^{-7} /month

OPTION

dBμ display and 75Ω input impedance are optional. Please inquire when ordering.

ACCESSORIES

-TR-1612 75Ω – 50Ω conversion adaptor
-TR-1619 Earphone for sound monitor
-TR-1625 RF coupler (DC ~ 1000MHz)
-TR-1626 RF coupler (DC ~ 500MHz)
-TR-1635 Carrying case
-TR-1652 Camera mount
-TR-1711 Log periodical antenna
-TR-1722 Half wave dipole antenna
-TR-1927 Battery pack (built-in Ni-Cd battery)
Available by external power supply (+10 ~ +15V)

-TR-1604 A/B Memory
-TR-1604P A/B Peak, (A-B), Chart Recorder O/P

Table 1.

Conclusions

With equipment like this available to Japanese development engineers, it's hardly surprising that they rule the roost on RF design. For £ 7 500, you get a package worth well over £ 10 000 from most other manufacturers in this field. The TR 4122 makes design and verification of all aspects of communications broadcast engineering so much simpler than any alternative test equipment array available.

If you work with RF development/test and you don't have access to something like the TR 4122, then you are at a tremendous disadvantage. There is no getting around the fact that the spectrum analyser is as essential to the professional RF designer as an oscilloscope is for general electronics. What a terrible indictment of the state of the UK electronics industry that we do not have a manufacturer of an instrument even vaguely near this specification within our shores.

Some **R&EW** readers may complain that spectrum analysers are outside the grasp of all but the most fortunate enthusiasts (other than those with access to such things at 'work') - but this does not change the facts. We hope that the **R&EW** lab can be regarded as the readers' own facility - since if **R&EW** use an analyser in the development of a feature, then *you* won't need one to get the project going. ■ R & EW

Your Reactions.........	Circle No.
Immediately Applicable	152
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Not Applicable	154
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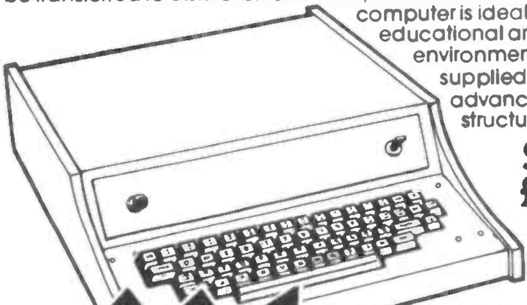

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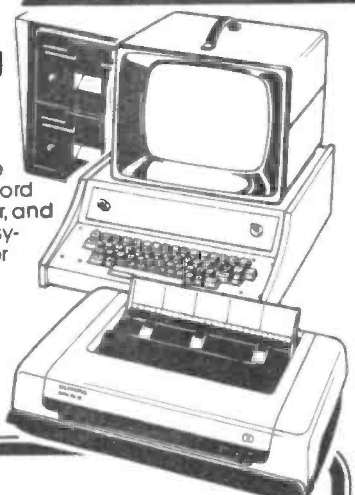

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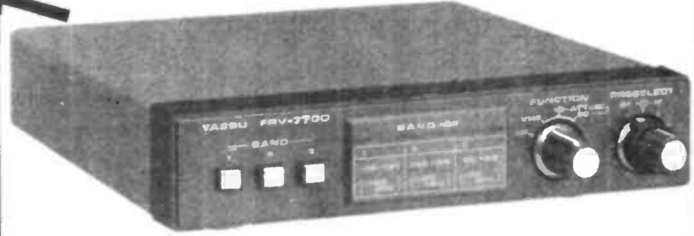

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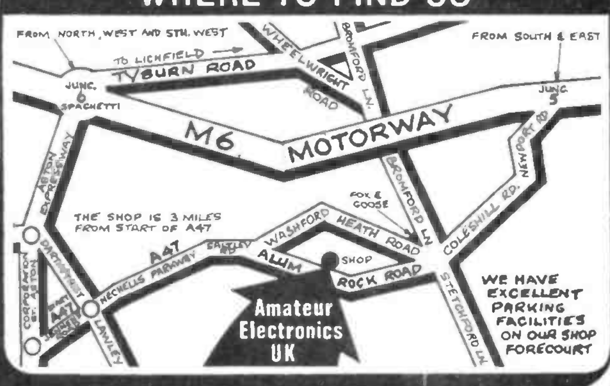

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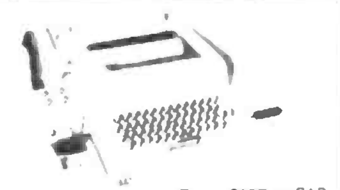

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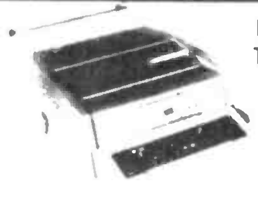

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and if that's not enough a fully floating 5v output @ 50 ma DC which may be senesed to give a host of other voltages. All outputs are brought out to the front panel via miniature jack sockets and are also duplicated at the rear on short flying leads. Units accept standard 240v mains input. They are ex GPO and may have minor scratches on the front panels, they are sold untested but in good internal condition. £16.50 each + £2.50 p+p complete with circuit and component list. Transformer guaranteed. HURRY WHILE STOCKS LAST!!

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*Permission may be required for connection to PO lines.

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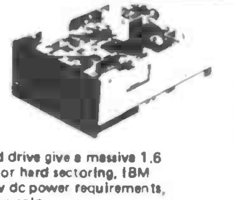

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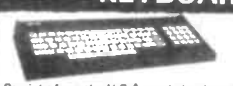

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Supplied complete with circuit at only £10.95 + £1.75pp. Believed working but untested, unguaranteed.

106 for further details

Using the RS232 ADA Board

Jon Burchell describes uses for the RS232 ADA board, ranging from programmable power supplies to robotics.

In case you missed last months article, the RS232 ADA is a complete stand-alone analog-to-digital and digital-to-analog convertr, using an on-board serial RS232 generator to provide almost universal interfacing capability. The unit is capable of receiving 8-bit digital words and converting them to a voltage in the range 0-2.55 V, (e.g. with a resolution of 10 millivolts). Alternatively, in response to a 'convert command' from the computer, the unit will digitize an analog voltage and transmit this to the computer as an eight bit word. The unit is capable of working at up to 19200 baud or around 1500 samples a second.

Having dealt with the constructional and theoretical aspects of the ADA unit last month, we will now take a look at a few practical applications of the ADA board. Full circuit construction details are not provided as the examples are meant for experimentation and to provoke further ideas.

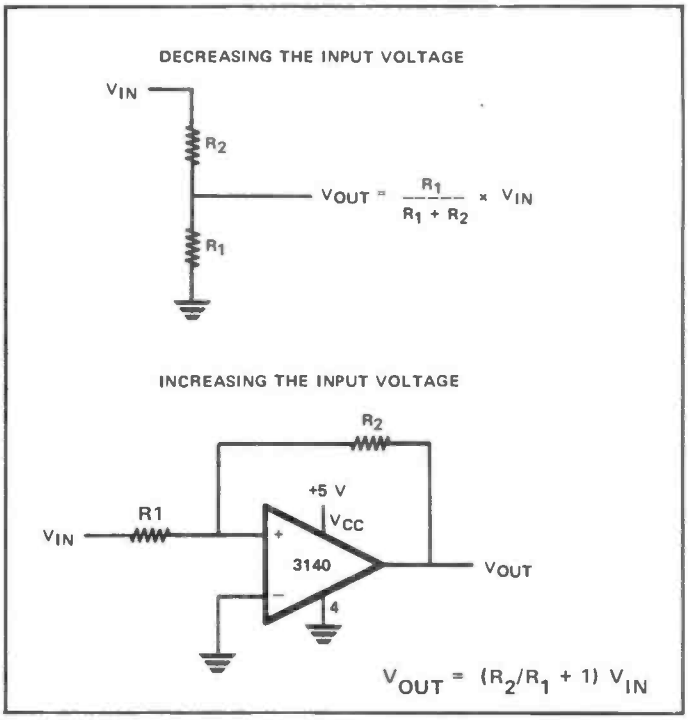


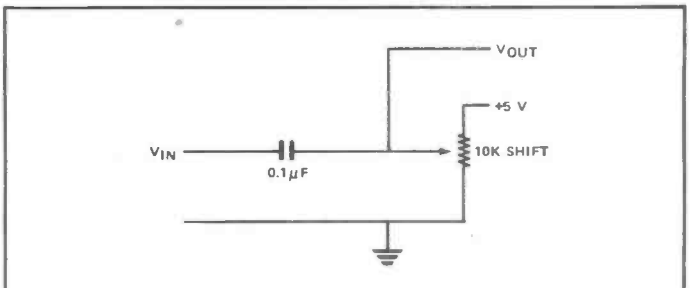
Figure 1: Input scaling methods.

WAVE-FORM SAMPLING

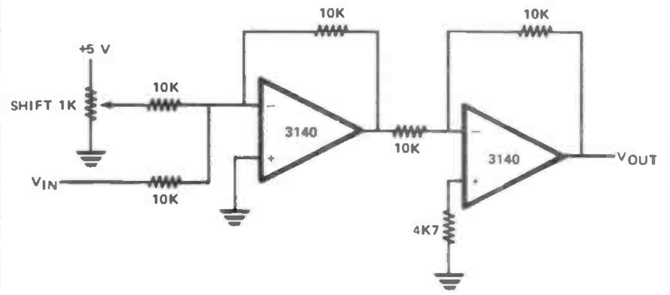
The analog converter will sample inputs in the 0-2.55 voltage range without additional circuitry. The maximum sample rate is not fast enough to accurately represent a signal of more than 500 Hz. Fortunately, most transducers do not produce data at anything like this rate.

If the input signal is outside of the converter's range, input scaling will need to be employed. *Fig 1* illustrates two simple methods of achieving both a reduction and an increase in input signal.

As the converter is uni-polar in operation, it will not sample a negative waveform. Thus, a sine wave fed to the converter looks (after it has been converted) as though it has been subject to half wave rectification. In order to sample the whole of a waveform with negative going peaks, it must be level shifted, so that at no time is the input voltage below zero. *Fig 2* illustrates two methods of doing this.



(a) Simple level shifter for low-impedance ac.



(b) A more sophisticated approach.

Figure 2

The simple shifter of *Fig 2a* will only work for AC signals from a fairly low impedance generator. The more sophisticated circuit of *Fig 2b* will work correctly with AC or DC signals: The first op-amp forms a voltage adder circuit, and shifts the input signal up in level by the voltage set on the wiper of VR 1. The second op-amp is connected as a unity-gain voltage follower with inversion, to correct for the inversion of the first op-amp.

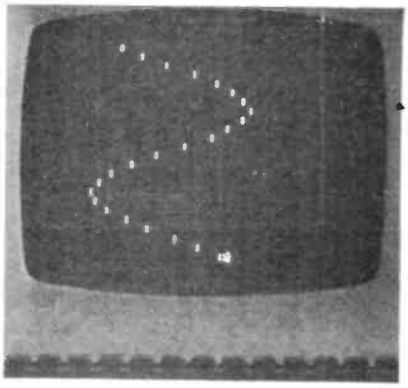
If you do not mind your signal becoming inverted, omit the second op-amp (you can restore the correct phase of the signal in software by subtracting the converter value from 255). Alternatively, if you require gain to be applied to the input signal, the values around the second op-amp can be altered to provide this.

The ADA card may be used to sample and generate very slow wave-forms. The programmes of *Fig 3* were used to sample a 1 Hz sine wave and to generate a 0.02 Hz sine wave.

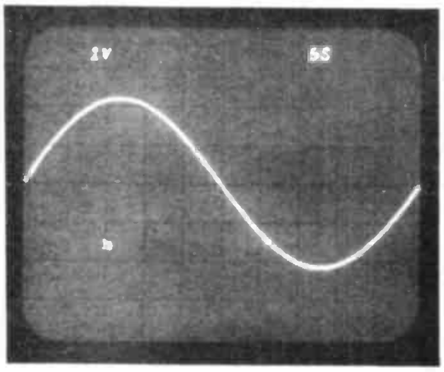
When generating a waveform, it is advantageous to employ a simple low-pass RC filter at the output of the D-to-A converter. This helps to remove the high frequency components present in the waveform.

A PROGRAMMABLE PSU

The unit may be used to construct a PSU whose output is programmable from the computer. In addition, the A-to-D converter may be used to provide current or voltage feedback. The parameters of the power supply are thus under software control. Simply by changing the programme, you can alter it from constant voltage to constant current, with either over-voltage or over-current limiting. A sophisticated power supply such as this would find uses in production testing, controlled electrolysis and heating situations, plus all sorts of parameter-measuring applications. ▶



```
10 REM PROGRAM TO READ A/D CONVERTER AND PRINT
12 REM SAMPLED WAVEFORM ON VDU
40 GOSUB 1000 :REM GET SAMPLE
50 X1=X*80/255 :REM SCALE X TO PRINT IT
60 PRINT TAB(X1);"*"
70 GOTO 40 :REM GET NEXT SAMPLED
1000 REM SUBROUTINE TO GET DATA
1010 REM SEE PAGE 33 DECEMBER R&EW
1020 REM 8251 LOCATED AT 14/15 HEX
1030 OUT(16R15)=16R27
1035 OUT(16R15)=16R07
1040 IF IN(16R15) AND 2 = 0 THEN GOTO 1040
1050 X=IN(16R14)  : REM GET SAMPLE
1060 RETURN
```




```
10 REM PROGRAM TO OUTPUT COMPUTED SINE WAVE TO A/D
20 REM CONVERTER
30 FOR I=O to 2*3.14159 STEP 2*3.14159/255
40 X=SIN(I)
50 X=INT(X*128)+128
60 GOSUB 80  :REM TRANSMIT VALUE TO D TO A
70 NEXT I
75 STOP
80 REM SUBROUTINE TRANSMITS VALUE TO D TO A
90 REM SEE R&EW DECEMBER PAGE 33
100 IF IN(16R15) AND 1 = 0 THEN GOTO 100
110 OUT(16R14)=X
120 RETURN
```

Figure 3

Figure 4 details just such a power supply, having a 0-25.5 V output, adjustable in 100 mV steps. The voltage output from the D-to-A converter is multiplied 10 times by the op-amp and used to control a series pass regulator. Current feed-back is provided by multiplying the voltage drop across a 0.1 ohm resistor and scaling this back to a 0-2.55 signal range. Voltage feedback is provided by the output potential divider arrangement shown.

MOTOR SPEED AND POSITION CONTROL

The programmable PSU of *Fig 4* may be used to make a motor speed controller with programmable RPM, with feedback to maintain the RPM at the preset value. The PSU with current feedback is connected to a small permanent magnet DC motor. Remember to include an inductive suppression diode across the motor.

The speed of a motor is approximately proportional to the current it draws: The software will adjust the PSU volts to maintain the speed constant. Software could be written to give the motor any desired torque/speed characteristic, and to deal with the special cases of starting up and slowing down.

The mechanics of a radio-control servo can be adapted to provide a position control mechanism as shown in *Fig 5*. *The theoretical accuracy of this system is better than 1.5 degrees. The electronics for the position controller are construction from an op-amp and a L149 bridge output device, which gives a current capability of 5 amps.*

By biasing the inverting input to 1.2 V the output is made bidirectional. An input of zero from the D-to-A converter causes the op-amp output to swing to —10 V. An input of 1.2 V will cause the op-amp output to be zero, and for an input of 2.55 V the op-amp output will be + 10 V. Finer control of the position of the motor is achieved simply by applying less volts to the motor. (e.g. using values closer to 1.26 V). Once again the complete

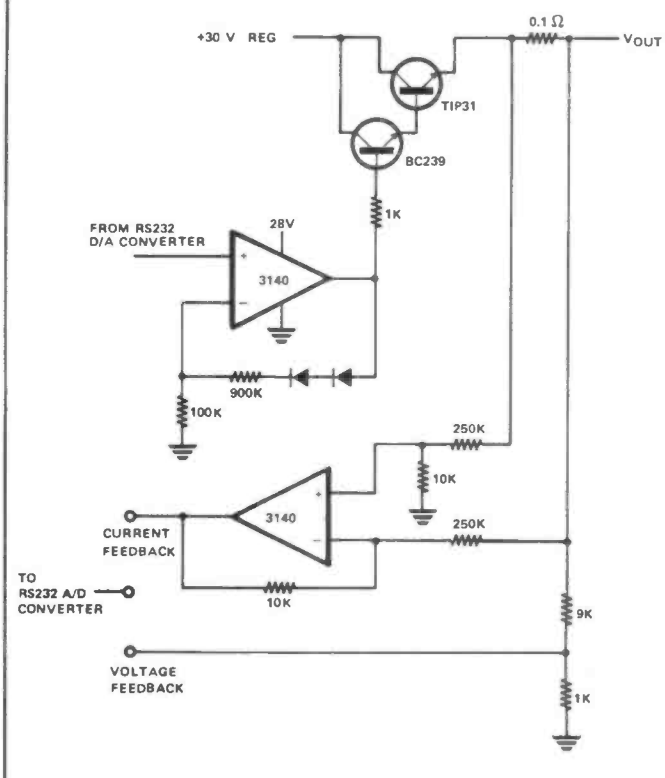


Figure 4: Programmable 0-25 V 1 Amp PSU.

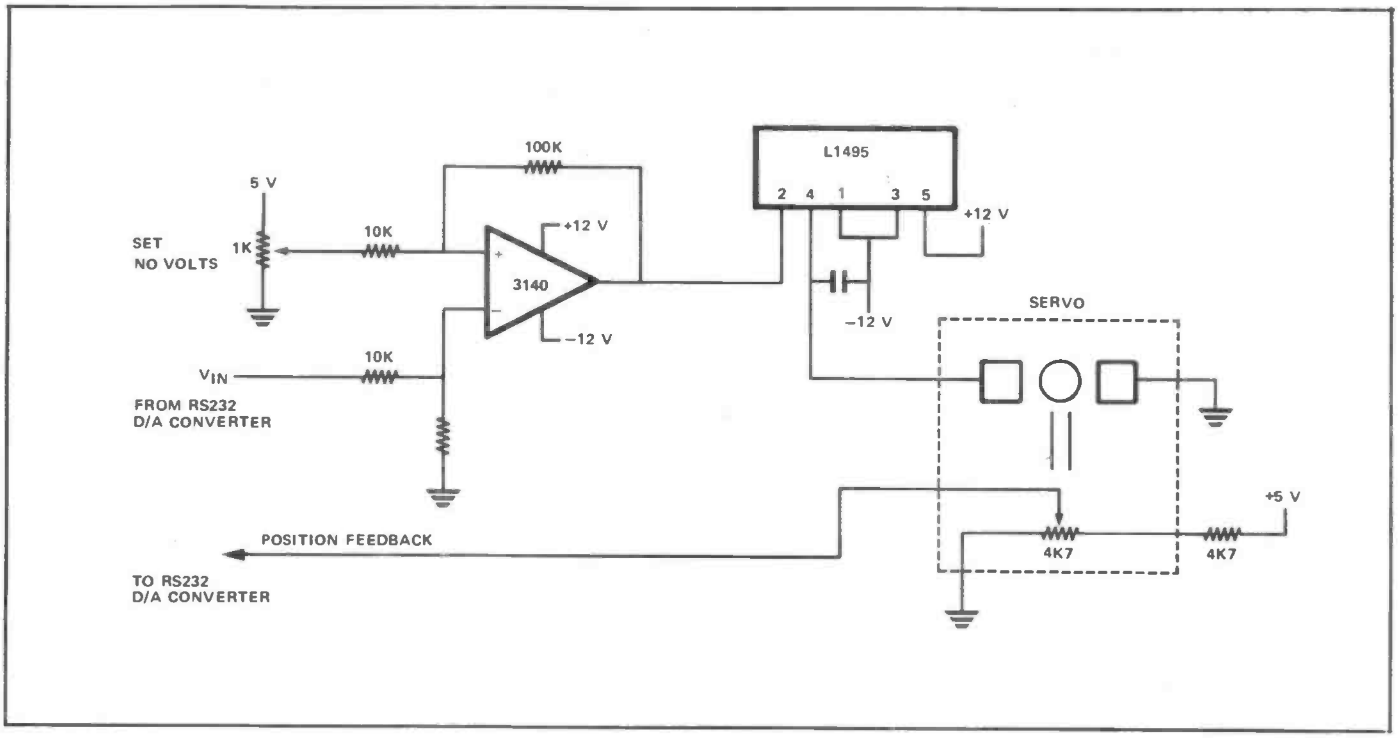


Figure 5: Simple computer controlled positioning mechanism.

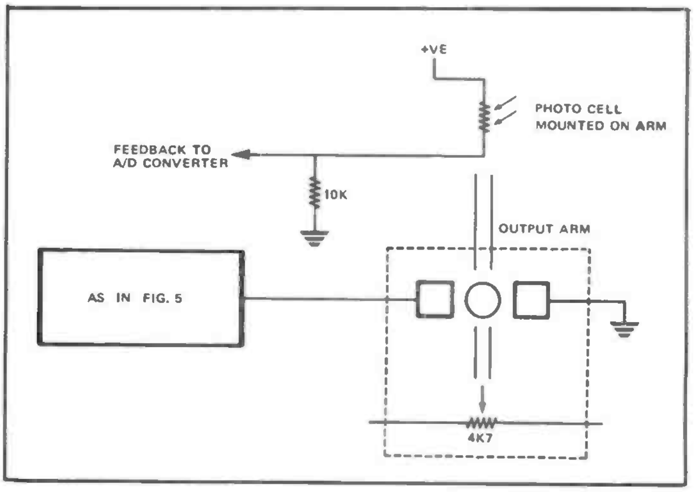


Figure 6: Simple computer controlled light-seeking robot.

characteristics of the servo are under software control, allowing almost infinite variations of the loop characteristics.

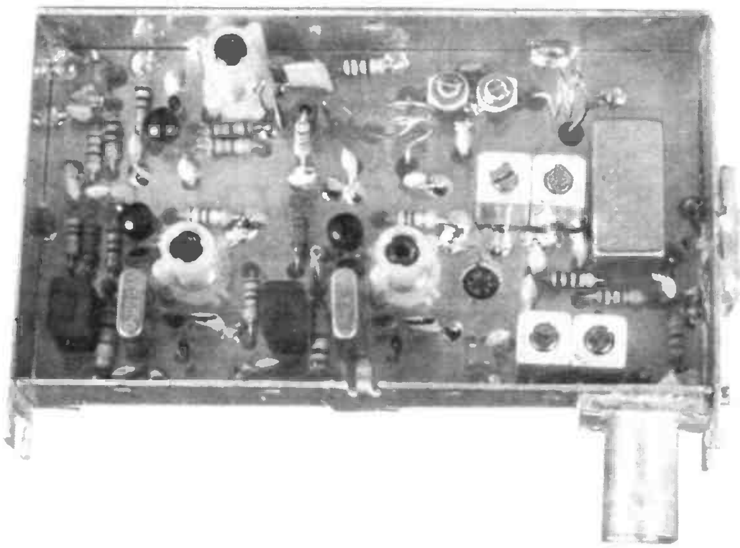
Feed-back of the servo arm's position provided by an integral 5 k pot within the servo mechanism. Small servo mechanisms can be obtained from a number of suppliers advertising in the Radio Control press, or from your local hobby shop.

SIMPLE ROBOT

The circuit of *Fig 5* may be adapted to produce a simple light-seeking robot. (See *Fig 6*). Although this robot would not be capable of translational movement, only rotational, it must offer the cheapest introduction into this field ever suggested. Once constructed and the controlling algorithms written, the finished unit could be incorporated as part of a scanning eye mechanism in a larger robot. ■ R & EW

Your Reactions	Circle No.		Circle No.
Immediately Applicable	184	Not Applicable	186
Useful & Informative	185	Comments	187

70 CM TO 2 M & TV CONVERTER.



SPECIFICATION	
COMMUNICATIONS	
Freq. Coverage	8MHz in the band 430-440MHz with a 144-148 MHz IF. 4MHz in the band 430-440MHz with a 144-146MHz IF.
RF Gain	8dB with single filter 6dB with two filters.
Noise Figure (approx)	2.5dB (single filter model) 5dB (two filter model)
AMATEUR TELEVISION	
Freq. Coverage	434-440MHz
IF Frequency	726-732MHz
RF Gain	5dB (single filter model)
GENERAL	
Supply Voltage	10V stabilised.
Supply Current	30mA approx
R&EW KIT PRICE £23.50 + VAT	

Two for the price of one: a sophisticated full coverage 70 cms to 2 m converter, plus a channel - 52 TV output for receiving and viewing.

Design by Graham Leighton.

Sound and vision.

THIS DUAL PURPOSE converter is designed to provide very good communications performance - plus a sensitive, stable and convenient amateur TV receive facility in conjunction with any UHF TV set. The block diagram is set out in *Fig 1.*

For communications operation, an output in the 2 m band allows the use of any popular 2 m rig as a tunable IF. (Don't press the PTT, please!). The TV output - around channel 52 - permits the use of an unmodified UHF TV set. A single local oscillator and a broadband double balanced mixer provide IFs of 144 MHz and 720 MHZ.

Table 1 gives details of the crystals which may be used, together with their various applications. For TV use, use the 97.33 or 98 MHz crystal to alleviate the major problems caused by the harmonic relationship of 144/288/432 MHz. A 'junk box' crystal may well work for TV use, since the absolute frequency value is unimportant (TV sets do not, as a rule, come calibrated in MHz). The two crystals should be within 4 MHz of each other, although if slightly inferior oscillator spurii are acceptable this figure may be increased.

If one of your local TV transmissions occurs on Ch 52, the second crystal can be selected to shift the IF frequency and avoid breakthrough - use of the optional input helical filter will also assist -although the filter losses will instantly compromise your noise figure by the degree of insertion loss (3-4 dB) - so something like the 70 cms preamp elsewhere in this issue is a virtual must for serious DX work. The bandwidth required for TV must also be borne in mind, or definition may be lost if the RF bandwidth is too narrow.

Budgeting for performance.

RF designers have at last overcome their passion for gain at the expense of all else, and today's designs are consequently mindful of the importance of correct gain distribution or 'budgeting'. This converter has been designed with just enough gain to overcome filter and mixer losses to give the optimum balance between large signal handling and sensitivity. The network of 70 cms repeaters is growing so rapidly that there is a good chance that most users will have at least one 'blockbusting' signal in their locality, and 30 dB of gain 'up front' will not endear 70 cms to a modern highly sensitive 2 m receiver.

The mixer losses increase marginally when used in TV applications (the higher frequency), and although the SBL1 is described as a 1-500 MHz mixer, no material difference could be detected between an SBL1 and the 1 000 MHz part, the SBL1-X. Save your money. Most modern TV sets enjoy a fairly outrageously high noise figure of 6-11 dB (by modern communications standards), so a further preamplifier between the converter output and the TV set may be beneficial - although the inadequate strong signal handling performance of most TV sets is likely to be a limiting factor.

Construction.

The printed circuit board is an integral aspect of the circuit design. No attempt at alternative constructional techniques

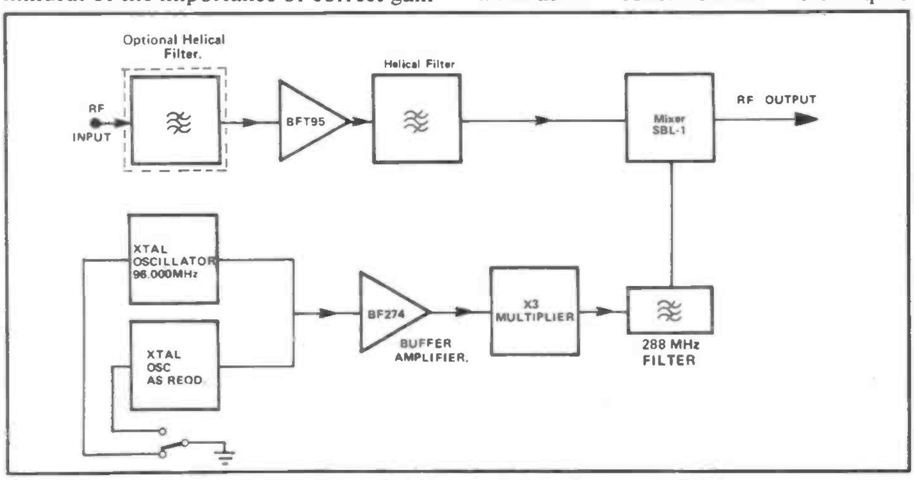


Figure 1: Block diagram of the converter system.

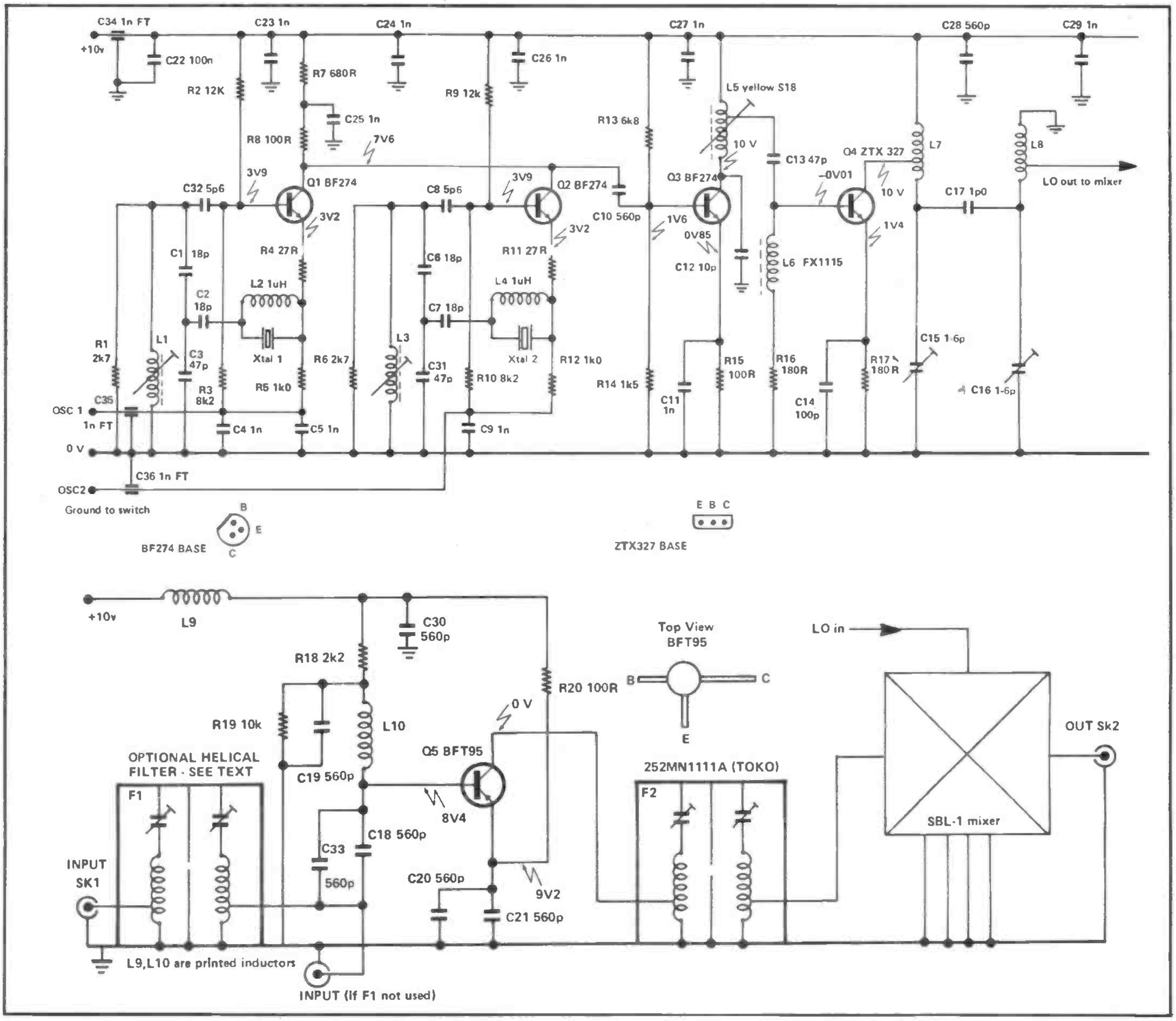


Figure 2: Full circuit diagram of the converter.

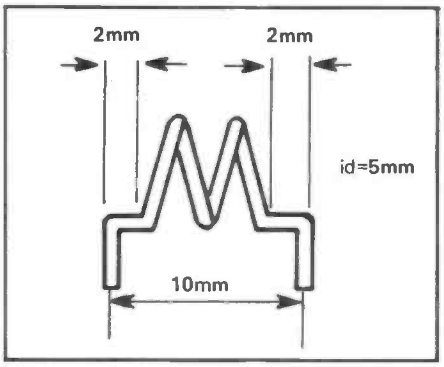


Figure 3: Winding details of L7 and L8.

should be attempted unless you are quite confident of your skills. A plated through hole PCB is a delightful luxury, but by no means vital on this small scale - soldering component legs top and bottom of the earth plane will suffice - but get it right first time, since extraction can be painful.

All leads must be kept as short as

CIRCUIT DESCRIPTION (FIG 2).

The input stage is a low noise UHF PNP transistor, the BFT95 (AEG, inter alia). One of the main advantages of a PNP device at UHF is the simple way in which the collector load is returned directly to ground (via the filter). Low inductance decoupling of the emitter is essential and by virtue of this capacitance from emitter to ground, a degree of low frequency roll off can be established.

The optional input filter has already been mentioned. Where it is not used, the space on the board may be populated with a simple high pass filter to alleviate the unwanted attentions of 27 MHz. The filter tap points are at 50 ohm impedance, and thus suitable for direct connection to the mixer. Ideally, such mixers should be terminated with a resistive load to maintain best intercept performance, but this is not likely to compromise this unit, since the mixer is primarily employed for its wide band characteristics.

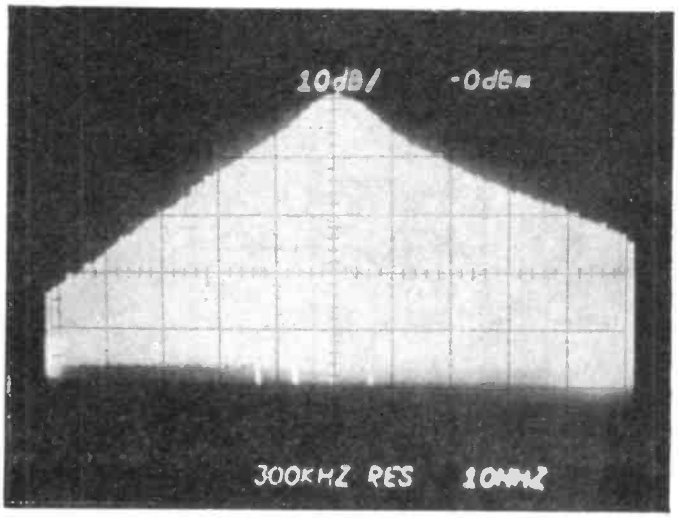
The local oscillator chain provides a choice of two crystals to cover the entire 70 cms band within the scope of a 2 m receiver's coverage. 5th overtone crystals are not generally the friendliest of quartz devices, and frequently tend to disappear on some obscure parasitic resonance unless carefully cajoled onto the right frequency. The resonant circuit established by L 1/C 1/C 3 must therefore be reasonably reliably 'presettable', so TOKO S 18 molded coils are used to avoid ambiguity. L 2 is placed in parallel with the crystal to enforce overtone operation.

Note that switching is performed at DC. Switching crystals is distinctly bad news and should be avoided. The system employed here enables remote operation if required.

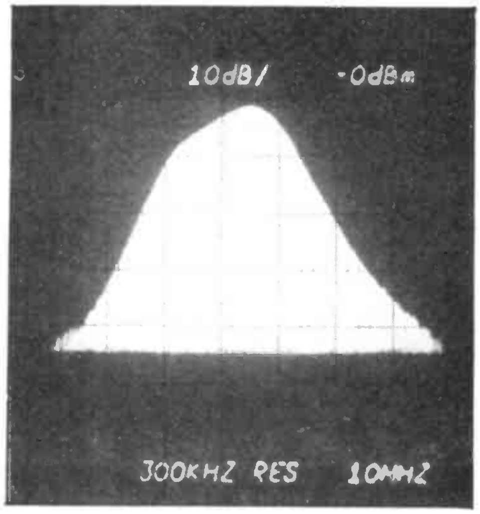
The mulitplier chain uses a ZTX327 in the 'final', driving a bandpass coupled filter which produces a clean (see spectrum analyser photo) LO drive to the mixer. The mixer requires a high level (+7 dB) injection, and the ZTX327 or ZTX3866 are necessary to achieve the required gain and power. In view of the broadband nature of the mixer, it is important that the LO should be kept free from excessive spurii, or various unexpected mixing processes will occur.

Careful decoupling is arranged throughout, and the whoe unit is built into a screened box with capacitive feedthrough terminations.

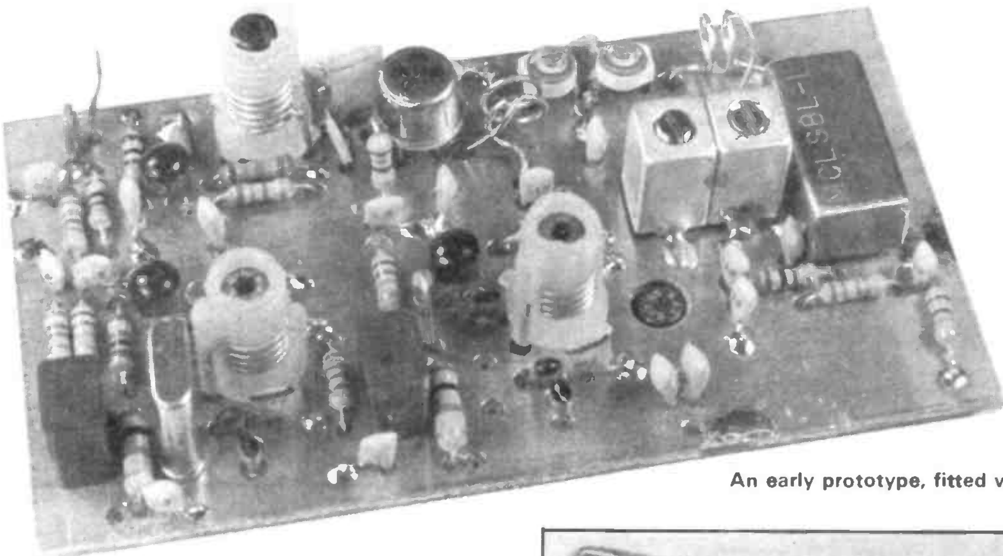
70 CM TO 2 M & TV CONVERTER.



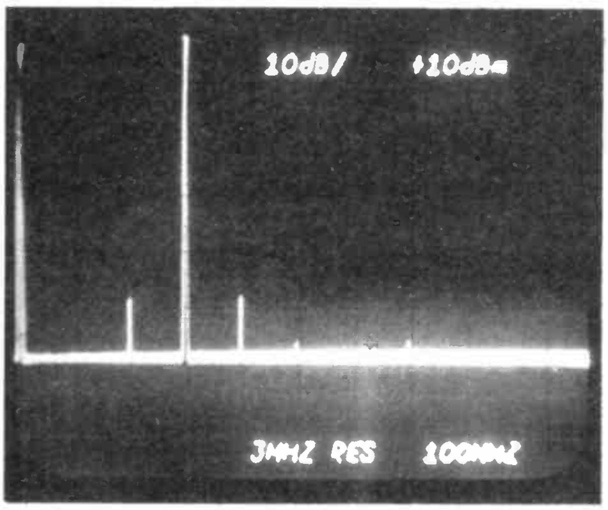
Bandpass response of converter (fitted with one filter). Centre frequency 435 MHz, 10MHz 10 MHz/division horizontal; 10 dB/division vertical.



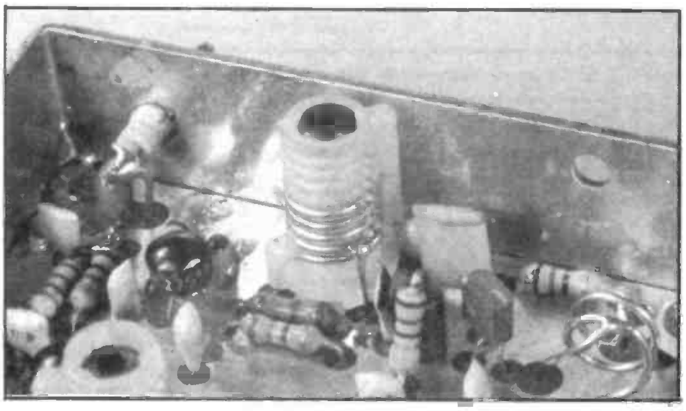
Bandpass response of converter (fitted with both helical filters). Centre frequency 430 MHz, 10MHz/division horizontal; 10dB/division vertical.



An early prototype, fitted with one helical filter.

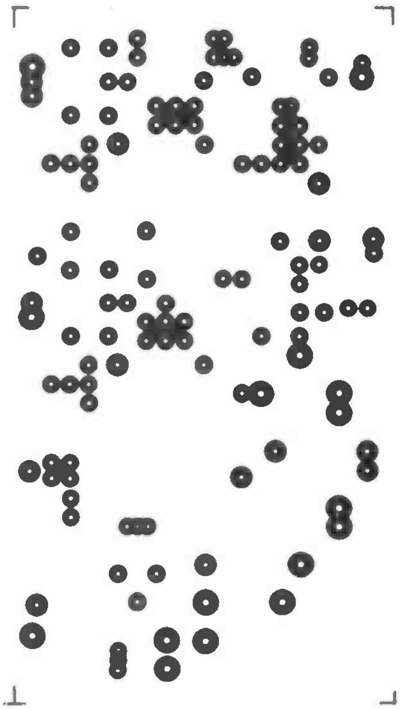


Analyser photo' showing the excellent output purity of the local oscillator; all spurious is greater than 46 dB down on the wanted signal, Centre frequency is 490 MHz, horizontal = 100 MHz/div, vertical = 10 dB/div.

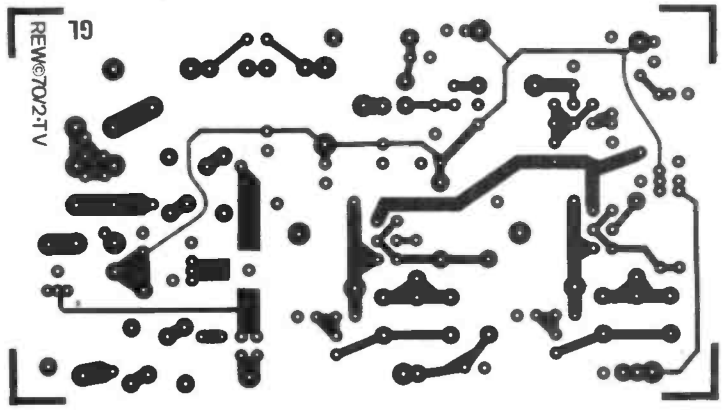


Details of L5.

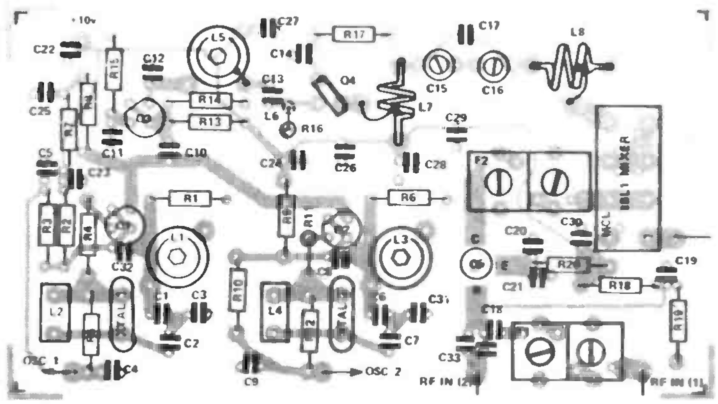
Communications RF Input Freq. (MHz)	IF output (Communications) (MHz)	IF output ATV (MHz,Channel)	Crystal Frequency MHz
432-434	144-146		
432-438	144-148	722-728	96.0000
434-436	144-146	724-730	96.6667
436-438	144-146	726-732	97.3333
436-440	144-148		
438-440	144-146	728-734	98.0000



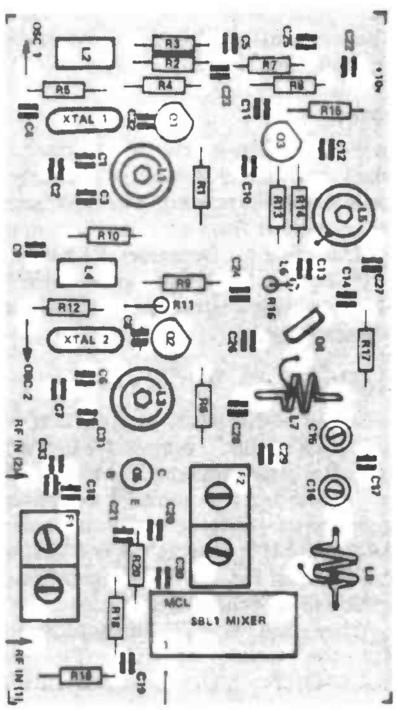
PCB Foil Pattern – Top .



PCB Foil Pattern – Bottom.



PCB Component Overlay.



PCB Component Overlay.

COMPONENTS LIST.

RESISTORS (¼W, 5%)

R1,6	2k7
R2,9	12k
R3,10	8k2
R4,11	27R
R5,12	1k0
R7	680R
R8,15,20	100R
R13	6k8
R14	1k5
R16,17	180R
R18	2k2
R19	10k

CAPACITORS (Miniature ceramic, 0.1" spacing).

C1,2,6,7	18p
C3,13,31	47p
C4,5,9,11 23,24,25 26,27,29	1n0
C8,32	5p6
C10,18,19 20,21,28, 30,33	560p
C12	10p
C14	100p
C17	1p0
C15,16	1-6p0 minature ceramic variable.
C22	100n monolithic ceramic.
C34,35,36	1n0 feedthru.

SEMICONDUCTORS.

Q1,2,3	BF274
Q4	ZTX327/ZTX3866
Q5	BFT95

INDUCTORS.

L1,3	4½ turn coil
L2,4	1uH
L5	4½t tapped at 1¼t.
L6	Ferrite bead on lead of R16 (FB2)
L7,8	2t 20swg t.c wire spaced 1 mm. 5 mm inside dia, tapped at ½t (photo).
L9,10	Printed on PCB.

HELICAL FILTERS.

F1 (optional)	Toko 252 MN 1132A F2
	Toko 252MN 1111A

MISCELLANEOUS.

SK1,2	4-hole-fixing BNC socket
Box	SCB3 **(R&EW)**
X1,2	Crystals (see text).
Mixer	SBL-1
PCB	Double-sided fibreglass

possible. Check through the photographs and diagrams herein to establish the correct constructional procedure. Note that components with an earth connection (barring mixer and filters) have one lead formed at right angles to the end soldered to the earth plane (topside). This is easier than soldering to both the earth plane and the pad on the track side of the PCB.

The layout has been designed to accommodate either BF274 devices or 'centre base' types (2N918 etc.). Take care to use the correct holes for Q 1,2,3. The tripler stage, Q 4, may be a ZTX/2N3866, in which case R 17 is 68 R - but comparative tests indicate that the ZTX327 is a shade better suited in view of the supply voltage (10 V).

Assembly points.

1. Thread some tinned copper wire (resistor lead trimmings will do) through the earth holes around the mixer, and solder top and bottom. Make certain that this does not raise the mixer more than a mm or so from the face of the PCB.
2. Solder all the resistors to the PCB - and don't forget the ferrite bead (L 6) over the hot end of R 16.
3. Fit F 2 (and F 1 if required). Solder the pins to the track side, and the can to the topside as well.
4. Solder L 5 to the PCB - care must be taken to attach the tap at 1.25 turns from the Q 3 collector end. This is best achieved by soldering a piece of 22 SWG to the PCB and forming it so that it just touches L 5 at the correct point. Briefly (or the coil former will melt) tin the tap point on L 5 with a fine tipped iron, and then the tap soldering process should be completed quickly.
5. Wind L 7 and L 8 (2 turns on a 5 mm diameter drill bit), and form the leads as shown if *Fig 3.* Solder to the PCB. Fit the taps, at ½ a turn, to L 7 and L 8 as described for L 5.
6. Fit C 15 and C 16 as shown in *Fig 4.* This will keep the tuning screw at ground potential, making adjustment far easier.
7. Fit the remaining capacitors.
8. Fit the remaining components, taking care to observe the mixer orientation and the transistor pinouts.
9. Solder about 2 cm of wire to the external input/output points indicated on the PCB.

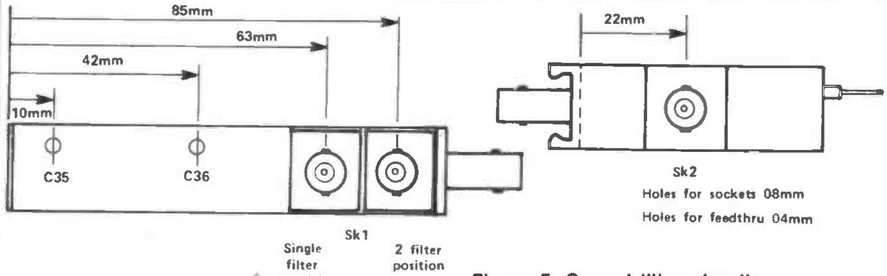


Figure 5: Case-drilling details.

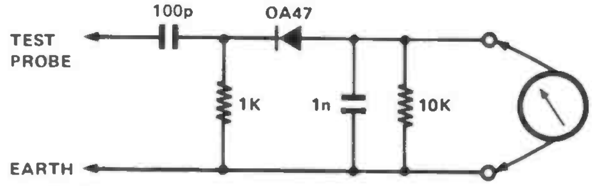


Figure 6: Method of setting-up the system for optimum performance.

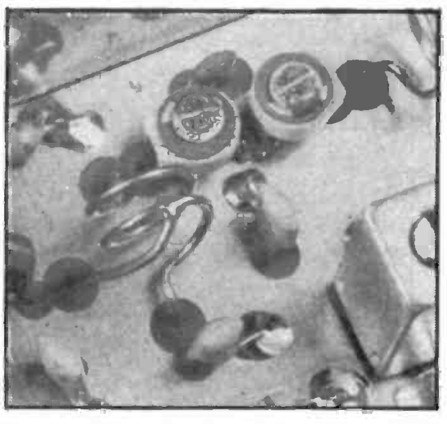


Figure 4: Mounting details for C15 and C16.

Finally.

1. Drill the box (WR&E 21-06052) as shown in *Fig 5.* and fix the feedthrough capacitors and sockets into place.
2. Place the PCB in the box and solder the lugs to the earth plane - take care not to overheat the whole thing. Solder the PCB to the earth plane close to the RF terminations.
3. Complete the external connections to the feedthroughs and the sockets.

Testing.

1. Perform the usual visual checks for solder bridges and incorrect insertions.
2. Adjust the cores of L 1 and L 3 to about 2 mm below the top of the formers. The core of L 5 should be level with the top of the former - and C 15, C 16 to mid position (slot in line with the pins).
3. Connect a 10 V power supply (preferably one with current limiting at 100 mA), and check that the current consumed is not excessive. It should be around 18 mA with neither crystal oscillator connected.
4. Connect a test meter between Q 3 emitter and earth. An initial voltage of about 1 V should be observed. Earth the centre of C 35 to turn on Q 1
5. Connect a test meter to Q 4 emitter. Adjust L 1 until a reading is obtained and adjust L 5 for maximum reading for Q 2 after earthing C 36 centre. Switch between Q 1 and Q 2 whilst adjusting L 5 to ensure an even level on both frequencies.
6. Using either an RF millivoltmeter of diode probe *(Fig 6)*, adjust C 15 and C 16 for maximum RF voltage at the output tap on L 8. With the oscillator chain correctly aligned, the current consumption will have risen to approx. 28 mA

If additional test equipment is available (i.e. spectrum analysers), further adjustment of such things as F 1 and F 2 may be undertaken.

Notes.

Since the oscillators are DC switched, the switch may be mounted as remotely as you like (within reason). The 10 V supply can be derived from an LM317 or similar (see Data File 1 - December **R&EW**).

If there is sufficient interest, we will follow up with a complete PSU, case and switching system.

Results.

Using the converter in conjunction with an FT290 (mic removed to avoid accidental transmission), the converter out performs most commercial counterparts - with the added convenience of 432-440 MHz coverage. The FT290 was modified for 144-148 MHz operation - a simple job of programming links.

When used for ATV, the improvement over the usual modified TV tuner (ELC1043/05 with modified BFR91 input) was significant. Using a chequer board pattern source, the pattern was resolvable down to an input of 7uV.

Your Reactions.........	Circle No.
Immediately Applicable	176
Useful & Informative	177
Not Applicable	178
Comments	179

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Buy Ambit's new concise component catalogue and get £1 vouchers. Use them for a £1 discount per £10 spent. But even without this, you will still find WR&E offers the low prices, fast service and technical support facility second to none. Here are some examples from the current issue:

I.C. SOCKETS

A range of high quality, low cost, low profile DIL sockets ideally suited for both the OEM and hobbyist. All types feature double sided phospher bronze contacts, tin-plated for low contact resistance.

8 x 0.3"	12p	22 x 0.3"	20p
14 x 0.3"	13p	22 x 0.4"	20p
16 x 0.3"	13p	24 x 0.6"	22p
18 x 0.3"	18p	28 x 0.6"	25p
20 x 0.3"	19p	40 x 0.6"	35p
20 x 0.4"	19p	42 x 0.6"	38p

DISCRETES

BC237	8p	BC556	12p		
BC238	8p	BC550	12p	2SK168	35p
ZTX238	9p	BC560	12p	J310	69p
BC239	8p	BC639	22p	J176	65p
BC307	8p	BC640	23p	40823	65p
BC308	8p	2SC1775A	22p	3SK45	49p
BC309	8p	2SA872A	18p	3SK51	54p
BC413	10p	2SD666A	30p	3SK60	58p
BC414	11p	2SB646A	30p	3SK88	99p
BC415	10p	2SD668A	30p	MEM680	75p
BC416	11p	2SB648A	40p	BF960	99p
BC546	12p	BF256	38p	BF961	70p
		2SK55	28p	BF963	99p

VOLTAGE REGULATORS

78XX1A TO-220 pos	0.58
79XX1A TO-220 neg	0.60
78G 1A TO-220 adj pos	1.10
78G 1A TO-3 adj pos	3.95
78H5A TO-3 5v pos	4.25
78H5A TO-3 12v pos	5.45
78HG5A TO-3 adj pos	7.45
79HG5A TO-3 adj neg	7.45
LM317.5A adj pos	1.30
LM337.5A adj neg	1.75
78S401.5A adj pos sw reg	1.20

XTALS

1MHz	3.00
3.2768MHz	2.00
4MHz	1.70
4.194MHz	1.70
4.43MHz	1.25
5MHz	2.00
6.5536MHz	2.00
7MHz	2.00
8MHz	2.00
9MHz	2.00
10MHz	2.00
11MHz	2.00

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CMOS

4000	0.13
4001	0.13
4002	0.13
4007	0.15
4008	0.70
4008AE	0.80
4009	0.30
4010	0.30
4011AE	0.24
4011	0.15
4013	0.32
4015	0.64
4016	0.30
4017	0.45
4019	0.38
4020	0.58
4021	0.68
4022	0.64
4023	0.15
4024	0.45
4025	0.15
4026	1.05
4027	0.50
4028	0.50
4029	0.75
4030	0.35
4035	0.75
4040	0.68
4042	0.58
4043	0.65
4043AE	0.93
4044	0.64
4046	0.69
4047	0.69
4049	0.30
4050	0.30
4051	0.65
4052	0.65
4053	0.65
4054	1.30
4055	1.30
4056	1.30
4059	5.75
4060	0.88
4063	1.15
4066	0.34
4067	4.30
4068	0.18
4069AE	0.18
4070	0.18
4071	0.18
4072	0.18
4073	0.18
4075	0.18
4076	0.60
4077	0.18
4078	0.18
4081	0.18
4082	0.18
4093	0.41
4099	0.93
4175	0.90
4502	0.79
4503	0.48
4506	0.63
4507	0.38
4508	1.95
4510	0.66
4511	0.66
4512	0.70
4514	1.45
4515	1.45
4516	0.75
4518	0.40
4520	0.75
4521	1.60
4522	0.89
4527	0.89
4528	0.78
4529	0.89
4531	0.85
4532	1.20
4534	5.30
4536	3.00
4538	0.97
4539	0.89
4543	1.05
4549	3.50
4553	3.20
4554	1.30
4555	0.48
4556	0.53
4557	2.30
4558	0.89
4559	3.80
4560	1.75
4561	2.18
4562	0.89
4566	3.80
4568	1.45
4569	1.50
4572	1.95
4580	3.25
4581	1.50
4582	1.65
4583	0.80
4584	0.45
4585	0.45
4702	4.50
4703	4.48
4704	4.24
4705	4.24
4706	4.50
4720	4.00
4723	0.95
4724	0.95
4725	2.24
40014	0.54
40085	0.99
40098	0.54
40106	0.69
40160	0.68
40161	0.69
40162	0.69
40163	0.69
40174	0.69
40175	0.69
40192	0.75
40193	0.75
40194	0.69
40195	0.69

TTL N

7400N	0.10
7401N	0.10
7402N	0.20
7403N	0.11
7404N	0.12
7405N	0.12
7406N	0.22
7407N	0.22
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7409N	0.15
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7444N	0.62
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74105	0.62
74107	0.26
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74390N	1.85
74393N	1.85
74490N	1.85

74LSN

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74LS01N	0.11
74LS02N	0.12
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74LS74N	0.18
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74LS390N	0.68
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74LS396N	1.99
74LS398N	2.75
74LS399N	2.30
74LS445N	1.40
74LS447N	1.95
74LS490N	1.10
74LS668N	1.05
74LS669N	1.05
74LS670N	1.70

RAM

2102	1.70
2112	3.40
2114/2	1.49
4027	5.78
4116/2	1.59
4116/3	1.49
4864P	12.50
6116P-3	12.50
6116P-4	11.25
8264	12.50

74CXX

74C00	0.20
74C02	0.20
74C04	0.20
74C08	0.20
74C10	0.20
74C14	0.55
74C20	0.20
74C30	0.20
74C32	0.20
74C42	0.80
74C48	1.03
74C73	0.50
74C74	0.50
74C76	0.48
74C83	0.98
74C85	0.98
74C86	0.26
74C89	2.68
74C90	0.80
74C93	0.80
74C95	0.94
74C107	0.48
74C151	1.52
74C154	2.26
74C157	1.52
74C160	0.80
74C161	0.80
74C162	0.80
74C163	0.80
74C164	0.80
74C165	0.84
74C173	0.72
74C174	0.72
74C175	0.72
74C192	0.80
74C193	0.80
74C195	0.80
74C200	4.52
74C221	1.06
74C901	0.38
74C902	0.38
74C903	0.38
74C904	0.38
74C905	5.64
74C906	0.38
74C907	0.38
74C908	0.84
74C909	1.52
74C910	3.62
74C914	0.86
74C918	0.98
74C925	4.32
74C926	4.32
74C927	4.32

Processors

8080 series

8080AFC/2	3.11
8212	1.70
8214	3.50
8216	1.41
8224	1.85
8251	4.26
8255	3.97

6800/6809

6800P	3.75
68A00	4.25
68B00	4.75
6802	5.55
6809	15.00
6810	1.75
68A10	1.85
68B10	2.04
6820	1.95
6821	1.75
68A21	2.10
68B21	2.34
6840	4.25
68A40	4.55
68B40	4.75
6850	1.75
68B50	2.17
6852	2.47
68A52	2.75
68B52	2.95
68488	5.25

Z80 series

Z80A	4.99
Z80AORT	7.50
Z80APIO	4.10
Z80ASIO/1	14.00
Z80ASIO/2	14.00
Z80ASIO/9	14.00
Z80CTC	4.00
Z80ACTC	4.50
Z8001	65.00

PROM

2708	2.00
2716	3.55
2532	8.50
2732	8.50

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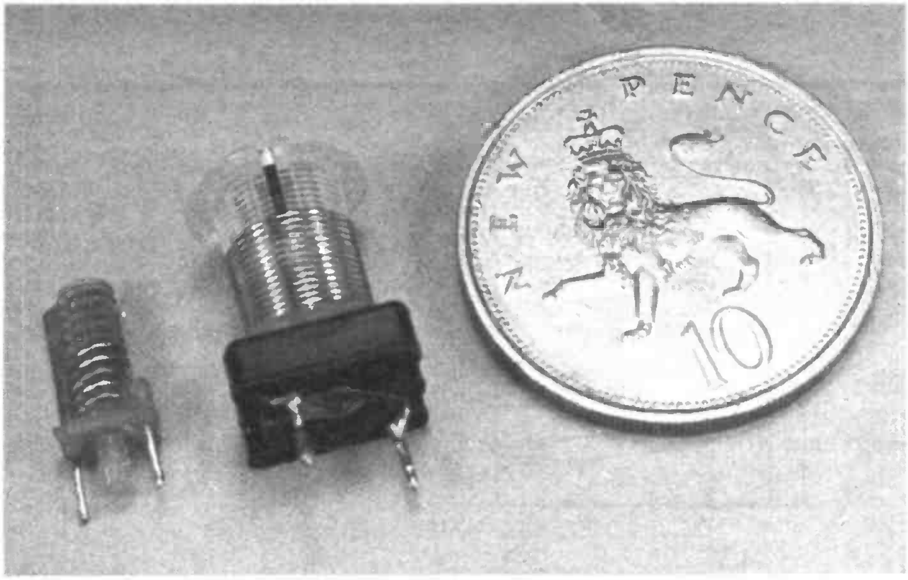
AMBIT international 200 North Service Road, Brentwood, Essex

41 for further details



Helical filters to simplify VHF/UHF receiver design

Peter Williams

As demonstrated in Timothy Edwards' VHF and UHF converter designs, the helical filter is the VHF/UHF RF designers' friend where consistency, performance and High Q are required above 100MHz.

Off the shelf

Since the Japanese coil and filter manufacturer TOKO added helical filters to their ranges of 'stock types', it has been a lot easier for VHF/UHF designers to get to grips with block selectivity, in much the same way as crystal and ceramic filters have taken a lot of the chore out of IF design.

If today's design engineer is to be able to get to grips with the multi-disciplinary aspects of radio design, then any time saved grinding through the tedium of LC selectivity design followed by the inevitable 'wet fingered' bread-board engineering, must be a good thing.

However, it is important that the helical filter should be appreciated from a theoretical as well as practical standpoint, so that the limitations and constraints placed upon the filter manufacturer may be better understood. Problems and 'strange' results from practical tests can also be more readily identified and cured if you know what you are looking for.

An introduction

It is just about possible to design a helical resonator from around 10MHz, although more elegant and compact alternatives exist up to around 100MHz. The basic principle of the helical resonator is that it should be a quarter wavelength section of transmission line in a virtually lossless dielectric medium. The 'Q' factor available approaches that of a resonant cavity, so it follows that the 'hot' RF end of the helix is at a very high impedance indeed.

Although it is tempting to regard a helical resonator that is trimmed with a capacitor as an LC tuned circuit - the temptation should be avoided, or the unwary will easily be led astray. When you consider the size of a helical resonator for 145MHz, placed alongside a 145MHz LC tuned circuit, the difference in size is dramatic *(Photo one)*.

Since the Q of the whole assembly will be drastically affected by that of the trimmer capacitor, the preferred trimming technique is to employ the helix to ground capacitance at the 'hot end' *(Figure 1)* under controlled conditions. The capacitance is kept to a minimum so as to avoid disturbing the Q of the resonator, and it follows that the possibility of small changes leading to large shifts in resonance due to thermal or vibrational considerations, must be considered in the overall design. The solution adopted by TOKO is to use a fine thread on a grounded brass slug that can be used to trim the 'case' distance from the hot end of the helix. Contact between the slug and the case is maintained by a spring washer.

The other considerations usually applicable to high Q inductor design still apply -namely the bigger the helix diameter, the larger the wire gauge and silver plating will help the cause.

The analysis for the helical resonator is another battle ground for the sort of large sums that are calculated to send the average maths lecturer into paroxysms of ecstacy, but leave us lesser mortals rather cold. Ref 1 and 2 contain the elegant mathematical considerations, although as with most things in the art of radio, an approximation exists which results in a practical conclusion that is well within the bounds of 'experimental' error in the practical domain. Practical RF Communications Data (Ref 3) to the rescue again. *(Figure 2 - design NOMOGRAM)* ▶

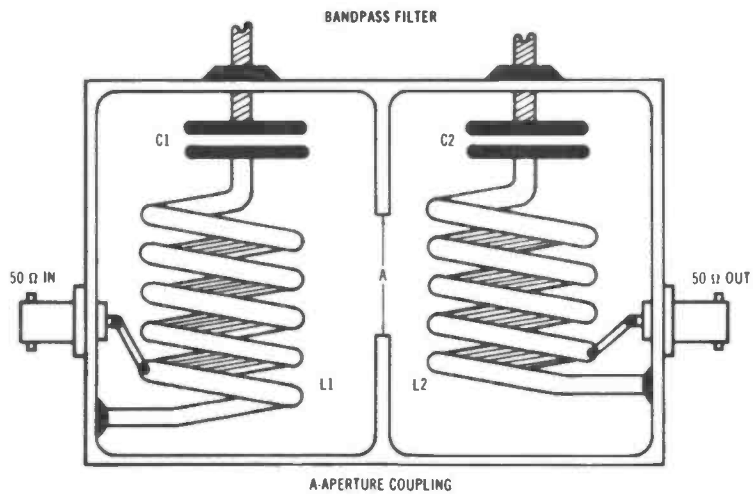


Figure one : Typical helical filter construction

The unloaded Q of this resonator is found from:

$$Qu = 50D\sqrt{fo} \qquad (1)$$

where
D is the diameter of the 'cavity' in inches
fo is the resonant frequency in MHz
The number of coil turns, N may be found from:

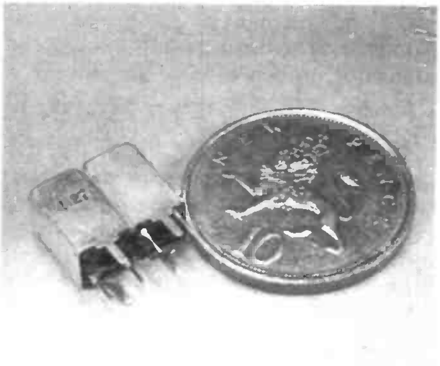
$N = 1900/foD$

and the mean distance between the turns is given by:

$\gamma = (foD^2/2300)$ inches

if (according to *Figure 2* Resonator and cavity dimensions) B is approx = $(b + D/2)$ and y is less than $d/2$.

The Helical Filter



TOKO 7HW UHF 2 pole filter

After the resonator comes the filter array, and since the ratio of the resonator Q (Qr) and the filter Q (Qf) are directly related to the insertion loss (IL), the approximation

Insertion Loss (IL) =

$$\frac{4.343\ Qf}{Qr} \cdot \sum_{K=1}^{N} Xk$$

where N is the order of the filter
Qr is the resonator Q
Qf is the filter Q
Xk is the normalized lowpass element value for the filter type employed.
(See the tables)

So taking the example of a filter centred at 460MHz, with a 3dB bandwidth of 10MHz, 50dB bandwidth of better than 90MHz, with an insertion loss of 1.0dB,

$$Qr = \frac{(4.343)\ Qf}{IL} \cdot \sum_{K=1}^{3} Xk$$

where a 3rd order Butterworth characteristic has been chosen to suit the required spec.

from tables for Butterworth filter:
X1=1, X2=2, X3=1
so

$$Qr = \frac{(4.343)\ (460\times10^6)}{(1.0)\ (10\times10^6)} \cdot 4 = 800$$

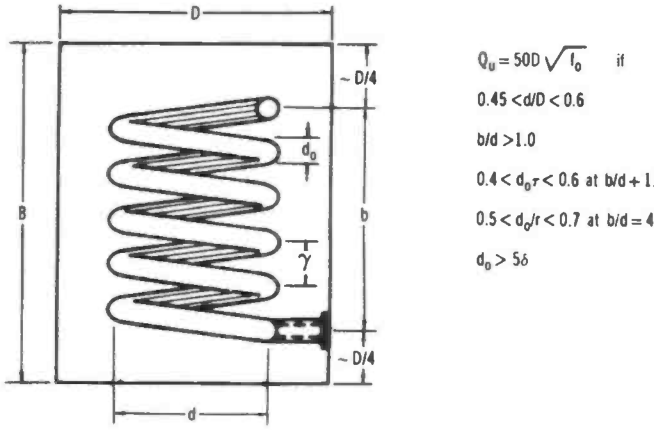
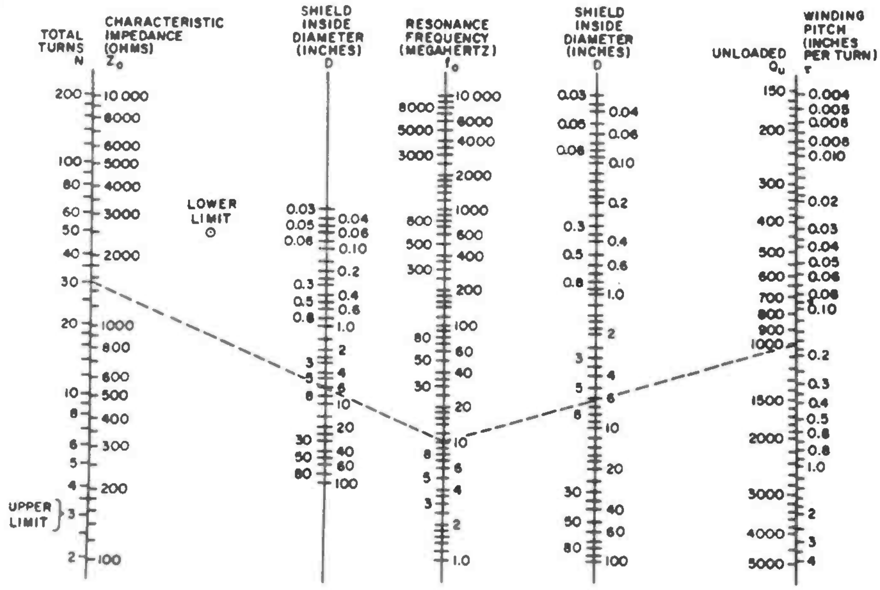
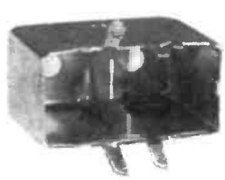


Figure 2: Design nomograph for helical resonators



Coupling the helical elements to form the filters is determined according to *(see Figure 3)*:

$$A_{ij} = d(1.075)10^{\frac{1}{1.91}\log_{10}\left(\frac{BW_{3dB}}{(0.071)(fo)(X_i X_j)}\right)}$$



where A is the coupling height between resonators one and two, in inches, with a shield thickness of 1/32". In practice, there is a large degree of cut and try in any prototype work involving helical filters, so some means of adjusting coupling is a good idea. *(Figure 4)*

Tapping in

The impedance match can be provided by selecting the right place to tap in, according to:

$$\text{Tap Point (TP)} = N\Theta$$

$$\text{Tap Point (TP)} = \frac{N\Theta}{90}$$

where:

N is the total turns on the resonator

$$\Theta = \text{Arcsin}\ \frac{R_b\, R_{tap}}{2\, Z_0^2}$$

$$R_{tap} = 50\Omega$$

$$R_b = \frac{\pi Z_0}{4} \cdot \left(\frac{1}{Q_d} - \frac{1}{Q_r}\right)$$

$$Z_0 = \frac{8.51 \times 10^{10}}{f_0 D}$$

D is found from the nomogram

$$Q_d = \frac{f_0 X_1}{2\, BW_{3dB}}$$

Q_r = 800 (already established from IL)

A 50 ohm tap will be found to be about 0.2 turns above ground - and this is of course difficult to locate. In many cases, trying to find a good 50 ohm match can lead to other problems (usually increased insertion loss), so there is a tendency to try and settle for a 'convenience' impedance achieved by a tap at least one turn in - say around 470 ohms in the case of the TOKO CBT/CBW series of VHF filters. N is the total number of turns on the resonator.

Other techniques

In view of the difficulty of tapping a helical resonator, one alternative solution is to continue the helix onto the surface of the PCB on which the resonator is mounted, so that the tap can then be made via the PC track tapping.

The stock solutions

TOKO helical resonators/filters are available in two basic ranges - from 130 to 170MHz in the 2 chamber CBT and CBW series. The UHF series includes the miniature 7 HW style of 2 chamber filters, and the much larger format HRQ (4 chamber) and HRW (2 chamber) types.

All these types may be trimmed by about 7% of the nominal centre frequency, but much beyond these limits, the characteristics can begin to change fairly substantially.

The CBT/CBW and 7HW types can be dismantled to provide the necessary parts for rewinding to your own specification if required, but the large format UHF series uses a technique whereby the helix is molded into a rigid low loss plastic 'former' that is not easily taken to pieces. You can still have a fiddle with the coupling apertures by adjusting the screen positions, but not much else.

References

1. Zverev, A.I. - Handbook of filter synthesis: Wiley, New York, 1967.
2. Humphreys, DeVerl S. - The Analysis, Design, and Synthesis of Electrical Filters, Prentice Hall, 1970.
3. DeMaw M.F. - Practical RF Communications Data: Howard Sams & Co., Indianapolis, 1978.

■ R & EW

Your Reactions.........	Circle No.
Immediately Applicable	160
Useful & Informative	161
Not Applicable	162
Comments	163

TABLE 1: Butterworth Normalized Element Values

Order	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
2	1.4142	1.4142								
3	1.0000	2.0000	1.0000							
4	0.7654	1.8478	1.8478	0.7654						
5	0.6180	1.6180	2.0000	1.6180	0.6180					
6	0.5176	1.4142	1.9319	1.9319	1.4142	0.5176				
7	0.4450	1.2470	1.8019	2.0000	1.8019	1.2470	0.4450			
8	0.3902	1.1111	1.6629	1.9616	1.9616	1.6629	1.1111	0.3902		
9	0.3473	1.0000	1.5321	1.8794	2.0000	1.8794	1.5321	1.0000	0.3473	
10	0.3129	0.9080	1.4142	1.7820	1.9754	1.9754	1.7820	1.4142	0.9080	0.3129

TABLE 2: Chebyshev 0.01 dB Ripple Normalised Element Values

Order	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
2	1.3472	1.4830								
3	1.1811	1.8214	1.1811							
4	0.9500	1.9382	1.7608	1.0457						
5	0.9766	1.6849	2.0367	1.6849	0.9766					
6	0.8514	1.7960	1.8411	2.0266	1.6312	0.9372				
7	0.9127	1.5947	2.0021	1.8704	2.0021	1.5947	0.9127			
8	0.8145	1.7275	1.7984	2.0579	1.8695	1.9796	1.5694	0.8966		
9	0.8854	1.5513	1.9615	1.8616	2.0717	1.8616	1.9615	1.5513	0.8854	
10	0.7970	1.8930	1.7690	2.0395	1.8827	2.0724	1.8529	1.9472	1.5380	0.8773

TABLE 3: Chebyshev 0.1dB Ripple Normalized Element Values

Order	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
2	1.2087	1.6383								
3	1.4329	1.5937	1.4329							
4	0.9924	2.1476	1.5845	1.3451						
5	1.3013	1.5559	2.2411	1.5559	1.3013					
6	0.9419	2.0798	1.6581	2.2473	1.5344	1.2767				
7	1.2615	1.5196	2.2393	1.6804	2.2393	1.5196	1.2615			
8	0.9234	2.0455	1.6453	2.2826	1.6843	2.2300	1.5091	1.2516		
9	1.2447	1.5017	2.2220	1.6829	2.2957	1.6829	2.2220	1.5017	1.2447	
10	0.9147	2.0279	1.6346	2.2777	1.6962	2.2991	1.6805	2.2155	1.4962	1.2397

TABLE 4: Chebyshev 0.3 dB Ripple Normalized Element Values

Order	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
2	1.0710	1.8171								
3	1.6854	1.3985	1.6854							
4	0.9601	2.3969	1.4127	1.6290						
5	1.6010	1.4039	2.4956	1.4039	1.6010					
6	0.9343	2.3676	1.4802	2.5116	1.3954	1.5853				
7	1.5756	1.3891	2.5116	1.4991	2.5116	1.3891	1.5756			
8	0.9248	2.3493	1.4784	2.5623	1.5042	2.5084	1.3846	1.5692		
9	1.5648	1.3813	2.5049	1.5053	2.5662	1.5053	2.5049	1.3813	1.5648	
10	0.9204	2.3395	1.4745	2.5537	1.5154	2.5713	1.5050	2.5018	1.3788	1.5617

TABLE 5: Chebyshev 0.5dB Ripple Normalized Element Values

Order	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
2	0.8341	2.2185								
3	1.8637	1.2804	1.8637							
4	0.9202	2.5865	1.3036	1.8259						
5	1.8069	1.3025	2.6915	1.3025	1.8069					
6	0.9053	2.5775	1.3675	2.7134	1.2990	1.7962				
7	1.7896	1.2961	2.7177	1.3848	2.7177	1.2961	1.7896			
8	0.8998	2.5671	1.3697	2.7585	1.3903	2.7176	1.2938	1.7853		
9	1.7823	1.2921	2.7163	1.3922	2.7734	1.3921	2.7163	1.2921	1.7823	
10	0.8972	2.5611	1.3683	2.7632	1.4009	2.7796	1.3927	2.7148	1.2908	1.7801

TABLE 6: Chebyshev 1.0dB Ripple Normalized Element Values

Order	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
2	0.8341	2.2185								
3	2.2157	1.0884	2.2157							
4	0.8310	2.9813	1.1208	2.2104						
5	2.2072	1.1280	3.1025	1.1280	2.2072					
6	0.8291	3.0056	1.1788	3.1353	1.1300	2.2052				
7	2.2039	1.1306	3.1470	1.1937	3.1470	1.1306	2.2039			
8	0.8283	3.0077	1.1849	3.1903	1.1994	3.1518	1.1308	2.2031		
9	2.2025	1.1308	3.1540	1.2020	3.2077	1.2020	3.1540	1.1308	2.2025	
10	0.8279	3.0076	1.1862	3.2006	1.2091	3.2159	1.2033	3.1550	1.1307	2.2020

TABLE 7: Gaussian Magnitude Normalized Element Values

Order	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
2	2.1850	0.4738								
3	2.2262	0.8167	0.2624							
4	2.2450	0.9321	0.5302	0.1772						
5	2.2533	0.9782	0.6485	0.3896	0.1312					
6	2.2568	0.9982	0.7050	0.5004	0.3045	0.1026				
7	2.2583	1.0073	0.7333	0.5606	0.4055	0.2473	0.0833			
8	2.2590	1.0116	0.7479	0.5942	0.4658	0.3388	0.2065	0.0695		
9	2.2593	1.0137	0.7556	0.6134	0.5025	0.3973	0.2892	0.1761	0.0591	
10	2.2594	1.0147	0.7597	0.6244	0.5250	0.4353	0.3451	0.2509	0.1525	0.0512

TABLE 8: Maximally Flat Group-Delay Normalized Element Values

Order	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
2	2.1478	0.5755								
3	2.2034	0.9705	0.3374							
4	2.2404	1.0815	0.6725	0.2334						
5	2.2582	1.1110	0.8040	0.5072	0.1743					
6	2.2645	1.1125	0.8538	0.6392	0.4002	0.1365				
7	2.2659	1.1052	0.8690	0.7020	0.5249	0.3259	0.1106			
8	2.2656	1.0956	0.8695	0.7303	0.5936	0.4409	0.2719	0.0919		
9	2.2649	1.0863	0.8639	0.7407	0.6306	0.5108	0.3770	0.2313	0.0780	
10	2.2641	1.0781	0.8561	0.7420	0.6493	0.5528	0.4454	0.3270	0.1998	0.0672

PLL FREQUENCY SYNTHESIS

Phase Locked Loop (PLL) circuits can be used to synthesize hundreds of 'spot' frequencies, all with crystal accuracy. Ian Campbell explains how in this new series.

PHASE LOCKED LOOP (PLL) BASICS

A PHASE LOCKED LOOP (PLL) circuit can be defined as a system that automatically locks the frequency and phase of a variable oscillator (*fo*) to the MEAN frequency and phase of a reference signal (*fr*). *Fig 1* shows the block diagram of the basic system, which consists of a phase detector, a loop filter, an amplifier and a voltage controlled oscillator or VCO.

The operating principle of the circuit is fairly simple. The phase detector receives the *fo* and *fr* signals, compares the phase and frequency of *fo* with that of *fr*, and generates a corresponding variable output error voltage. This error voltage is then filtered and amplified and fed to the input of the VCO in such a way that any frequency or phase differences between *fr* and *fo* are progressively reduced until they fall to zero, at which point he loop is said to be 'locked'.

The low pass loop filter is an essential part of the system. It is used to convert the output of the phase detector into a smooth DC control voltage. Inevitably, it has a finite time constant, so 'locking' is not instantaneous, and *fo* locks to the MEAN value of *fr*, rather than to it's instantaneous value. This is useful if a clean output frequency is wanted from a noisy input signal.

In practice, if the free-running frequency of the VCO is too much at variance with *fr*, the PLL will not be capable of locking the two signals. The frequency range over which the VCO can achieve locking is known as it's 'capture range'.

BASIC PLL FREQUENCY SYNTHESIS

In the basic PLL circuits of *Fig 1*, the output signal frequency simply locks to that of the input signal, and no frequency multiplication occurs. A far more useful circuit is shown in *Fig 2*. Here, a programmable divide-by-N counter is simply inserted in the feedback loop between the VCO and the phase comparator. Consequently, instead of the phase detector locking to the output frequency of the VCO, it locks to the output of the divide-by-N counter. Thus, at lock, the VCO frequency (*fo*) is 'N' times *fr*. The circuit acts as a programmable frequency multiplier.

Figure 3 shows how the above circuit can be converted into a true frequency synthesiser. Here, a 1 MHz crystal oscillator and a — 100 counter are used to generate a stable reference frequency of 10 kHz, and the programmable counter is variable from — 1000 to 1200 in two hundred discrete steps. Consequently, the output frequency of the PLL is variable from 10 MHz to 12 MHz in two hundred 10 kHz steps, with crystal accuracy in all cases.

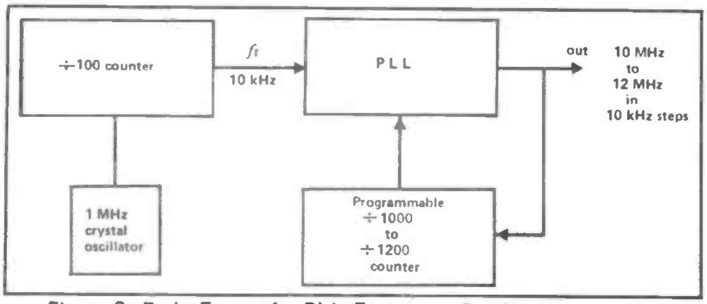


Figure 3: Basic Form of a PLL Frequency Synthesiser.

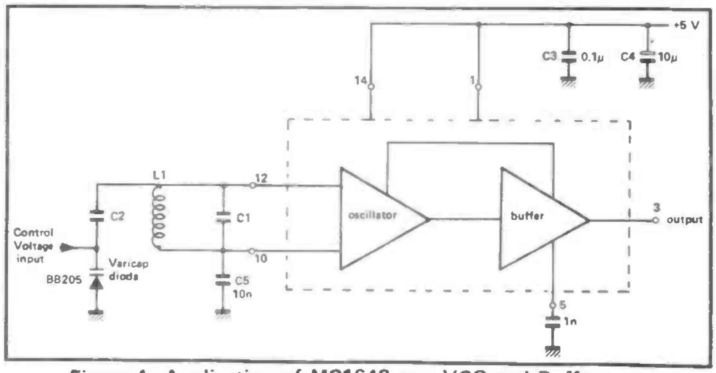


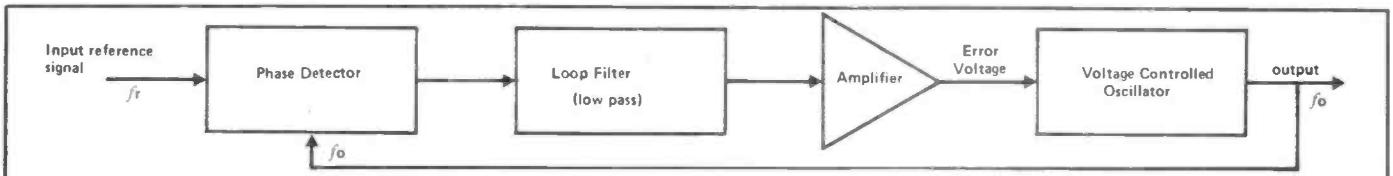
Figure 4: Application of MC1648 as a VCO and Buffer.

Note from *Fig 3* that the step magnitude of the synthesiser is equal to *fr*, and the frequency span range is determined by the range of the programmable counter and the frequency limitations of the VCO.

Now let's take a detailed look at some of the circuits which are actually used in PLL synthesisers.

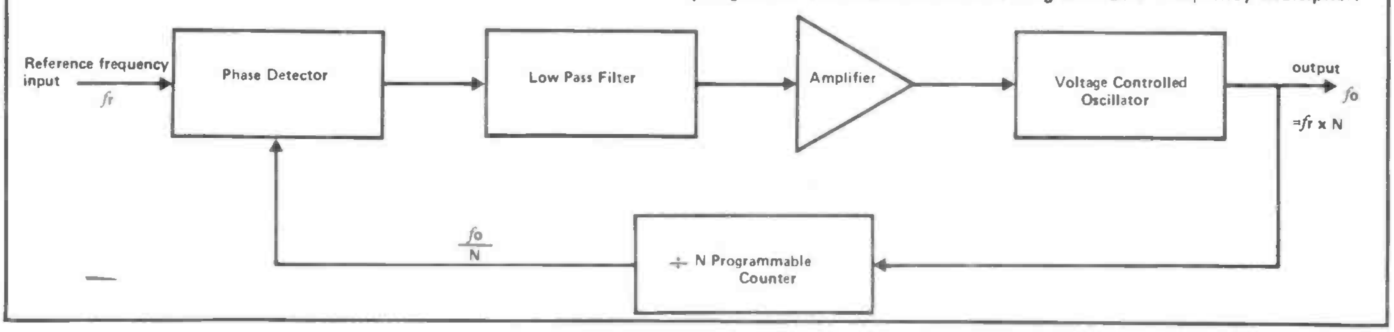
THE VCO

In high frequency synthesisers, the VCO usually takes the form of a varicap-controlled oscillator plus a buffer stage. A particularly useful 'dedicated' IC that can be used in this application is the Motorola MC1648, a high frequency oscillator-plus-buffer chip that can be used in FM tuner and CB transceiver synthesiser applications, etc. *Fig 4* shows a typical applications circuit of the device.



▲ Figure 1: Basic Phase Locked Loop.

▼ Figure 2: The Basic Form of a Programmable Frequency Multiplier.



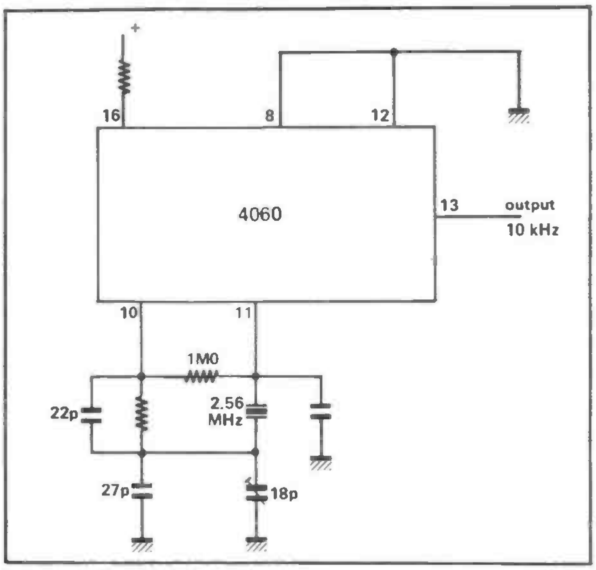


Figure 5: A Reference Oscillator/Divider in One Chip.

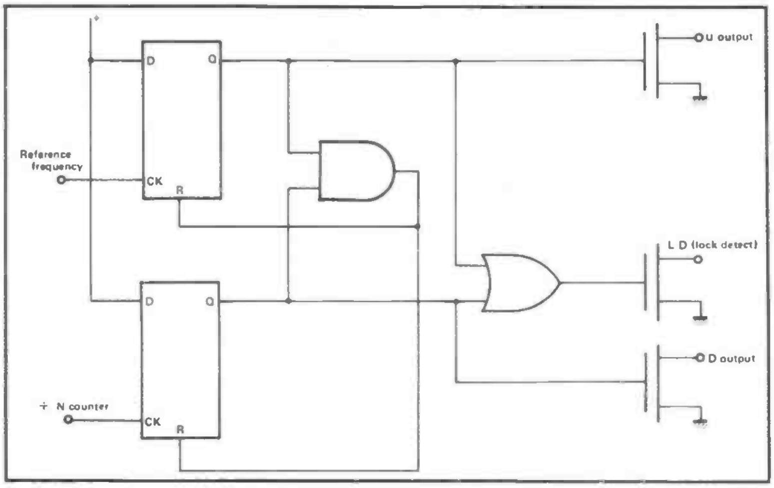


Figure 6: A Modern Phase Frequency Detector as used in the Plessey NJ8811.

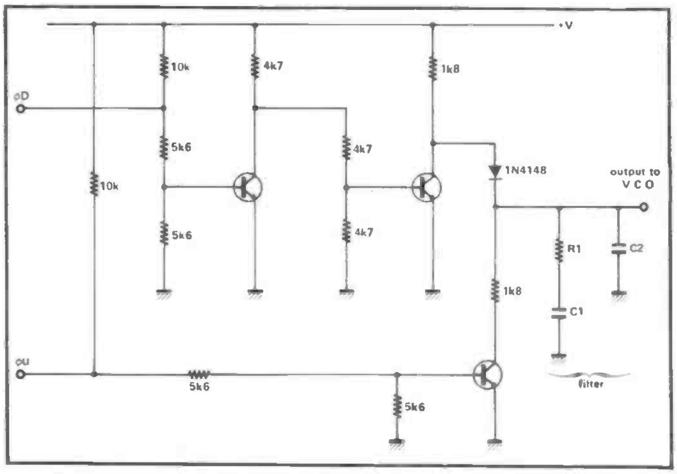


Figure 7: Charge pump and filter.

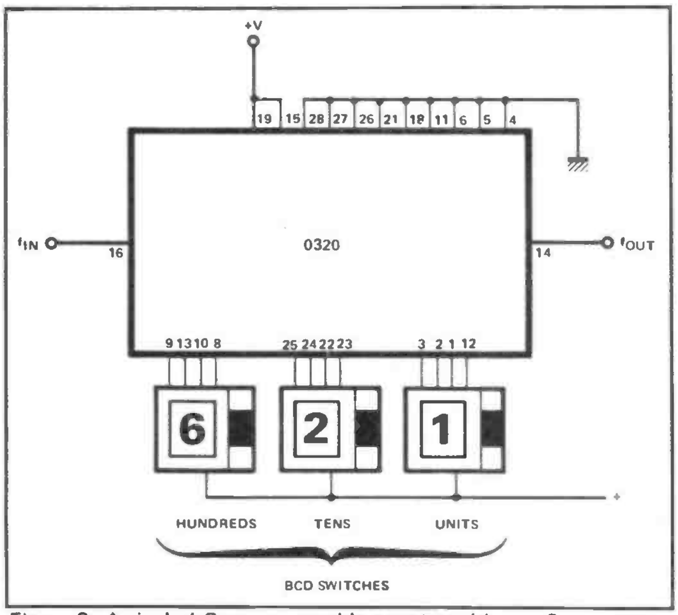


Figure 8: A single I.C. programmable counter with a – 3 to – 999 capability.

THE REFERENCE OSCILLATOR

In frequency synthesis, the reference frequency determines the step magnitude or channel spacing of the system, and usually has a value of only a few kHz. Consequently, to give the required frequency stability, the reference oscillator almost invariably consists of a crystal oscillator and a multi-stage divider network.

A one-chip reference oscillator can be built using the CMOS 4060 IC, which contains an in-built oscillator and a 14-stage binary counter. Stages 4 to 14 of the counter are externally accessible, and *Fig 5* shows how the device can be used to generate a 10 kHz reference frequency by using a 2.56 MHz crystal and taking the output from the 8th binary counter stage.

THE PHASE DETECTOR

Most modern phase detectors are digital devices and produce an output that takes the form of a series of variable duty cycle pulses, with the duty cycle controlled by the difference between the *fo* and *fr* signals. Detectors may be simple single-ended devices such as an EX-OR gate or a D-type flip-flop, or a complex multi-output multi-element network such as the circuit shown in *Fig 6*, which is the basic detector used in the Plessey NJ8812.

The Plessey circuit has outputs which are capable of responding when *fr* and *fo* are in any phase relationship, i.e. whether *fr* is leading, trailing or in phase with *fo*: The Lock Detector output can be used to activate a visual alarm (LED) or disable the transmitter section of a transceiver, etc., when the PLL is not locked.

In practical PLL applications, two of the outputs of the NJ8812 detector have to be combined via a charge pump and filter circit (see *Fig 7*) in order to provide an error control voltage that is suitable for driving the VCO.

THE DIVIDE-BY-N COUNTER

Multi-stage presettable divide-by-N counters can be configured in either of two basic ways. One method is to cascade a number of resettable decade counter/decoders so that they repeatedly count up to a pre-set number (selected via thumb wheel switches) and then reset to zero again. The alternative method is to similarly cascade a number of presettable count down dividers, so that they repeatedly preload a fixed number (selected via switches) and then count down to zero, at which point they re-load again.

The easiest way to make a presettable divide-by-N counter is to use a dedicated chip such as the 0320. *Fig 8* shows how to wire this device so that it can divide by any number in the range 3 to 999, depending on the setting of the three BCD switches.

THE LOOP FILTER

The loop filter is a prime element in the PLL system. It is required to convert the output of the phase detector into a smooth DC voltage. It's time constant must be short enough to give rapid locking without excessive overshoot, but must not be so short that the VCO 'jitters' in response to stable reference signals. ▶

PLL FREQUENCY SYNTHESIS

Figure 9 shows the basic circuit of a simple loop filter for use with a single-ended detector. The R1/R2 ratio determines the damping of the loop, and the R1-C1 values determine the roll-off frequency. A high R1/R2 ratio causes under-damping of the loop, with lots of consequent overshoot, as shown in *Fig 10a*. A low R1/R2 ratio causes under-damping (*Fig 10b*), with consequent VCO jitter. With an optimum R1/R2 ratio (*Fig 10c*), the VCO quickly stabilises to the correct frequency, with negligible overshoot and no jitter.

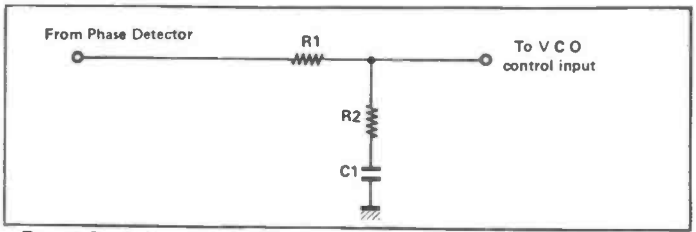


Figure 9: A simple loop filter

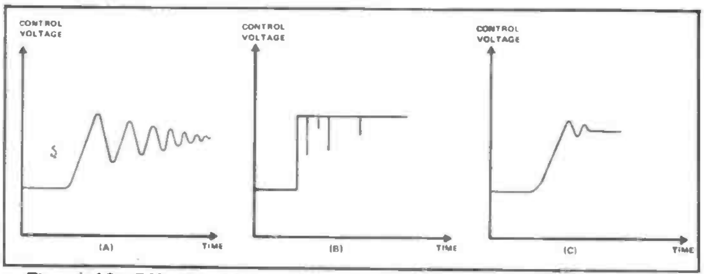


Figure 10: Effects of loop filter on VCO Control voltage.

GETTING IT ALL TOGETHER

At this point the reader may suspect that the modern PLL frequency synthesiser is a not-too-complicated device. If so, your suspicions may be confirmed by looking at *Fig 11*, which shows the block diagram of a 3-chip Plessey transceiver synthesiser that spans 26.895 MHz to 27.525 MHz on transmit and 10.695 MHz lower on receive.

Here, in the SP8921, a 1.25 kHz reference frequency is derived from a 10.24 MHz crystal and fed to one side of the phase detector, the other signal being derived from the SP1648 VCO via the SP8922 programmable divider. The output of the detector feeds to the VCO via an on-chip charge pump and via the loop filter shown in the diagram.

In the SP8921 counter, the VCO signal (nominally 27 MHz) is first prescaled by 4, so that a 6-7 MHz signal is fed to the — M counter, which is programmable via a 6 digit binary number starting with a 2, to give 10 kHz channel spacing (8 x 1.25 kHz): The R/T1 terminal and the R/T2 terminal of the SP8921 are used to program extra divisions into the counting system, to provide for transmit and receive offsets.

Note that the SP8921 contains a — P counter, which is clocked by the M counter and determines the 'load' point of channel information.

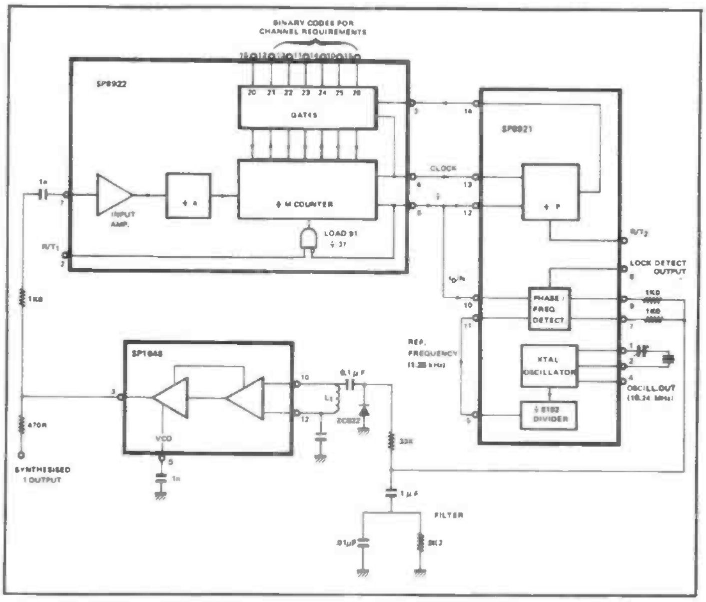


Figure 11: Plessey CB synthesiser - Block diagram.

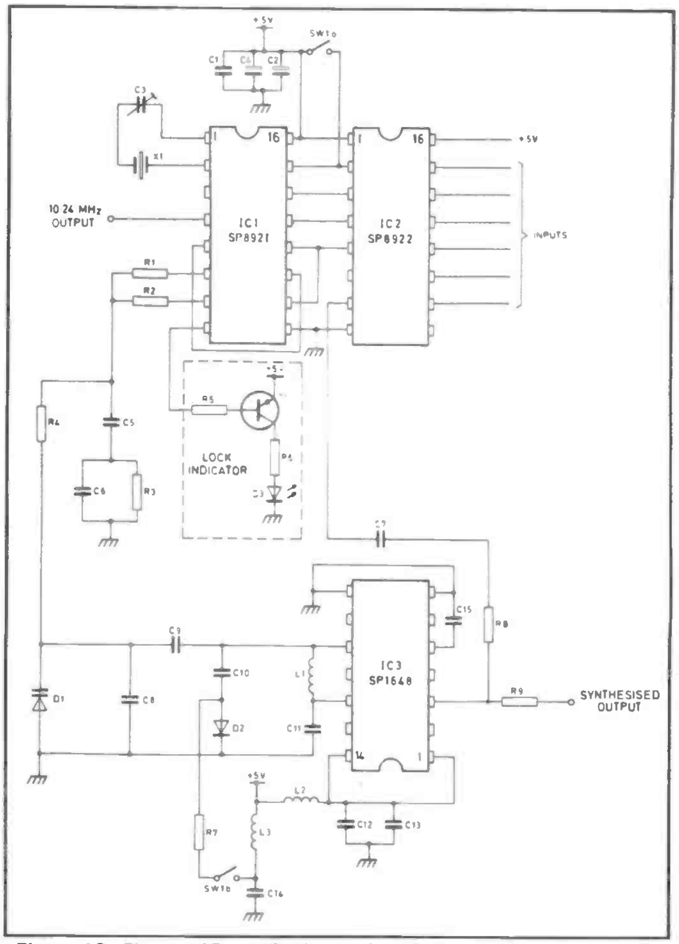


Figure 12: Plessey CB synthesiser - circuit diagram.

The overall counting action of the circuit is fairly complex. Let's call the total division of the VCO 'N'. When a — 4 pulse occurs at the M input, if the R/T terminal of the SP8922 is high, 91 is loaded into the M counter which, since it normally divides by 128, will count from 91 to 128 (37 + 1) for one cycle. If R/T1 is low the M counter divides by 128 + 1 for one cycle. The M counter then reverts to dividing by 128. The N pulse also zeroes the P counter which is programmed to count to 26 with R/T2 high and 42 with R/T2 low. Each cycle of the M counter produces a clock output which increments the P counter by 1.

When the P counter has reached 26 (or 42) in it's count, the REC output goes high for one cycle of the M counter. At the end of that cycle, M will have counter 128 x 25 or 128 x 41, plus one cycle of 38 or 129 and a clock pulse loads the channel-selecting number into the M counter, which then counts the number + 1. An N pulse then occurs and a new sequence starts. □ **R & EW**

Next month: Dual modulus prescaling.

Your Reactions

	Circle No.		Circle No.
Immediately Applicable	172	Not Applicable	174
Useful & Informative	173	Comments	175

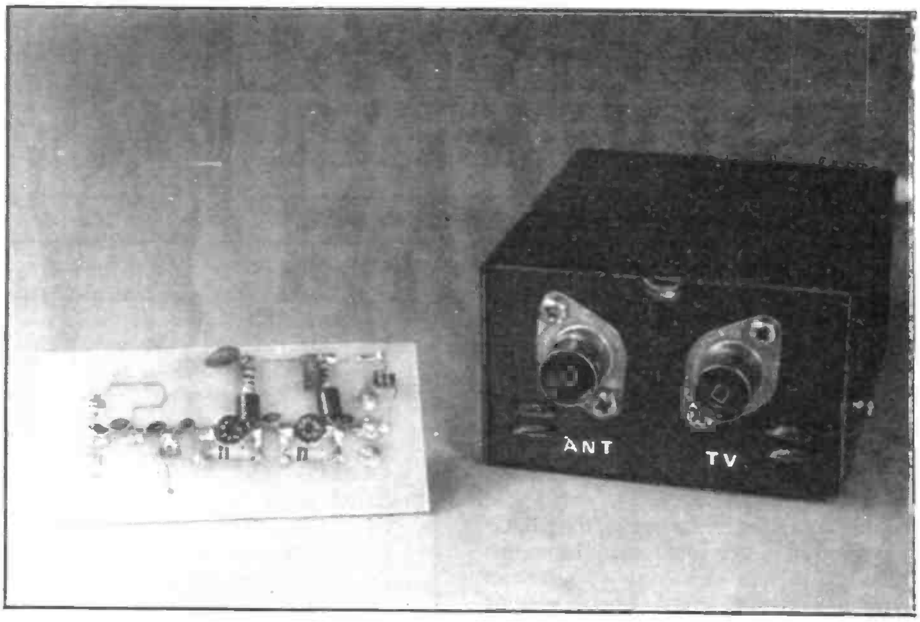
MASTHEAD TV AMPLIFIER.

Boost TV reception with this neat and rather cunning little wide-band pre-amplifier project. Design by Roger Ray.

IN WEAK SIGNAL AREAS a pre-amplifier placed between the aerial and the TV set can greatly improve picture quality. The ideal position for the pre-amp is at the aerial; failing this, a good improvement in picture quality can still be obtained if the pre-amp is simply placed next to the TV set and wired in series with the co-axial downlead.

The **R&EW** TV pre-amplifier project can be placed in any position between the aerial and the TV set and provides an overall gain of 17 dB across the 470-860 MHz range (band IV and V). It has a measured noise figure of less than 3 dB. The really 'cunning' feature of the project is that it is powered (from a special mains-powered 12 volt supply unit) via the central core of the existing co-ax cable, which thus functions as both a supply and a signal path.

Our pre-amp project can be used to simply improve picture quality in areas of weak reception, or to boost all signals and aid the reception of foreign TV signals (DXTV). It can even be used as a pre-amplifier for the 70 cm and 23 cm amateur bands. The unit has a high-pass filter built into its input stage, greatly reducing the possibility of interference from CB and from Amateur and Private Mobile Radio sources.



The Completed Unit.

CONSTRUCTION: The Pre-Amp

The project comprises two separate modules, one being the actual pre-amplifier unit, and the other the power supply (PSU). Start off by constructing the pre-amp, which is built on a small (2.55 ins x 1.2 ins) double-sided PCB, which is then fitted into a small metal box. The top side of the PCB is etched as shown in *Fig 2*, the bottom being left as an earth plane.

To start the construction, first drill the PCB as shown in *Fig 2*, then use a large drill to remove copper from the earth plane around the centre pin of each of the two co-axial connectors. Now solder the two co-axial sockets into place on the PCB as shown in *Fig 3*. ▶

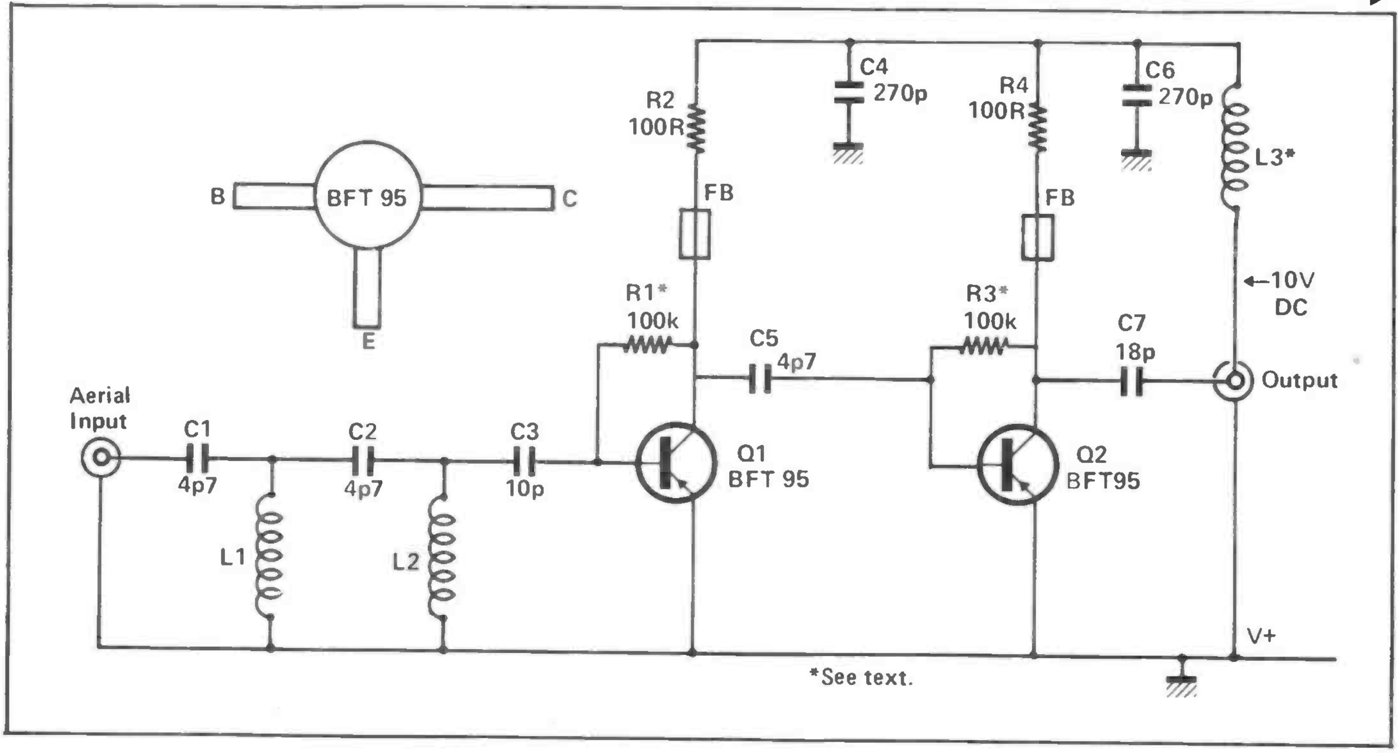


Figure 1a: The TV pre-amp circuit diagram.

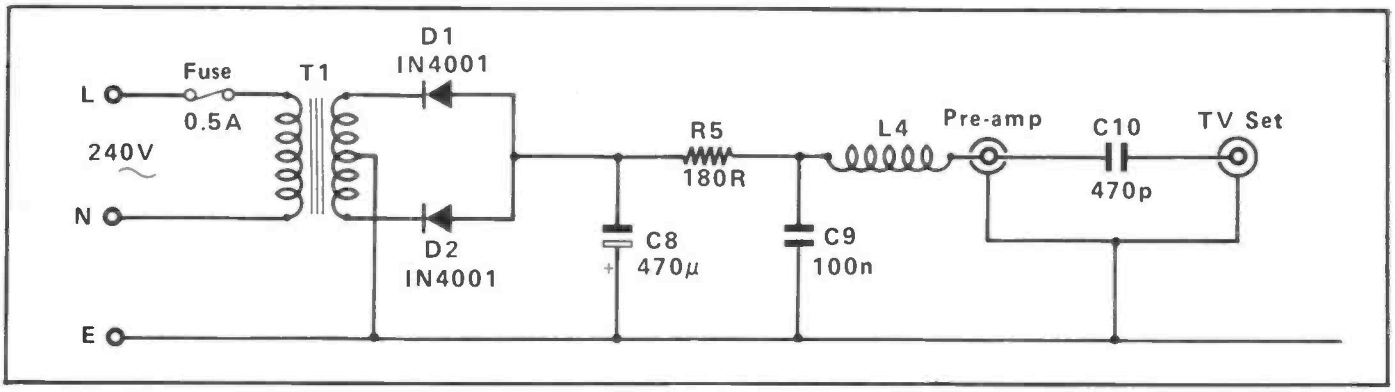


Figure 1b: The PSU circuit diagram.

Now proceed with the assembly of the remaining components on the PCB. Coils L 2 and L 3 can be wound on a 1/8th inch drill or similar. Each transistor is fitted by bending it's emitter lead down close to the body of the device and pushing the lead through the PCB hole so that the base and collector leads can be soldered to the pads on the upper side of the board; the emitter (centre) lead is then soldered to the copper earth plane. The remaining components should be assembled to the board, keeping their leads as short as possible. Ferrite beads should be threaded onto the leads of the two 100 R resistors, as shown in *Fig 3*.

PARTS LIST.

RESISTORS (¼ W, 5%)	
R1,3	100 k (see text)
R2,4	100 R
R5	180 R
CAPACITORS	
C1,2,5	4p7 ceramic
C3	10p ceramic
C4,6	270p disc ceramic
C8	470u 16V electrolytic
C9	100n polyester
C10	470p ceramic

SEMICONDUCTORS		
Q1,2	BFT 95	
D1,2	IN4001	
INDUCTORS		
L2	3t,26swg, 1/8th in dia	
L3,4	10t, 26swg, 1/8th in dia	
T1	Mains, 9.5-0-9.5V, 3VA	
MISCELLANEOUS		
Ferrite bead, FX1115		(2 off)
TV co-ax socket		(4 off)
PCB's		(2 off)
Boxes, SCB2 case (Ambit)		(2 off)

Note that base resistors R 1 and R 3 have nominal values of 100 k and will produce collector currents in the range 3 to 10 mA in each transistor. In most applications this variation range makes little difference to the performance of the amplifier. If absolute optimum performance is required, however, the values of R 1 and R 3 can be selected, R 1 being chosen for a Q 1 collector current of 3 to 5 mA, and R 3 for a Q 2 collector current

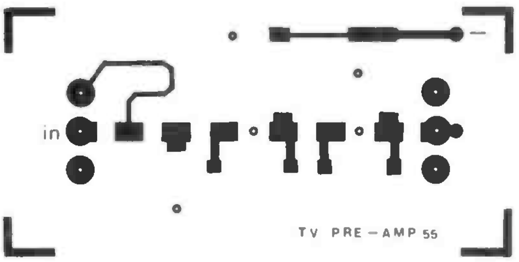


Figure 2: Pre-amp PCB foil pattern (top side). The lower side of this double-sided board is unetched and used as an earth plane.

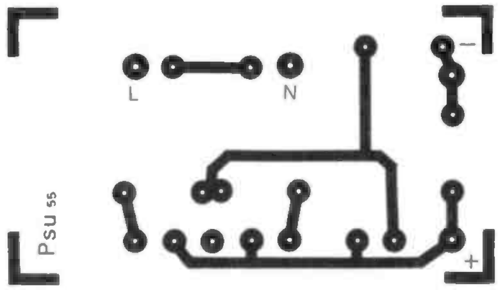


Figure 4: PSU PCB foil pattern.

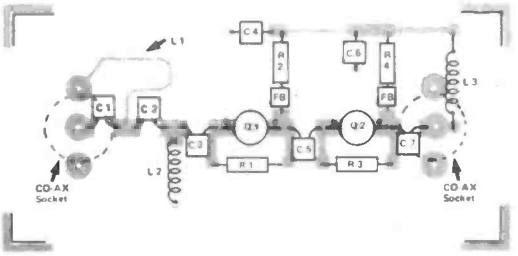


Figure 3: Pre-amp overlay
Note that components are assembled on the top track side.

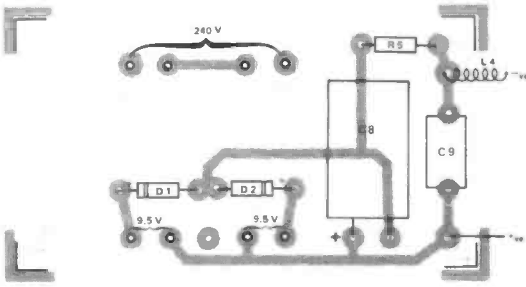


Figure 5: PSU overlay
The components are assembled on the track side.

of 5 to 10 mA: These values give the best compromise between UHF gain and noise performance.

CONSTRUCTION: The PSU

The PSU is assembled on the single-sided PCB shown in *Fig 4*. Components are mounted on the track side of the board, as shown in *Fig 5*, and the assembled board is then pushed into the connecting pins of the transformer and soldered into place.

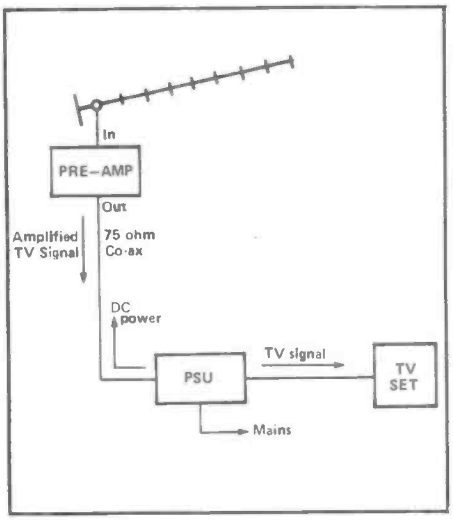


Figure 6: Basic installation set-up.

CIRCUIT DESCRIPTION

The circuit theory of the project is pretty simple. The aerial signal is first passed through a high-pass filter comprising C 1-C 2-L 1 (note that L 1 is part of the PCB), which rolls off the frequency response below 200 MHz and gives lots of rejection to unwanted signals: Attenuation is 30 dB at 145 MHz and 70 dB at 27 MHz. The input impedance of the unit is matched to the 75 ohms of the co-ax line via L 2 and C 3.

The output of the high-pass filter is next amplified by Q 1 and Q 2, a cascaded pair of wide-band common emitter amplifiers which give an overall gain of 17 dB, with a relatively flat response from 470-860 MHz, and with a measured noise figure of less than 3 dB. R 4 and it's ferrite bead combine with C 7 to give an output impedance of 75 ohms, forming a correct match with the co-ax line.

Measured input output matches of the unit are better than 2:1 VSWR. This means that reflections are not caused on the co-ax cable (a poor match can cause errors when receiving Teletext transmissions).

The PSU is fairly conventional, giving a NEGATIVE 10 to 12 volt DC output. Chokes L 3 and L 4 provide DC connections via the co-ax down feed, while looking like open circuits to the UHF feeder signals. Capacitor C 10 acts as a DC blocker between the PSU and the TV set.

The transformer and co-ax sockets are then mounted using suitable fixing screws. Capacitor C 11 is soldered between the two co-ax sockets, and choke L 4 is soldered between the pre-amp socket and the PCB.

The mains earth connection is made to a solder tag on one of the transformer fixing screws, while neutral is connected directly to the transformer tag marked 'N' on the PCB. Mains live is connected through the fuse to the transformer tag marked 'L' on the board. All mains connections should be carefully insulated with tape to prevent accidents.

INSTALLATION.

The pre-amp unit can be installed in any dry location between the TV set and the aerial. The closer the pre-amp is to the aerial, the better the results will be.

The PSU can be located anywhere between pre-amp and TV set: *Fig 6* shows the basic set-up.

■ R & EW

Your Reactions.........	Circle No.
Immediately Applicable	140
Useful & Informative	141
Not Applicable	142
Comments	143

THE BIG MATCH : ROUND 2

FRG7700 VERSUS R1000

Continuing R&EW's analysis of the leading communications techniques, this month we take a closer look at intermod behaviour, and delve into the method of frequency generation.

Out of the Woodwork

Just as the first section of this review was being completed, a strange thing happened. Completely coincidentally, we received a copy of a Press Release from Trevor Brook of the broadcast studio equipment specialists, Surrey Electronics.

The subject was an FRG7700 that Surrey Electronics have prepared specially for the broadcast monitoring market, incorporating a balanced line audio output, several safety mods - and a series of modifications to gain distribution of the main receiver to place more gain behind the selectivity, and thus improve the front end overload performance. In fact, a whole series of detail changes that were running through out minds as we delved deeper into the circuit. So we were intrigued to be able to compare the results and see just how much better the Surrey Electronics version was 'on the air'.

Onward and Inward

The set from Surrey Electronics contained a note explaining that it had been a victim of some Cranleigh flooding, and that the VFO was prone to drift as a result. The set supplied was in fact the Surrey Electronics 'prototype' and not an example of something generally for sale.

So we were surprised to find it in any sort of working condition at all - presumably it had been given a dipping in one of the proprietory cleaning solutions, which also happen to be good at drying things out. The VFO box is a sealed unit which would not have been quite so effectively flushed.

Well, we switched it on and the DFM read 39.54MHz - which long experience with OKI readout LSI led us to conclude that the frequency display wasn't getting a sniff of a Hertz, since the 'no input' condition of these frequency displays is '0' minus the IF (in this case, 455kHz). The display thus rolls over the top (40.000MHz), since negative frequencies don't exist.

Off came the lids. This FRG7700 was complete with memory and being naturally suspicious of the copious numbers of wires and connectors disappearing into the memory pod on the back of the set, this was taken off to see what happened. Nothing.

With memory option duly refitted, the board itself was given a gentle prod. Someone clouted the receiver and crackles of life emerged for an instant; all was not lost - yet. 'Things' were prodded with the trained finger until the offending intermittent joint revealed itself without the need for a tedious and frighteningly longwinded methodical voltage check. Q43, the main supply regulator to the PLL unit appeared to be loose.

Out came all the plugs on the PLL board and some ten screws later the fault was clearly visible (see *Photo 1*) - one of the legs of Q43 was indeed the victim of an absolutely classic dry joint. It seems possible that some of the residual silt from the flooding had worked its way around the leg and eventually - together with some of the corrosion that must inevitably result from such an experience - it chose the day we switched it on, to make itself felt.

By this stage, we were feeling sufficiently brave to go the whole hog and fix the 2.545 to 3.545MHz VFO for Trevor Brook 'while we were at it'. So out came the VFO assembly and out came the PCB, tuning capacitor etc. As you can see from *Photo 2*, there was good evidence of the silt in the box, so the board was given a thorough cleaning in the **R&EW** Arklone processor, although the tuning capacitor was treated more cautiously to a bath is meths, since the stickier residues that are sometimes left as a result of Arkone wouldn't do much for the stator action.

In fact, the VFO coil and trimmer capacitor were both removed and given a careful cleaning and the trimmer was replaced with another of the same value and temperature coefficient (since it must be assumed that Yaesu designed the unit with a carefully balanced TC). This was because the ceramic trimmer capacitor seemed to be about the only part in the circuit that might have suffered some permanent impediment from the effects of a good dousing. The other components were pretty well sealed from the effects of such things.

By now, the VFO was in many pieces and there was some conjecture how the thing would go back together. If Trevor Brook had walked in at the point at which the VFO was in as many pieces as you can see in the *Photo 3*, he would probably have passed out in fright.

Well, we did get it back together again, and we didn't even end up with any homeless screws. With the minimum of persuasion, it all worked.

Land of Hope and Glory

The sense of achievement was considerable. Despite any inclination to curse Yaesu for their QC, the fact that we virtually took the entire FRG7700 apart and put it back together gave some small hope that the Japs don't have it all their own way yet. But it did confirm that the FRG7700 is a mighty lot of transceiver for your money, and I cannot imagine anyone outside the Far East being able to compete with that sort of 'intensive' hardware.

Further oblique satisfaction was gained when the mute in the NBFM demodulator (*Fig. 1*) on our original FRG7700 refused to open. A brief check revealed that demodulation was occurring, but the mute was stuck. A couple of happy hours were spent checking the works out until some

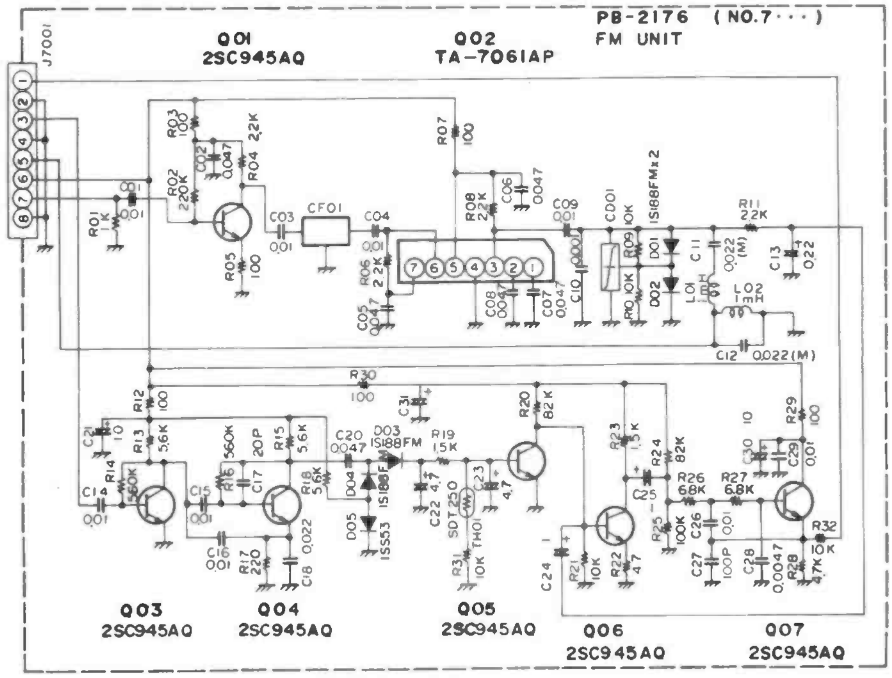


Fig. 1: The NBFM demodulator.

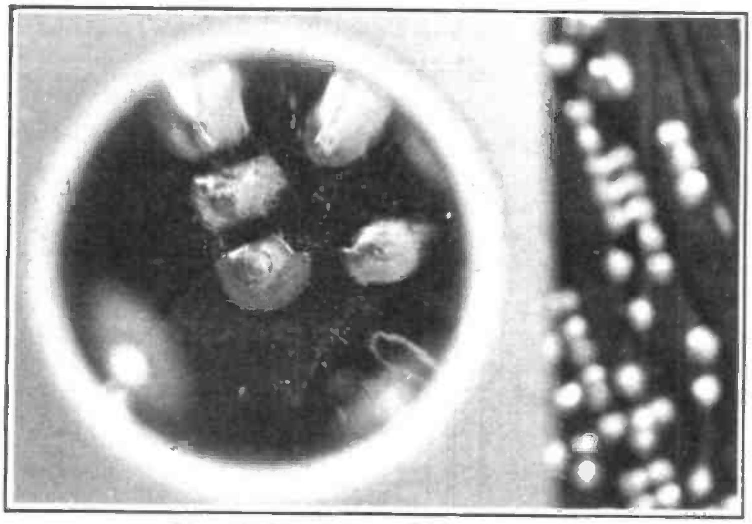


Photo 1: A dry joint on Q43

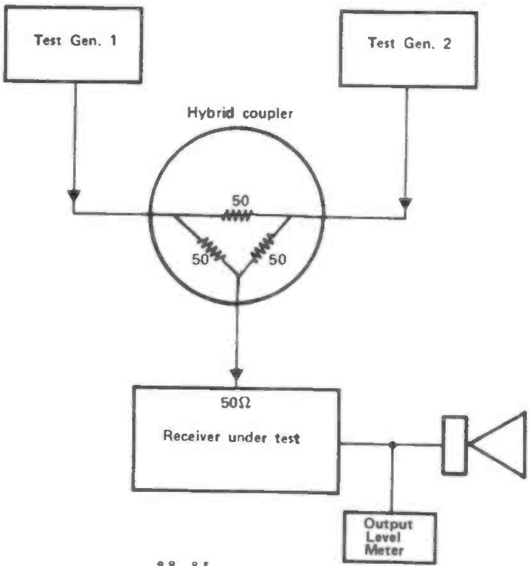


Fig. 2: The equipment configuration for checking IMD.

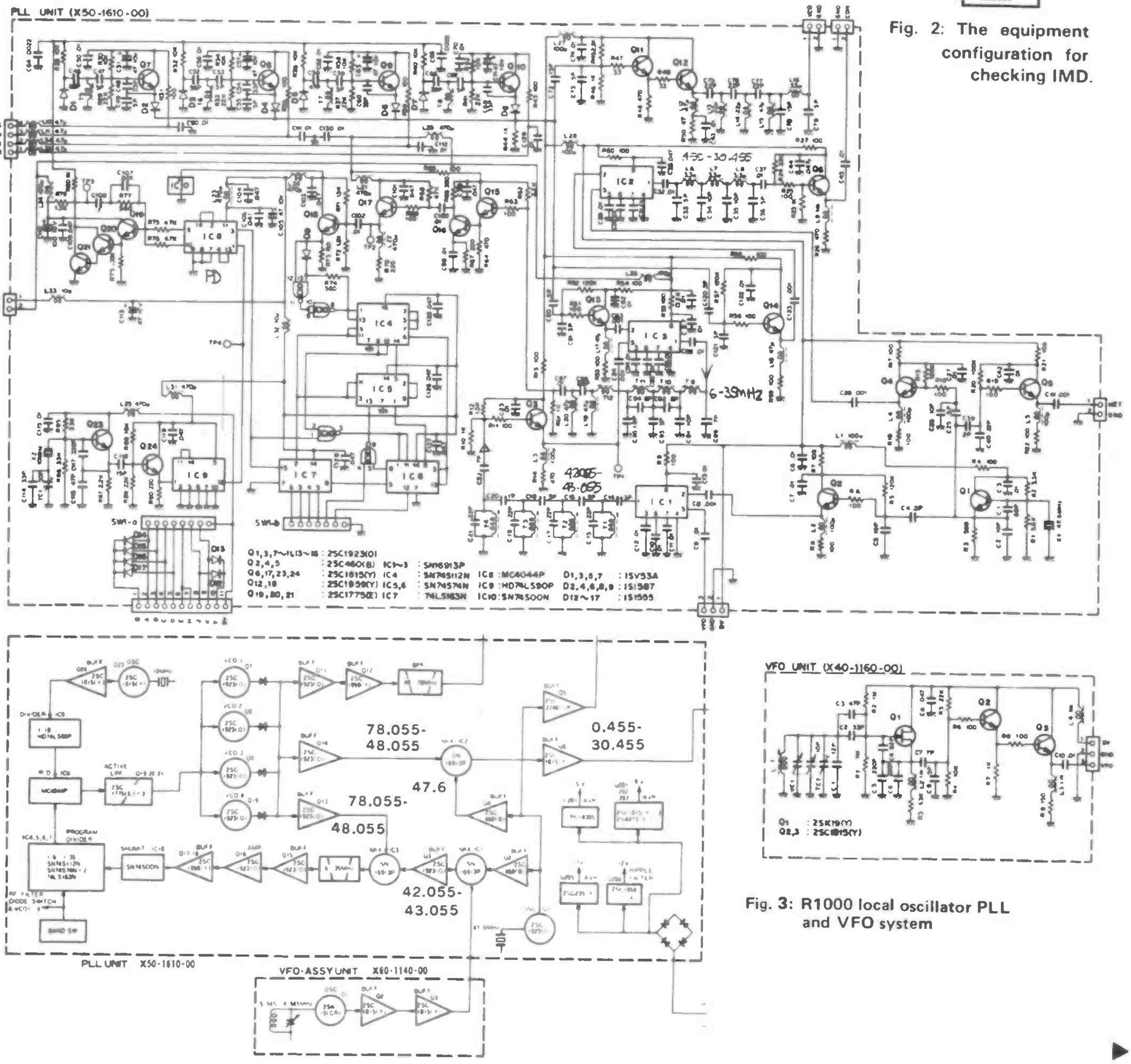


Fig. 3: R1000 local oscillator PLL and VFO system

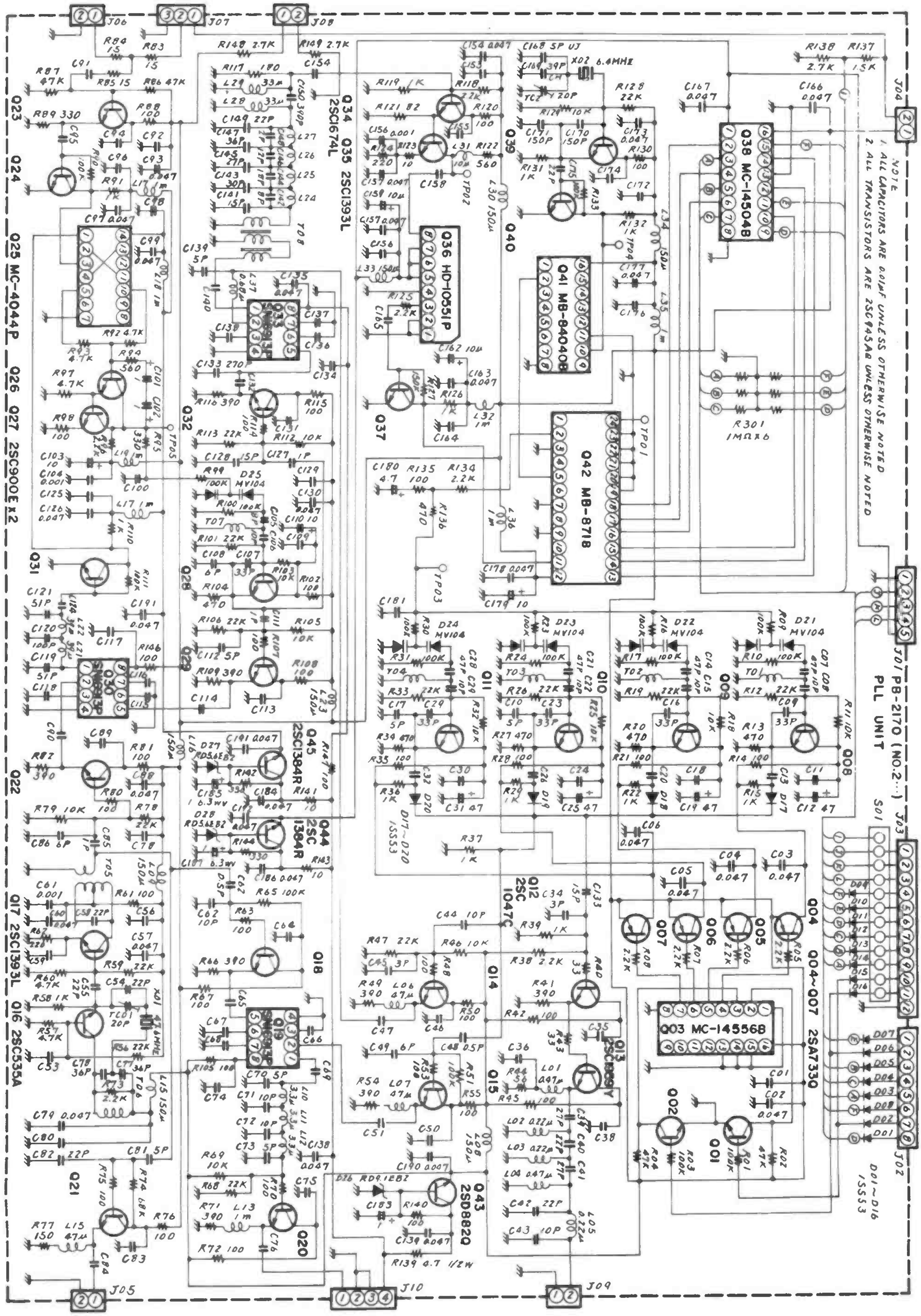


Fig. 4a: FRG7700 local oscillator PLL system.

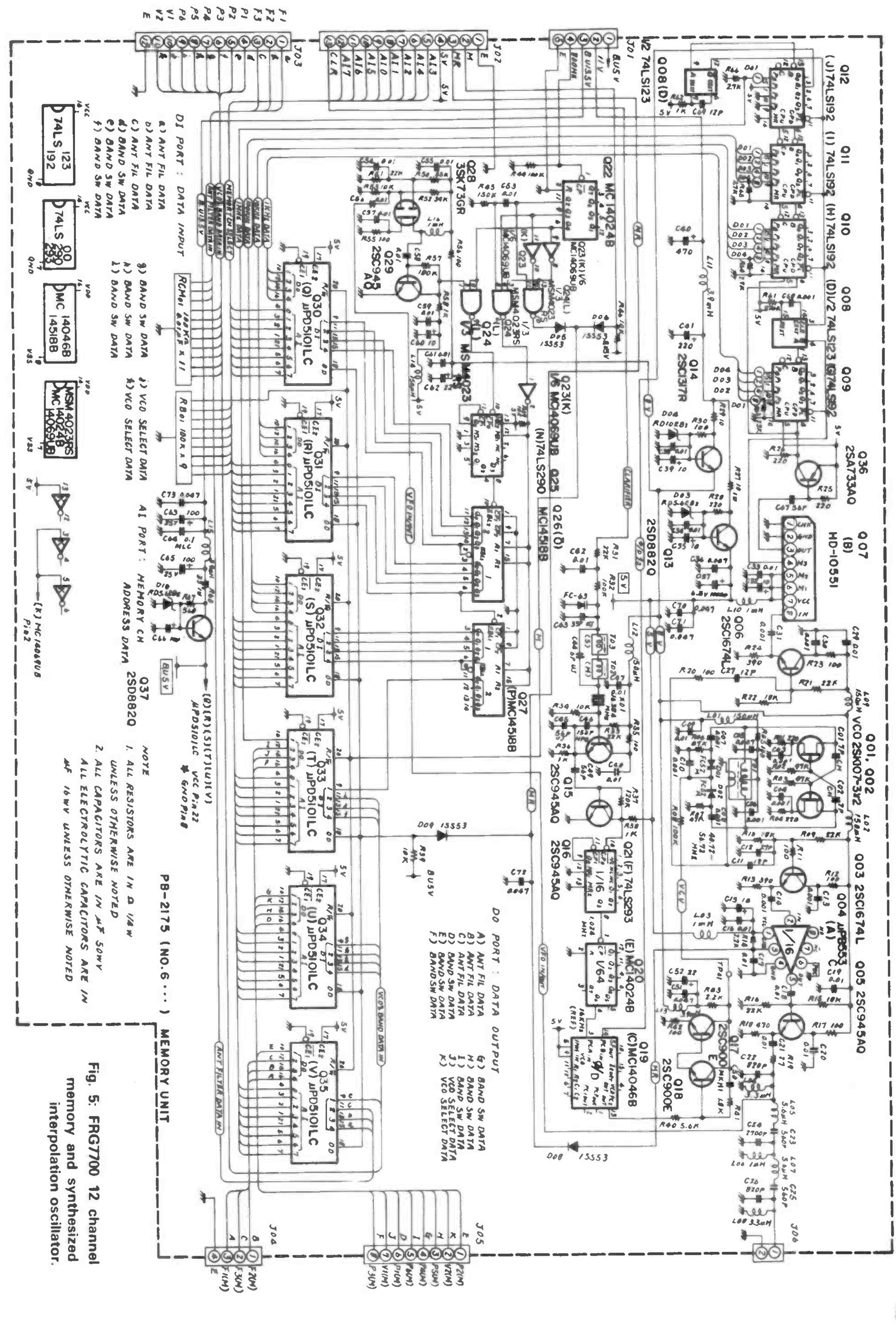


Fig. 5: FRG7700 12 channel memory and synthesized interpolation oscillator.

anomalous voltage reading isolated the problem around QO4. Well, C20 had gone short circuit, but a fault of that kind in a ceramic capacitor seemed so remote that it was discounted until virtually everything else had been changed around it. This exercise served to highlight the desireability of test voltages on circuit diagrams. Everything else in the FRG7700 handbook is beautifully presented.

R&EW and Yaesu did not appear to be getting on too well. When we told the supplier of the original FRG7700, his only remark was that we were lucky there were only two faults (remember the dry antenna socket joint shown in 'round one'?). So we gave an 'official' Yaesu importer a call, which resulted in a complete set of FRG7700 equipment and accessories on the doorstep the next day.

On with the Tests - IMD

The method used to measure the intermodulation products is shown in *Fig 2*. This is a standard test configuration, where the outputs of two generators are combined in a hybrid coupler and fed to the input of the receiver under test. The test determines the input level at which the RF stages cease to be linear and act as mixers themselves, resulting in many unwanted mixing products when tuning through a section of the HF spectrum where strong signals are used, whereas the HF bands contain many thousands of signals. Many of the broadcast signals can be in the 'tens-of-millivolt' range, and these pose quite a threat to a front-end where selectivity is basically only broadband, without the effects of a 'preselector' RF tuned circuit.

The technique is to apply two signals 10kHz apart, say 28.500MHz (f1) and 28.510MHz (f2) and then look for the mixing products at 28.520MHz (f3) and 28.490MHz (f4).

One of the signals is used to determine a lower level reference, say the set is tuned to 28.500MHz, and the 28.500MHz (f1) signal is wound back to around 2uV (1uV after the hybrid coupler is taken into account). Then the generators are wound up together until the output due to the mixing product (2f1-f2, or 2f2-f1) is the same level as for the desired frequency reference at f1.

Both the FRG7700 and R1000 gave an input range of 73dB - which is about 6mV or —40dBm at the antenna socket. We used two rather old Marconi signal generators to perform the test. Firstly, because they have reliable output attenuators, secondly because being valve oscillators with direct mechanical tuning, the oscillator noise level is very low, and thirdly they don't suffer from IMD themselves when used for such tests. We have a couple of modern transistorized 'mixing' type generators that have too many spurious products and noises to be of any use in this test.

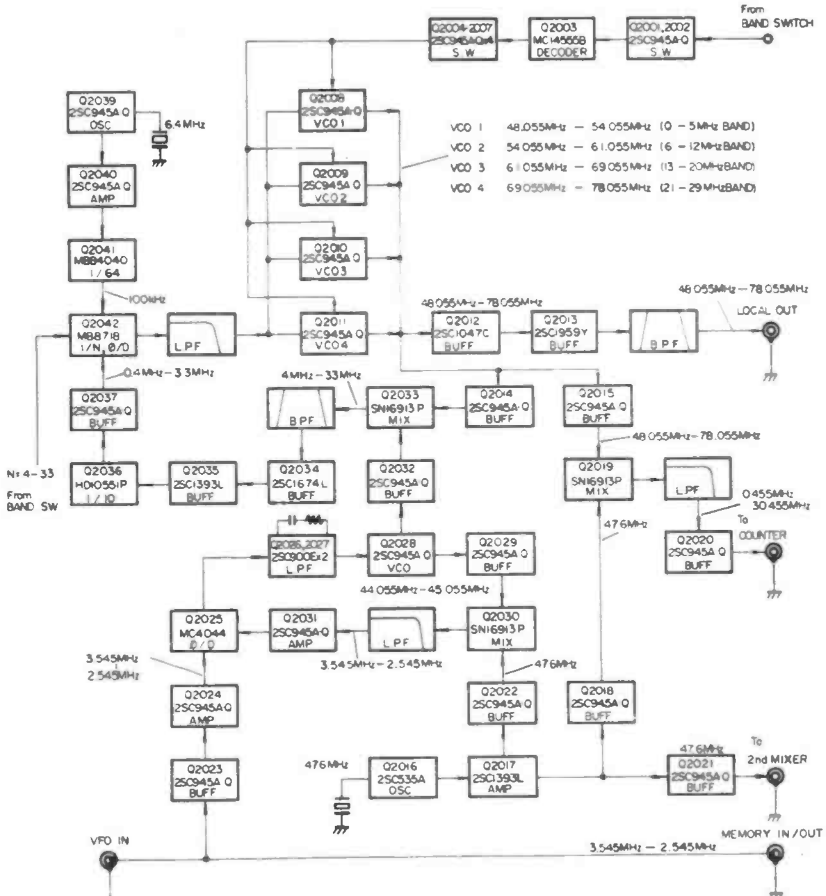


Fig. 4b: FRG7700 PLL unit block diagram.

However, we got the impression that the far more nebulous problem of reciprocal mixing was at least as serious by this input level. This is basically where the noise sidebands of the local oscillator are mixed into the IF amplifier by a strong signal outside the desired RF range.

A deeper analysis of the joys of reciprocal mixing will have to wait for another issue, however.

It's about now that the uninitiated get bogged down, so in a nutshell, the results are good - but not particularly outstanding by the standards of professional HF communications. The Surrey Electronics version gave the same basic IM results, but the modified set was better equipped to handle signal levels above this, with the onset of blocking and noise from reciprocal mixing being at around —20dBm. For the standard sets, this occurred around —35dBm - but as mentioned, it's a fairly nebulous factor to quantify.

The conclusion after all the tests so far is that the R1000 and FRG7700 are remarkably similar animals. The comparison of 'S' meter behaviour only confirms the futility of this device on most receivers:

Input levels at 28MHz/10MHz

	R1000	FRG7700
S9	5uV/5uV	53uV/34uV
S9 + 40dB	500uV/500uV	2mV/2mV

The R1000's 0-40dB attenuator worked very well, and it is a better means of cutting down signal level that using the control gate of the MOSFET RF stage as in the case of the FRG7700. Cutting the current through the MOSFET will certainly attenuate the gain, but it will also cause the IMD potential to increase at the very time you don't want any. The local/distant switch on the back panel serves its purpose, but isn't quite as convenient and it is easy to forget it's there.

Both sets take into account the different nature of the antenna at lower frequencies and provide high impedance 'broadcast antenna' inputs. The R1000 recognizes that this antenna is likely to be a high impedance of 1k0, and adjusts the attenuator values accordingly to maintain a reasonable match. The R1000 also offers a 1k0 impedance SW antenna input, with a step down transformer to match the 50 ohms of the regular PL259 input so that the SW section of the attenuator can handle it more readily. A 1k0 impedance attenuator would present severe screening problems at the further reaches of HF.

Getting on Down

The FRG7700 input isn't quite so particular, and the very lowest frequency filter in the set appears to be simply an LPF - with no HPF section to restrict the lower limits of the RF stage. The values of the coupling capacitors seems to determine the LF limits, and MSF was quite a strong signal on 60kHz, although the intermod from the broadcast stations was rather severe. If you want to take the R1000 down to 40kHz approx., then the LPF values have to be changed. Using the circuit published last month:

L1, L2 and L3 (in the top right-hand corner of the octave filter array) are replaced by 1.8mH, 820uH and 1.8mH respectively. C7 and C8 are replaced by 4n7 capacitors.

In view of the similarity of results, it is interesting to see that the R1000 and FRG7700 use different octave filter networks - the R1000 uses a 'pi' high pass section, followed by a 'pi' low pass section and the FRG7700 uses a double constant-k pi section.

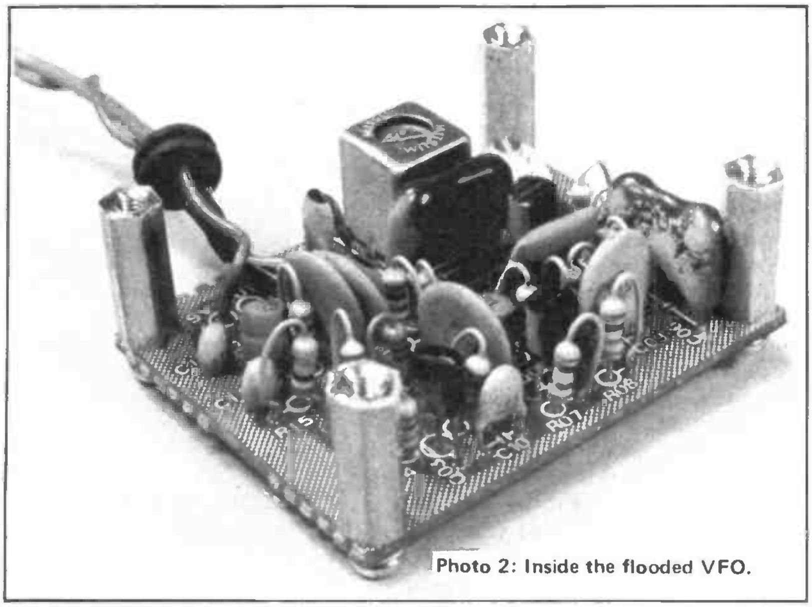


Photo 2: Inside the flooded VFO.

Looping the Loop

The PLL units of both sets are outlined in *Figs. 3 and 4.* The mixing frequencies are not quite the same - the FRG uses a lower frequency VFO for interpolation of the 1MHz steps set by the 'bandswitch', and this VFO is used directly to control a 44.055 to 45.055MHz VCO. The output of this VCO is then mixed down with the final LO frequency to provide an output that is an exact integer between 4 and 33MHz, e.g.:

LO equals 49.155MHz (for an RF frequency of 1.1MHz)
VFO equals 3.445MHz
VCO equals 44.155MHz (47.6MHz -3.445MHz)
thus LO minus VCO equals 5MHz exactly - and will remain 5MHz for the range LO equals 49.055 to 51.055.
Thus the programmable divider is fed exact MHz at all times.

The R1000 uses a single loop approach, where the VFO is directly mixed from 5.645 to 42.155, then mixed with 49.155 (from the final LO), resulting in 7MHz, which is fed directly to the programmable divider without prescaling. It seems the FRG7700 uses a programmable divider that will not operate at the 'direct speed' - and it may also be constrained on the frequency of the VFO by considerations applicable to the 12 channel memory option.

Thanks for the Memory

The memory of the FRG7700 (*Fig. 5*) is quite mind boggling. Without specific details of its operations, we have delved in and concluded that it operates by logging the data from the band select switch to determine antenna filter condition, the number of MHz selected and then it counts the VFO frequency to the nearest kHz. The data is then loaded so that it can be recalled to the programmable counters to provide a programmable divider to control yet a third PLL that reproduces the VFO frequency. The antenna switching and 1MHz data is simply recalled as 'data' and overrides the 'manual' control when the memory is recalled.

There *must* be an easier way, but this system appears to work remarkably well on the FRG7700. It bears the marks of having been conceived as a bit of an afterthought (the memory sits on the back panel in a 'pod'), and it seems hard to believe that such an intricate system could have evolved if conceived from day one of the design. It is notoriously difficult to fully digitally synthesize an HF receiver in 1kHz steps using a single loop VCO - all nigh impossible in view of the jitter, noise & settling time compromises called for, but the FRG7700 does seem to go a shade over the top. Perhaps the advent of devices such as the Motorola MC145151 will make this aspect rather more straightforward when we come to consider the **R&EW** HF receiver.

Inter round summary

Well, we're still not finished yet. One more round should see a conclusion, and it looks like the FRG7700 is winning on sheer volume of circuitry and feature. The R1000 is still possibly the choice for the listener who is not concerned with the FRG7700's options. It is very difficult to actually pinpoint any real difference in the signal handling behaviour, but the R1000 has a better first filter stopband, and that must tell somewhere.

Don't miss next month's thrilling conclusion - which - amongst other matters - includes a look at the FRG7700's optional trimmings in the shape of VHF converter and antenna tuner. □ **R & EW**

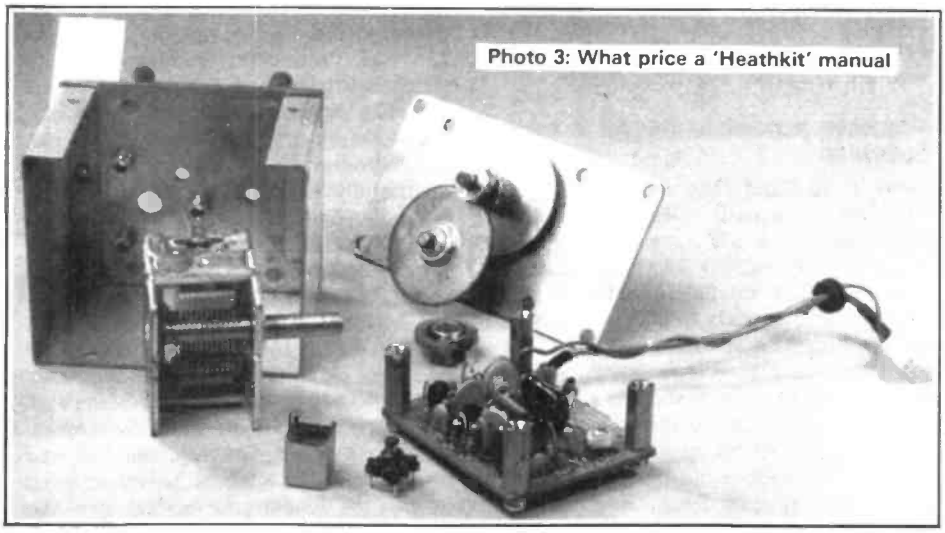


Photo 3: What price a 'Heathkit' manual

Your Reactions.........	Circle No.
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Not Applicable	166
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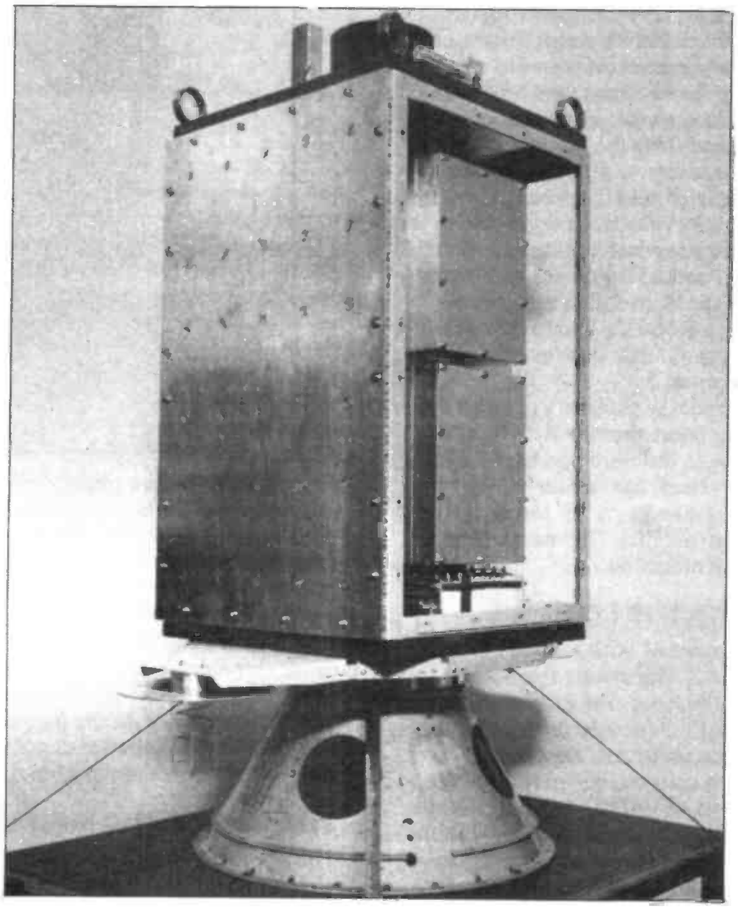
Satellite News

Oscar 7 Deceased?

Almost daily, satellites are being born, are falling ill, or are dying. We bring you the latest news....

At the time of writing, it seems highly probable that the amateur radio satellite Oscar 7 has reached the end of its life. It ceased to function correctly about the second week in June last, but it was hoped that it might pick up and become useable again. It was thought that the fault was possibly associated with the satellite going into 'eclipse', that is it went into the period when it was mainly in the earth's shadow and its solar panels were thus not functioning. However, we are well out of that period now, and so far no reliable reports of its reactivation are to hand.

AMSAT Satellite Report, in its July 13th issue, suggested that the problem was that the NiCad cell which failed 'open' in 1978, has, because of the thermal stresses associated with the eclipse period, now come 'back on-line'. However, in the interim period, since 1978 one or more of the remaining nine cells has failed shorted. This resulted in the solar cells looking into a relatively low impedance, the potential at the active hardware components, then being too low to make them function. Should the cell which failed in 1978 go 'open' again, the satellite might regain some activity. Their issue for July 27th enlarged on this conjecture. They point out that it is most unusual for NiCad cells to fail in the 'open mode'. Most NiCads fail, when they finally do pack up, by shorting. As a result of this unusual failure of the 1978 cell, the whole battery went out of circuit. Oscar 7 from then on only functioned when the solar panels were in sunlight, it having lost its capability of storing energy. On those occasions when in early summer it would come close to the eclipse zones, during the past three years, its function would often be disrupted. This year the eclipse shadow was darker and longer than in any prior season because of the slow precession of 0.7's orbit. Consequently Oscar 7 experienced the sharpest drop in temperature it had so far had - perhaps as much as 10 degrees Centigrade. The only hope now is that when it comes out of eclipse, a similar rise in temperature may occur and effect the battery structure again - hopefully in the right direction - but so far this has not happened.



New Geo-Sync Satellite on Station

From the same issue of *AMSAT Satellite Report*, we learn that India has become the fifth country to put a communications satellite into a geo-synchronous orbit. Their "Apple" experimental satellite was put into orbit by the European Space Agency Ariane L03 on June 19th last.

Apple ran into initial difficulties, when it was found its controllers were unable to extend one of its two solar panels. Despite attempts to deploy the second array, such as spinning the spacecraft, the faulty mechanism could not be corrected. It is not thought however, that this will seriously affect the performance of the satellite. It is now situated over the Equator at 102 degrees East, roughly above the island of Sumatra. Apple was designed and developed entirely by Indian scientists who are delighted with their efforts.

Possible Japanese OSCAR 8 Type Satellite

News is to hand that JAMSAT - The Japanese Amateur Radio Satellite Organization - is considering the feasibility of building and launching an amateur radio satellite similar to 0.8, which would be ready to take the place of 0.8 on its demise. It would be in a similar orbit and have similar facilities. This is indeed good news, as Oscar 8 is a popular satellite and in spite of the attractions of the Phase 3 AMSAT series of satellites, a less sophisticated satellite such as 0.8, has a lot in its favour. Since the failure of Oscar 7, 0.8 has become even more heavily used than heretofore, and in fact, at times, 'QRM' has almost become a problem! News was also recently released to the effect that Japan has launched its first meteorological satellite from its own launching site, so JAMSAT may well be able to carry out their plans.

Meteosat-2 On Station

Following the successful launch of Ariane L03, the European Space Agency's second meteorological satellite, Meteosat-2, was successfully injected into geostationary orbit on Saturday 20th June last. The Apple satellite was placed into geostationary orbit on Sunday 21st June. The apogee boost motor was fired successfully with command issued from the Indian Space Research Organization's Apple Control Centre at Shar in India at 22hrs 43mins 16secs GMT, whilst it was above Africa at 2 degrees East.

Meteosat-2 was put into a high circular orbit by the European made 'MAGE' apogee boost motor. This operation, which took place 15 hours and 40 minutes after lift-off while the satellite was above South America, was followed by a series of altitude manoeuvres designed to give the satellite the correct spin axis and to bring its spin-rate up from the initial 10 rev/min to its final figure of 100 rev/min. Following that operation, the satellite drifted eastwards towards its intended position at 0 degrees longitude and it reached this position during the early hours of the morning of 21st July. A seven minute burn of the thrusters stopped the satellite's drift, and it is now on station in a geo-synchronous orbit.

The first images, in the two visible channels, from Meteosat-2 were recorded at the European Space Operations Centre at Darmstadt in Germany on 28th July and the first image in the infra-red channel was recorded at 0730hrs GMT on 30th July. The images received are all of excellent quality.

The first European Meteorological satellite, Meteosat-1, launched on 23rd November 1977, was fully operational for two years. During that time, it provided permanent monitoring of weather conditions over Europe, Africa and some parts of South America. This satellite is still gathering measurements from a number of data-collecting platforms located on land and sea and carried by aircraft. It made an especially valuable contribution to the Global Atmospheric Research Programme (GARP) in 1978.

Your Reactions.........	Circle No.
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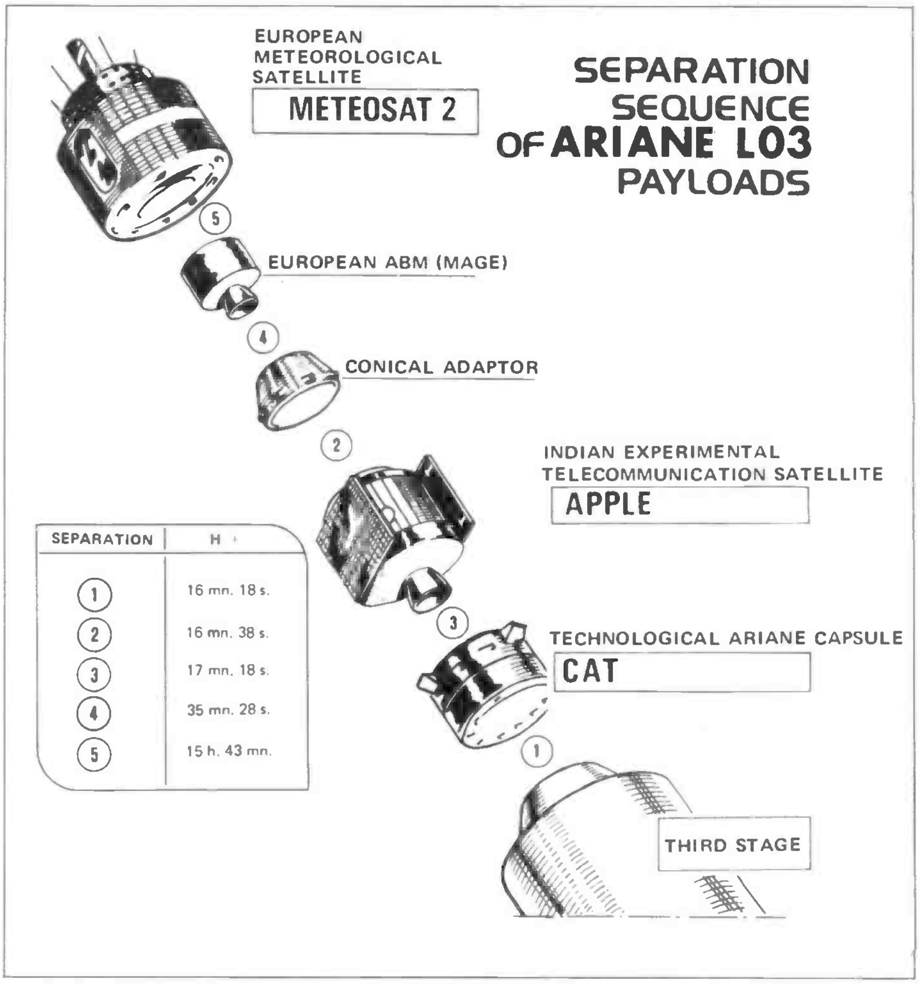
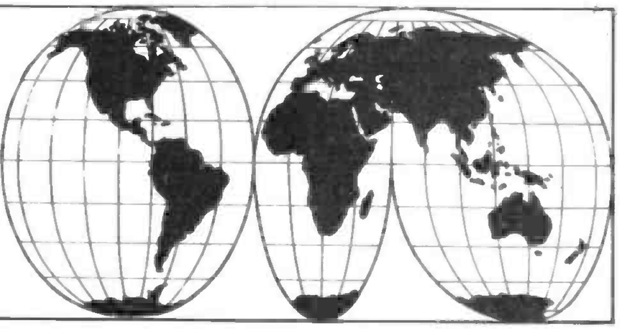
Not Applicable	158
Comments	159



SHORT WAVE NEWS FOR DX LISTENERS

Frank A. Baldwin



All times in GMT, bold figures indicate the frequency in kHz.

SHORT WAVE NEWS FOR DX LISTENERS

By the time this article appears in print many of you will be searching the lower frequency bands for those elusive - for that is what they are - signals that emanate from the spice islands of Indonesia and the local regional stations in the rice lands of China, not to mention Malaysia, India, Burma, Thailand, Kampuchea and Laos. This latter country is probably one of the most difficult of all to receive here in the U.K. If you wish to join the 'Quest for Laos' then make a note of the details that follow.

Laos.

Vientiane, the capital, is on **7142** with the Foreign Service from 2230 to 0130, 0400 to 0630 and from 1100 to 1430. The power is 10 kW and the frequency can vary around that shown, sometimes reported on **7145**. English programmes are from 0100 to 0130, 0600 to 0630 and from 1330 to 1400. Also operates a Domestic Service on **6130** from 2230 to 0200, 0400 to 0700 and from 0900 to 1600 with a power of 10 kW.

Regional transmitters are - Houa Phan on **4658** but reported on **4652.8** with the Domestic Service in Laotian and vernaculars from 2300 to 0100, 0330 to 0530 and from 1000 to 1155, 1255 to 1425. The power is unknown.

Luang Prabang on **6996** as listed but reported as being on **6998** with programmes in both Laotian and Lao Soung from 2300 to 0200, 0400 to 0600 and from 1000 to 1400 with a power of 1 kW.

Pakse on **6602** as listed but reported as being on **6615** and **6617** with the Domestic Service in Laotion and Lao Soung from 2300 to 0200, 0400 to 0600 and 1000 to 1400, power unknown.

More information on Laos next month.

Around the Dial.

In which are presented some items from the log for the interest of both the short wave listener and the Dxer. All details are correct at the time of writing.

Finland.

Helsinki on **15265** at 1938, OM (Old Man = male announcer) and YL (Young Lady = female announcer) with the programme in English intended for European and African consumption and scheduled from 1930 to 2000. At the time shown, there was a programme about local political affairs and by local I mean Finland.

Albania.

Tirana on **7075** on 1941, Yl with a newcast in English in the transmission directed to Africa during the scheduled period 1930 to 2000. The address for reports is Radiotelevisione Shiqptar, Rruga Ismail Qemali, Tirana.

Romania.

Bucharest on **9690** at 1945, OM with the English programme for Europe, all about 18th and 19th century authors in Romania - and very interesting at that! The English programme is scheduled from 1930 to 2030 and if a report is sent to the following address they will reply with their QSL card. Radio Bucharest, P.O. Box 1-111, Bucharest.

Bulgaria.

Sofia on **15110** at 1950, OM with the English programme for Europe, scheduled from 1930 to 2000 on this channel. On this occasion it was all about internal sporting events - no large transfer fees were mentioned! If you wish to commence your QSL card collecting activities with one from Bulgaria, the address is Bulgarian Radio, 4 Bd.Dragan Tsankov, Sofia.

Spain.

Madrid on **9765** at 2003, OM with a programme in English to Europe, scheduled from 2000 to 2100, After the newcast at the time listed there were items about Gibraltar and the on-going dispute over sovereignty. Write to them at this address -Radio Exterior de Espana, P.O. Box 150.039, Madrid 24.

Italy.

Rome on **9710** at 1949, YL with a programme in English directed to the U.K. and scheduled daily from 1935 to 1955 on this channel. It was once axiomatic that all roads led to Rome, if you tune to this frequency you will have arrived in the Eternal City.

Yugoslavia.

Belgrade on **9620** at 2000, YL with station identification followed by OM with a newscast of both external and internal affairs as seen from their point of view. All in the English programme intended for Europe, the Middle East and Africa and scheduled on the frequency from 2000 to 2030 daily. If you are interested in obtaining their QSL card, send your reports to Chief Editor of External Broadcasting, 2 Hildendarskaa, Beograd.

Czechoslavakia.

Prague on **7345** on 2008, YL with a programme in English for Europe, scheduled from 2000 to 2030 on this channel. It was all about a local film festival, the arrangements, the personalities and the films.

Syria.

Baghdad on **21585** at 1944, OM with station identification in Arabic as "Sowt al Surija al Arabia" (Voice of Arab Syria) followed by a male chorus with a martial song. I well remember my first evening in Baghdad, sitting outside a cafe watching a chameleon on a wall-climbing tree busily catching settled flies on his long sticky tongue. Fascinated as I was by this, to me, unaccustomed sight, I was amazed to find that the locals took not the slightest notice of this wildlife drama going on within a few inches of their heads.

Familiarity breeds even more familiarity I suppose!

Morocco.

Rabat on **15335** at 1928, OM with religious chants in the Arabic Domestic Service, scheduled on this frequency from 1000 through to 0100 daily.

Iran.

Tehran on **9022** at 1907, OM with the news in the Turkish programme for Europe, scheduled from 1830 to 1930 on this frequency. The English programme is timed from 1930 to 2030 after which there is a programme in Persiam radiated under the "Familiar Voice" (Seday-e Ashna) announcement to Europe, North Africa and North America, scheduled from 2030 to 0230. Tehran is another old stamping ground of mine, I lived there for some months many years ago and well remember the wide tree lined streets, the (then) new and imposing Palace of Justice and the even more magnificent railway station with the statue of the Reza Shah Pahlevi out in front. The rail journey from Tehran to Bandar Sharhpur, if I recall aright, on the Persian Gulf was really something, mostly a single track snaking through mountains and around steep gorges through some of the most magnificent scenery in the world. The bends in the rails were such that, at times I should think the guard could almost shake hands with the driver! The golden dome of Qum and the gardens of Isfahan were also something worth seeing, if ever you go to Persia...

Egypt.

Cairo on **9805** at 1910, YL with a news commentary in the German programme for Europe, scheduled from 1900 to 2000. The programme in English is timed from 2115 to 2245 and directed to Europe, as is the German programme. The land of the Pharoahs had the dubious pleasure of my company for some years -I'll regale you with that saga some other time! Reports to P.O. Box 1186, Cairo.

United Arab Emirates.

Dubai on **17775** at 0656, local style music with songs in Arabic. This is a relay of the Arabic Domestic Service radiated on this channel from 0425 to 1100 with an English programmed 'slot' from 1015 to 1055. Time pips at 0700 and OM with station identification in Arabic followed by a newscast. All this is intended for the Gulf Area, Europe, North Africa, North America and South East Asia. The address is P.O. Box 1695, Dubai. Another English programme from RCTV (Radio & Colour TV) Dubai is timed from 1630 to 1700 on **17710**, **21625** and on **21655**.

Israel.

Jerusalem on **17630** at 1533, OM with announcements after a programme of songs and music in a relay of the Domestic Service Network B in Hebrew for listeners abroad and scheduled from 0400 through to 2210 on this channel.

U.S.S.R.

Radio Moscow on 7330 at 1925, YL with an English programme directed to the U.K. and Eire, scheduled from 1900 to 2000. On this occasion it was all about women authors within the Soviet Union. This programme is also scheduled on **7440**, **9490**, **9685**, **11820** and on **15535** but on the evening in question I could'nt find any trace of the **7440** transmission.

Switzerland.

Berne on **15430** at 0630, OM with station identification followed by a newscast in the Italian part of a relay of the Domestic Service in that language and also German and French. All for Europe and Africa and timed from 0600 to 0645.

Sweden.

Stockholm on **15390** at 0625, OM with announcements in Swedish in a relay of the Domestic Service to Africa and Europe and scheduled from 0330 to 0830 on this frequency.

Madagascar.

Radio Nederlands Relay on **15220** at 1912, OM with the English programme directed to Africa, scheduled from 1830 to 1920. On this occasion it was all about listener's letters and questions together with the answers.

Writing of Radio Nederland reminds me that I recently received a letter from Jonathan Marks of the English Section informing me that a range of material of interest both to the Dxer and SWL is availble free of charge. The address is Radio Nederland Wereldomroep, P.O. Box 222, 1200 JG Hilversum, Holland. The published material includes the following - **Latin Americal Dxing;** much useful information including a comprehensive English/Spanish/ Portuguese reporting section, each section being numbered for easy translation. **Radio Booklist;** containing many titles of specific interest to the Dxer SWL, some of them published privately by other enthusiasts. Addresses and prices -some of them quoted in IRC's (International Reply Coupons) are included. **Receiver Shopping List;** this 12-page guide has been produced in response to requests from listeners for information with respect to various communication receivers available on the markets today. It does not claim to be complete but it does provide a good general guide to those considering purchasing a receiver in the near future. **This is Dxing;** contains introductory advice to the beginner SWL and Dxer alike. **Very Low Frequencies;** all about these, the Long Wave Club and the Datong VLF Converter. **Give Your Antenna some Air;** a pamphlet explaining which type of aerial is best for your locality.

All the above are free and are in English. For additional information on Dxing and SWLing there is a Dx programme on Thursdays. For Entertainment there is the well known "Happy Station" programmes on Sundays. When writing, ask for their latest schedule.

Dial Search.

Whilst writing about publications I should also include **Dial Search.** This is a comprehensive and up-to-date check list and instruction guide of interest to those who explore the Long, Medium and VHF ranges for British and European station. The booklet gives a clear listing of the radio stations that can be heard on a normal domestic radio, without special aerials. A unique feature is the inclusion of a map on the centre-spread which gives the exact positions of all the stations listed, using fixed bearings. Full instructions on how to use the map are included. **Dial Search** costs 80p plus 20p p & p and is available direct from G. Wilcox, 9 Thurrock Close, Eastbourne, East Sussex, BN20 9NF.

Singapore.

Radio Singapore on **5052** at 1547, YL announcer in English with a programme of records of U.S.A. and U.K. pop music. The Singapore Broadcasting Corporation schedules this station from 2230 to 1630 in English (Sundays until 1700). The power is 20 kW and the address is Department of Broadcasting, Caldecott Hill, Thomson Road Singapore 1129.

Indonesia.

Jakarta on **11790** at 1450, YL announcer, YL with a ballad in the English programme directed to South East Asia and the Pacific, being timed from 1400 to 1500. There is a newscast in English from 1400 to 1415. This is the Foreign Service, the address being Voice of Indonesia, P.O. Box 157, Jakarta.

North Korea.

Pyongyang on a measured **11352** at 2008, YL with songs, orchestral music local-style in a transmission of the Domestic Service, scheduled on this channel from 2000 through to 1800.

China.

Radio Peking on **6665** at 2011, OM and YL alternate with announcements in the Domestic Service 1, scheduled here from 2000 to 1735.

Colombia.

Radio Cinco, Villavicencio, on **5040** at 0500, OM with station identification, announcements and a programme of local-style pops on records. the schedule of this one is on an around-the-clock basis and the power is 3 kW. The address for reports is Apartado Aeareo, 2284, Villavicencio, Meta, Colombia.

Radio Super, Medillin, on **4875** at 0506, OM with a newscast in Spanish mainly composed of local events according to all the Colombian place-names announced. A full station identification at 0515 then into a programme of local pops. Radio Super has a 24-hour schedule and a power of 2 kW.

Brazil.

Radio Tabajara, Joao Pessoa, on a measured **4797.4** at 0125, with a sports commentary in Portuguese. The schedule is from 0730 to 0400 and the power is 1 kW. The address of Radio Tabajara da Paraiba, to give it the full title, is Rua Jaoa Machado 938, 58000 Joao Pessoa, Paraiba. I hope you manage to get the QSL!

Radio Cultural do Para, Belem, on **5045** at 0155, local-style music, OM with a ballad in Poruguese. The schedule is from 0700 to 0300 and the power is 10 kW.

Radio Clube Paranaense, Curitba, on **6045** at 0158, OM announcer with a programme of recorded local pops - all in typical style. This one operates around the clock and has a power of 7.5 kW.

Afghanistan.

Kabul on **4740** at 0217, local-style orchestral music, OM with songs in the Home Service 1 programme schedule from 0125 to 0330 and from 1230 to 1930. The power is unknown, this transmitter may be located within the borders of the U.S.S.R.

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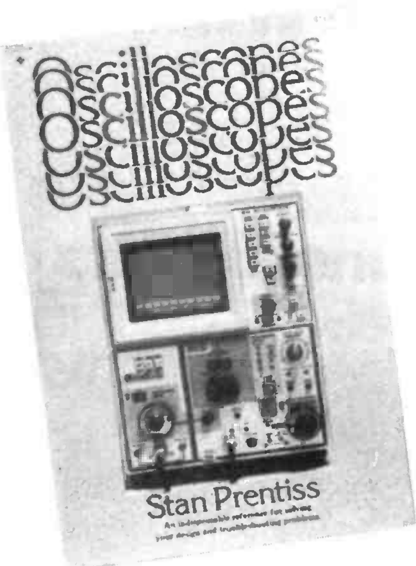
BOOK REVIEW– R&EW. BOOK SERVICE



OSCILLOSCOPES

By Stan Prentiss

1981; 161 pages; 150 x 225mm; Paperback

£8.20

This book shows in great details what and oscilloscope does and why. All manner of applications are included ranging from basic service procedures to highly complex design and evaluation studies.

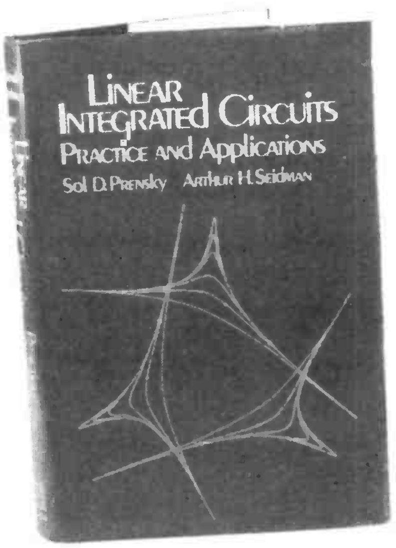
LINEAR INTEGRATED CIRCUITS

By S D Prensky & A H Seidman

1981; 354 pages; 155 x 240mm; Hardback

£14.95

Finally, a practical reference on linear-integrated circuits written in an easy-to-read style for the technician, the engineer, and the student.



PET BASIC: TRAINING YOUR PET COMPUTER

By R Zamora et al

1981; 310 pages; 150 x 225mm; Paperback

£9.70

If you are a newcomer to the PET, you will discover that this book is perfect for you. The material in each chapter is written for people who are learning to use the PET. There are plenty of examples, do-it-yourself exercises, and fun-filled explorations. You are encouraged to experiment with your machine and try out the many features and capabilities.

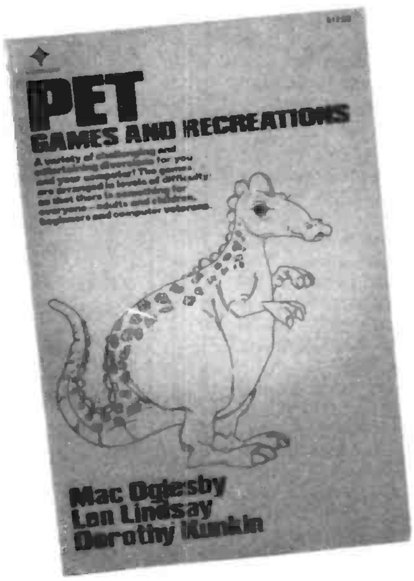
PET GAMES AND RECREATIONS

By M Oglesby et al

1981; 246 pages; 150 x 225mm; Paperback

£9.70

A variety of challenging and entertaining diversions for you and your computer. The games are arranged in levels of difficulty so that there is something for everyone - adults and children, beginners and computer veterans.



AN END USERS GUIDE TO DATA BASE

By J Martin

1981; 144 pages; 175 x 230mm; Hardback

£16.45

This book was written with no technical words except where they are unavoidable and clearly explained.

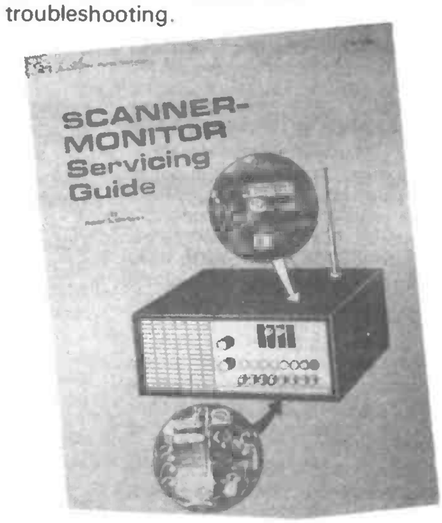
SCANNER MONITORING SERVICING GUIDE

By R G Middleton

1975; 96 pages; 210 x 280mm; Paperback

£4.55

This servicing guide starts at the beginning and proceeds step by step through the complete scanner-monitor system, with particular emphasis on specialised circuit action and troubleshooting.



GENERAL BOOKS

ABCs OF FETS
by R P Turner — £2.75

ABCs OF INTEGRATED CIRCUITS
by R P Turner — £4.15

ACTIVE FILTER COOKBOOK
by Don Lancaster — £10.45

ANALOG I/O DESIGN AQUISITION: CONVERSION: RECOVERY
by P H Garrett — £16.45

BEGINNER'S HANDBOOK OF IC PROJECTS
by D L Heiserman — £9.70

BUILDING AND INSTALLING ELECTRONIC INTRUSION ALARMS
by J E Cunningham — £4.55

CMOS COOKBOOK
by Don Lancaster — £9.05

DESIGN OF OP-AMP CIRCUITS - with experiments
by H M Berlin — £7.65

DESIGN OF PHASE-LOCKED LOOP CIRCUITS - with experiments
by H M Berlin — £7.65

DESIGN OF VMOS CIRCUITS - with experiments
by R T Stone — £8.35

DIGITAL LOGIC DESIGN AND APPLICATIONS
by L B McCurdy et al — £9.70

EFFECTIVELY USING THE OSCILLOSCOPE
by R G Middleton — £6.95

HOW TO BUILD A FLYING SAUCER
by T B Pawlicki — £4.45

HOW TO BUILD YOUR OWN STEREO SPEAKER
by Christopher Robin — £5.20

INTEGRATED CIRCUIT PROJECTS
by R P Turner £4.55

LOGIC AND MEMORY EXPERIMENTS USING TTL BOOK 1
by D G Larsen & P R Rony £8.35

LOGIC AND MEMORY EXPERIMENTS USING TTL BOOK 2
by D G Larsen & P R Rony £9.05

99 PRACTICAL ELECTRONIC PROJECTS (2nd Edition)
by Herbert Friedman £4.15

ONE EVENING ELECTRONIC PROJECTS
by Calvin R Graf £4.55

OP AMP HANDBOOK
by F W Hughes £16.45

OPERATIONAL AMPLIFIER CHARACTERISTICS AND APPLICATIONS
by R G Irvine £18.70

PRACTICAL LOW-COST IC PROJECTS (2nd Edition)
by Herbert Friedman £4.15

SECURITY ELECTRONICS (2nd Edition)
by J E Cunningham £5.25

SON OF CHEAP VIDEO
by Don Lancaster £6.95

SCRS & RELATED THYRISTOR DEVICES
by C Laster £9.05

TTL COOKBOOK
by D Lancaster £8.35

THE 555 TIMER APPLICATIONS SOURCEBOOK - WITH EXPERIMENTS
by H M Berlin £5.25

UNIQUE ELECTRONIC WEATHER PROJECTS
by Tom Fox £6.25

COMPUTER BOOKS

THE ADA PROGRAMMING LANGUAGE
by J C Pyle £8.95

THE ARCHITECTURE OF CONCURRENT PROGRAMS
by P B Hansen £19.45

BASIC BUSINESS SOFTWARE
by E G Brooner £8.35

CALCULATOR CLOUT — PROGRAMMING METHODS FOR YOUR PROGRAMMABLE
by M D Weir £6.70

CIRCUIT DESIGN PROGRAMS FOR THE TRS-80
by Howard M Berlin £10.15

COMPUTER GRAPHICS PRIMER
by M Waite £10.45

COMPUTER LANGUAGE REFERENCE GUIDE
by Harry L Helms £5.55

CP/M PRIMER
by S Murtha & M Waite £10.45

CRASH COURSE IN MICROCOMPUTERS
by Louis E Frenzel £13.95

DIGITAL CIRCUITS AND MICROCOMPUTERS
by D E Johnson et al £9.50

EXPERIMENTS IN ARTIFICIAL INTELLIGENCE
by J Krutch £6.25

GUIDEBOOK TO SMALL COMPUTERS
by W Barden Jnr. £4.85

HOW TO DBUG YOUR PERSONAL COMPUTER
by J Huffman £5.95

HOW TO PROGRAM AND INTERFACE THE 6800
by A C Staugaard Jnr £11.15

HOW TO TROUBLESHOOT AND REPAIR MICROCOMPUTERS
by John D Lenk £5.95

INTRODUCTION TO MICRO-COMPUTERS FOR THE HAM SHACK
by Harry L Helms £4.15

MICROCOMPUTER INTERFACING WITH THE 8255 PPI CHIP
by P F Goldsbrough £6.95

MICROPROCESSOR SOFTWARE, PROGRAM CONCEPTS AND TECHNIQUES
by G A Streitmatter £14.20

MINICOMPUTER IN ON-LINE SYSTEMS
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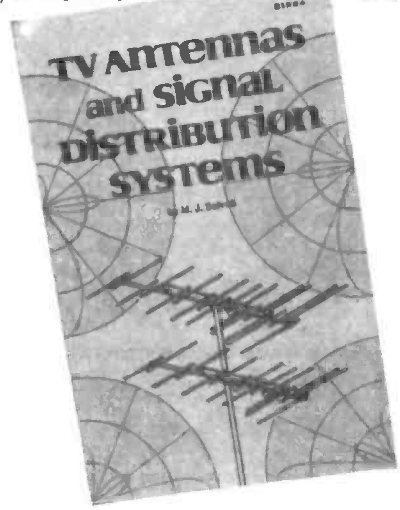

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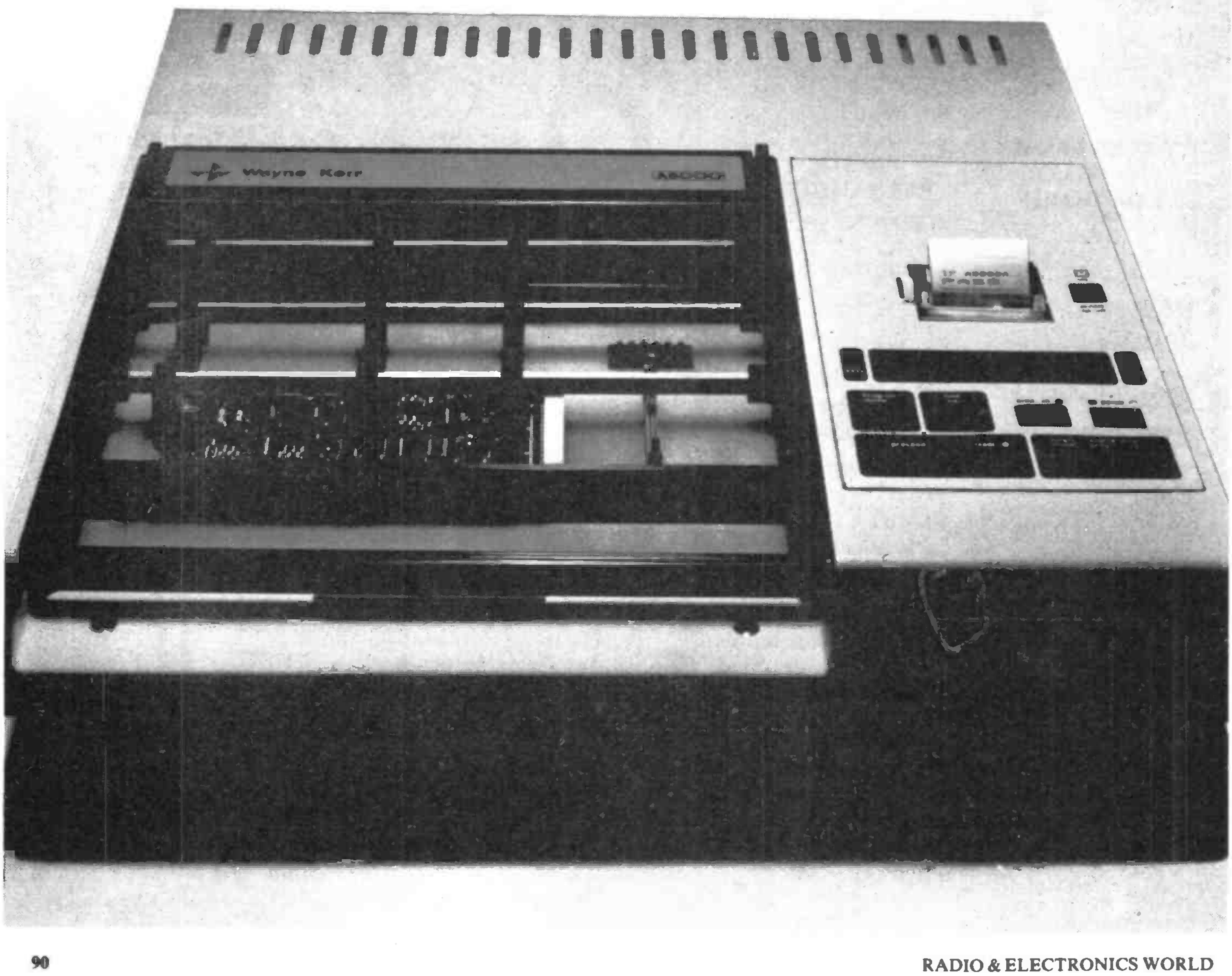

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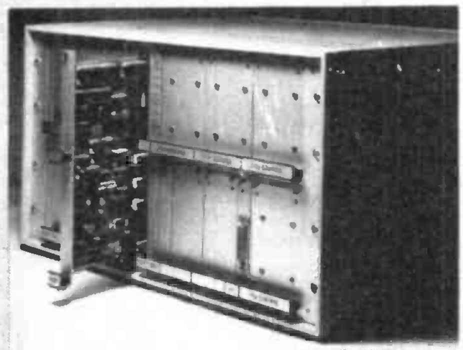

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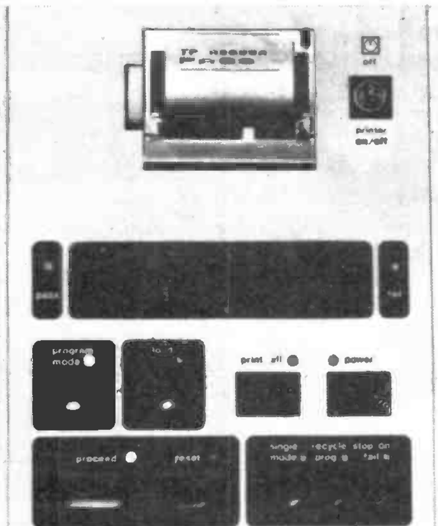

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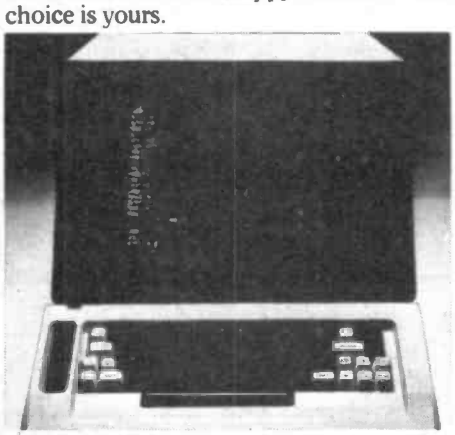

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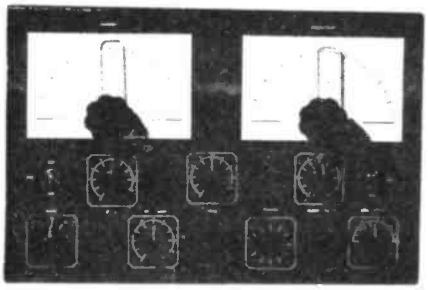

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