

## TRANSCENDENT 2000 SINGLE BOARD SYNTHESIZER

All kits also available as separate packs (e g PC B , component sets, har
Prices in FREE CATALOGUE

LIVE PERFORMANCE SYNTHESIZER DESIGNED BY CONSULTANT TIM ORR (FORMERLY SYNTHESIZER DESIGNER FOR EMS LIMITED) AND FEATURED AS A CONSTRUCTIONAL ARTICLE IN ELECTRONICS TODAY INTERNATIONAL.
The TRANSCENDENT 2000 is a 3 octave instrument transposable 2 octaves up or down giving an affective 7 octave ranige There is portamento, pitch bending, a VCO with shape and pitch modulation, a VCF with both low and high pass outputs and a separate dynamic sweep control, a noise generator and an ADSR envelope shaper There is also a slow oscillator, a new pitch The kit, includes fully, finishe metalo, and special The kit includes fully finished metalwork, fully assembled solid teak cabistors either $2 \%$ meial oxide or $1 / 2 \%$ metal triml) and conents (all complete - right down to the last nut and bolt and tast puece of wire There is even a 13 A plug in the kit - you need buy absolutely no more parts before plugging in and making great musici, Virtually all the components are on the one professional quality fibreglass PCB printed with component locations. All the controls mount directly on the main board. all connections to the board are made with connector plugs and construction is so simple it can be built easily in a few evenings by almost anyone capable of neat soldering' When finished you will possess a synthesizer comparable in performance and quality with ready-buil units selling for many times the price


WE'VE MOVED! NEW FACTORY UP! INCREASED CAPACITY AT OUR BIG NEW FACTORY PRICES DOWN! MEANS MANY PRICES DOWN! ALL OTHERS FROZEN!

## TRANSCENDENT DPX

DIGITALLY CONTROLLED, TOUCH SENSITIVE, POLYPHONIC, MULTI-VOICE SYNTHESIZER ANOTHER SUPERB DESIGN BY SYNTHESIZER EXPERT TIM ORR - PUBLISHED IN ETI
The Transcendent DPX is a really versatile new 5 octave keyboard instrument. There are two audio outpuls which can be used simultaneously On the first there is a beauriful harpsichord or reed sound - fully polyphonic, i.e you can play chords with as many notes as you like On the second output there is a wide range-of different voices, still fully polyphonic 1 l can be straghtiforward piano or a honky tonk piano or even a mixture of the twol Alternatively you can play strings over the whole range of the keyboard or brass over the whole range of the
keyboard or should you prefer - strings on the too of the keyboard and brass at the lower end ane keybord is eletronicallysplit keyboard or sho st you prefer - strings on the top of the keyboard and brass at the lower end (the keyboard is electronically split after the first two octaves) or vice versa or even a
combination of strings and brass sounds simultaneously And on all voices you can switch in circuitry to make the keyboard touch sensitivel The harder you press down a key the louder it sounds - just like an acoustic prano. The digitally controlled multiplexed system makes practical touch sensitivity with the complex dynamics law necessary for a high degree of realism. comes in masty comes

## TITI <br> TRANSCENDENT DPX <br> ITTITIIIIIIIIITIIITITIT

 describes construction and telis you how to set up your synthesize with nothing more elaborate than a mult-meter and a parr of ears!Cabinet size $36.3^{\prime \prime} \times 15.0^{\prime \prime} \times 5.0^{\prime \prime}$ (rear) $3.3^{\prime \prime}$ (front)
To add interest to the sounds and make them more natural there is a chorus/ensemble unit which is a complex phasing system using CCD (cinarge coupled device) analogue delay lines The overall effect of this is similar to that of several acoustic instruments playing the same piece of music. The ensemble circuitry can be switched in with either strong or mild effects. As the system is based on digital circuitry digital data can be easily taken to and from a computer (for storing and playing back accompaniments with or without pitch or key change, computer composing etc, etc $)$
Although the DPX is an advanced design using a very large amount of circuitry, much of it very sophistucated, the kit is mechanically extremely simple with excellent access to all the circuit boards which interconnect with multiway connectors, just four of which are removed to separate the keyboard circuitry and the panel circuitry from the main circuitry in the cabinet
The kit includes fully tinished metalwork, solid teak cabinel, professional quality components (all resistors $2 \%$ metal oxide), nuts, bolts, etc, even a 13 A plug - you need buy absolutely no

## ORDERING INFORMATION AND MORE KITS

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## GENTS MEMORY CALENDAR ALARM CHRONO



A really successful watch incorporating all the latest technology.

Hours, mins, secs, weokday and snooze alarm indication on constant display.

A further two optional display modes are available, one being the calendar and month, which can be increased or decreased to give the appropriate month of the year.

A 1/106th second chronograph with split and lap mode facilities are built into the watch with a 12 -hour capacity.

A 21-hour alarm with a 10 minute snooze function is also standard to this watch. A further feature is the backlight and fully adjustable stainless steel bracelet.

## $\star$ <br> STAR VALUE <br> £19.95

## GENTS QUARTZ ANALOGUE

A truly superb timepiece with extreme accuracy. A choice of two colours on this outstanding watch are available, blue or white.

The calendar in the watch can be set to give a readout in either French or English with date indication being automatic

An infinitely adjustable stainless steel strap is built in as part of the watch.

The watch is fitted with a longlife battery and comes with luminous markings to aid nighttime vision

YES ONLY £19.95


## GENTS DIGITAL ANALOGUE CHRONOGRAPH

Just look at this outstanding watch
i) 6 functions (hours, mins, secs, month, date, weekday); ii) chronograph resolution; iii) automatic 4 -year guarantee; iv) five buttons control all functions; v) back-light available

ONLY £29.95 + P/P


The above watch is a new style digital analogue featuring complete up-to-date modern technology. The watch basically constitutes a traditional hand watch plus a modern digital watch, both battery powered

Hours, mins and seconds are on constant display and with the press of a button, month, date and weekday is displayed.

This unique timepiece also has a chronograph built in which runs to a $1 / 100$ th sec, and has a 12 -hour capacity. Features include: i) the chronograph can be frozen; ii) two people can be timed simultaneously, and iii) split and lap mode facilities are available.

The watch is finished off with an elegant infinite adjustable stainless steel strap

## ORDER NOW TO AVOID DISAPPOINTMENT!!!

## ! MITRAD!

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## M

D

Phone or write for free full comprehensive catalogue on the complete range of watches we offer. Large discounts available for bulk buyers. Trade lists on application. Agents wanted everywhere. P/P per item 85 p which includes insurance. Cheques or PO's made payable to MITRAD and sent to (Dept. ET), 58 Windmill Ave, Kettering, Northants NN16 8PA. (0536) 522024.


## WATFORD ELECTRONICS

THE DIGITAL FREQUENCY METER with a Difference


Large 8 -digit display for high accuracy Period and time interval facility. Unit counter up to 99,999,999 10 MHz crystal timebase Hold and reset buttons pl
All these features and more for less than half the price of an ordinary frequency meter. The on one double sided PC board. Assembly is simplicity itself especially since interwiring has on one double sided PC board. Assembly is simplicity iself especially since interwiring has
been eliminated. This is a high quality design and will make a truly professional digital frequency meter that any constructor will be proud to own

Price: Only $£ 64.50$ Kit (P\&P 65p). Probes: Optional
Ready built and tested. $£ 75.50(65 p p \& p)$

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## C3OD|ES2OO

high performance electronic ignition,to add power, economy, reliability, sustained smooth peak performance, instant all weather starting, to your car.
Surefire has sold in its thousands in ready made form from big name accessory firms, but it is now available in quality kit form to fit alt ES 200. A high performance inductive discharge ignition incerporating a power integrated circuit (spectal seiection): electronic variable dwell circuit (maxımises spark energy at all speeds) pulse processor
(overcomes contact breaker problems). Colt governor (protects-coil) Long burn output. Negative earth only. Compatible with all rew. counters C300. In it's ready built form (C3000) it came top of all systems tested by an independent national authority July 79. A high energy capacitive discharge ignition incorporating a high output short circui proof inverter, top grade Swedish output capacitor, pulse processor circuit, transcient overload protection. Fast rise bidirectional output ideal for fuel injection, sports carburation, oily engines. Compatible with most rev. counters. How cost adaptors available for rare cases. Application list enclosed with each kit. Note: Velncles with Smiths Jaeger rev. counters code RVI on dial will require adaptor type TCI)
What's in the kits. Surefire's own precision anodised aluminium extruded case. P.C. mounted security changeover switch, static timing light. Special selection Motorola semi-conductors. Capacitors, resistors etc. selected after 5 y
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Fully illustrated comprehensive instructions

Suretron Systems (UK) Lid.
Piccadilly Place, London Rd., Bath BA1 6PW. Tel: Bath (0225) 23194
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| Tacho Adapt. TCl |  | f 3.90 |  |

# DIGEST 

## Vending Over Backwards

Asource of constant frustration to many people is vending machines. Invariably they have run out of what you want, or give you chicken soup flavoured coffee, or refuse to refund your money. The average vending machine certainly bears signs of the dislike its customers have for it, mostly in the form of dents, framed by boot marks. The wonderfully inscrutable Japanese have, of course, developed a cure in the form of the machine pictured here - not particularly beautiful to look at, but with a heart of gold. When the customer approaches it, a sensor picks up the infra-red rays emitted by

## Ex-Static

D
iscguard' from Metrosound is an everlasting anti-static treatment for records. In the kit you find a spray pump, a bottle of 'special' fluid and a record cleaner for buffing.

The makers claim that there is no detectable change in sound quality except as we found that the treble sounds cleaner, as it
him, and a 'soft female voice' says "Welcome" and lists the merchandise in the machine. It also tells the customer when there is no change available, when items are out of stock and reminds him if he has not fed enough money into it for the item he requires. Finally the machine says a cheerful "Thank you" and reminds the buyer to pick up his change. This machine, although a novelty at the moment, has quite interesting possibilities, but there are no marketing plans for it as yet. Wouldn't it be nice to walk away from a vending machine, clutching exactly what you asked for and with the echoes of that warm welcome ringing in your ears? The system was developed by Mit. shushita Reiki, a Mitshushita Electric subsidiary, which specialises in refrigeration equipment.

## Solid Security

This is Clarke's Instruments Ltd motor driven door lock type 838. It is a remotely operated door lock, which is last to be released on strong doors that give public access to high security areas. After the dead locks have been unlocked by key, the door is held by the motor lock, whose double shear action gives 4 to 6 tonnes of shear strength. When relocking the door, the motor lock is first to be operated. The new microswitching system ensures greater reliability of operation and permits positive indication of full lock closure. Auto matic locking of the door each time it closes can also be arranged. It is mains operated and needs no other power supply, great if you don't live in a high risk area for power cuts, although there is an integral manual emergency release on the inside of the door-unless of course, you're trying to get in! Further information is from Clarke Instruments Ltd, 91a High Street, Camberley, Surrey GU15 3 RN


## Doctor Who

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ne of our readers, Mr. S. Knowles of Hampshire, sent us a scope picture he took whilst
designing with a Textronix 7403 on $500 \mathrm{nS} / \mathrm{div}$ with $x 10$ expand. It seems he was looking for a pulse, but he may well have discovered the secret of time travel!


## CHROMATHEQUE 5000

## POWERTRAM



## 5 CHANNEL LIGHTING EFFECTS SYSTEM

## COMPLETE KIT

ONLY
$£ 49.50$ + VAT!
Panel size 19.0' $\times 3.5^{\prime \prime}$. Depth 7.3'
This versatile system featured as a constructional article in ELECTRONICS TODAY INTERNATIONAL has 5 frequency channels with individual level controls on each channel. Control of the lights is comprehensive to say the least. You can run the unit as a straightforward sound-to-light or have it strobe all the lights at a speed dependent upon music level or front panel control or use the internal digital circuitry which produces some superb random and sequencing effects. Each channel handles up to 500 W and as the kit is a single board design wiring is minimal and construction very straightforward.
Kit includes fully finished metalwork, fibreglass PCB controls, wire, etc. - Complete right down to the last nut and bolt!


DE LUXE EASY TO BUILD LINSLEY HOOD 75W STEREO AMPLIFIER £99.30 + VAT

This easy 10 build version of our world-wide acclaımed 75 W amplifier kit based upon circui boards interconnected with gold plated contacts resulting in minimal wiring and construction delightfully straightforward. The design was published in HI -Fi News and Record Review and eatures include rumble filter, variable scratch filter, versatile tone controls and tape monitoring whilst distortion is less than $0.01 \%$.

All kits also available as separate packs (eg PCB, component sets. hardware sets etc) Prices in our FREE CATALOGUE.

$\mathbf{T} 20+20$ 20W STEREO AMPLIFIER £33.10 + VAT
This kit. based upon a design published in Practical Wireless, uses a single printed circuit board and offers at very low cost, ease of construction and all the normal facilitios found on quality amplifiers. A 30 -watt version of this kit $(T 30+30)$ is also available for $538.40+\mathrm{VAT}$

Above 2 kits are supptied with fully finished metalwork, ready assembled high quality teak veneer cabinet, cable, nuts, bolts, etc and full instructions - in fact everything! Matching TUNERS
and CASSETTE DECK - see our free cataloguel and CASSETTE DECK - see our free cataloguel


## LAST MONTH'S FRONT COVER FEATURE!

The BLACK HOLE designed by Tim Orr. is a powerful new musical effects device for processing both natural and electronic instruments, offering genuine VIBRATO (pitch modulation) and a CHORUS mode which gives a 'spacey feel to the sound achieved by delaying the input signal and mixing it back with the original. Notches (HOLES) groduced in the requency response, move up and down as the time delay is modulated by the chorus sweep with toot switch controls. IED effect selection indicators has variable sensitivity input has high signal/noise ratio btained by an audio compander and is mans powered - no batteries to change! Like all our kits everything is provided including a highly superior, rugged steel beautifully finished enclosure.

COMPLETE KIT ONLY £49.80 + VAT (single delay line system)
De Luxe version (dual delay line system) also available for $£ 59.80$ + VAT

## MPA $200{ }_{100}$ WATT ( (rms into 8 8 ) MIXER/AMPLIFIER

Featured as a constructional article in ETI, the MPA 200is an exceptional!y low priced - but professionally finished - general purpose high power amplifier. It features adaptable input mixer which accepts a wider range of sources such as microphone, guitar, etc. There are wide range tone controls and a master volume control. Mechanically the MPA 200 is simplicity itself with minimal wiring needed making construction very straightforward
The kit includes fully finished metalwork. fibreglass PCBs, controls, wire, etc. - complete down to the last nut and bolt


Penol size $19.0^{\prime \prime} \times 3.5^{\prime \prime}$. Depth 7.3"'

## COMPLETE KIT ONLY

 $£ 49.90$ + VAT!MATCHES THE CHROMATHEQUE 5000 PERFECTLY!

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Our pendant contains a (working - but what a shame to ruin it by wiring!) chip with quartz window, beautifully clasped in either silver or gold, depending just HOW generous you're feeling.
The price is pretty tasteful too and as the holder is emblazoned with the ETI logo, there is no better way of advertising the extent of your appreciation of the


To. ETI Pendant Offer, Modmags Sales Office, 145 Charing Cross Road, London WC2H OEE

Please send me . . . . . . . silver/gold pendants. I enclose cheque/PO p
$\qquad$
$\qquad$
$\qquad$

Allow 21 days for delivery.

## Invasion Monitor?

$\mathrm{H}^{+}$ere is the model 606B display monitor from Tektronix. It is a high resolution display for anyone needing critical sharpness for displays or display photographs. This monitor gïves a spot size of only 0.079 cm , and the manufacturers are aiming this at areas
such as medical multi-imaging and electron microscopy. For further information contact Tektronix UK Ltd, Beaverton House, PO Box 69, Harpenden, Hertfordshire.

But what we'd like to know is what is being displayed on the screen! A free subscription to whoever out there can tell us what it is!


## Instant Surgery

This may look like the surgical equipment of a mad doctor, but we are assured that this isn't its only function. Alternatively it can be used for DIP $J C$ insertion and extraction. The kit has extractors for $14-16$ pin
devices, 24-40 pin chips plus inserters for 14-16, 24-28 and $36-40$ pin ICs. All the surfaces that could engage conductive surfaces are CMOS safe. It is available from OK Machine \& Tool (UK) Ltd, Dutton Lane, Eastleigh, Hants SO5 4AA, and costs $£ 22.35$, a small price to pay for budding Dr. Frankensteíns.


Count On It


It was on a Monday morning that a small package arrived at ETI. It was greeted with the usual Monday morning enthusiasm - we ignored it-until suddenly. . it went off. The entire ETI staff dived for cover (we needed an excuse for a lie down anyway),

## Metal Locator (March)

Well, the world famous ETI mistake maker has struck again, this time his mistakes were located (!) in the Metal Locator project from our March edition. These were many and varied so here goes: In figure 1 the circuit diagram, starting from the left, the unmarked resistor is R4 $18 k$, at top centre $V / 2$ is not +18 V and underneath that R19 100 k does not go to +18 V but to Vs. IC4d should be labelled IC4a
and at bottom centre the common line to C2 470n, L1 and R2 15 k should be connected to 0 V . C18 10 n and C20 470 u should be transposed, and transistor Q9 is BC158. In figure 3, the component overlay, the tag which says White/WH should be White/ BLK and the unmarked IC should be IC4, Q8 and Q9 should be transposed and the missing resistor value is R45. Track C17 should go to pin 13 and not to 12. Figure 4 connection for front panel, lead marked Blue/BLK should be Blue/WH.

## Radio Control Protector (April)

We made an incorrect statement last issue with regard to the PPIM -4 CH from Chromatronics. We said that their device
would not operate if one of the decoder outputs locked high. Well it does and we were wrong. Sorry Chromatronics.

## B\&B 1537 VCA Article

$\mathrm{H}^{\mathrm{e}}$ere they are again. Errors. Rearing their ugly heads amongst the otherwise unsullied pages of ETI. But wouldn't you miss them if they weren't there?

The first error was on the schematic on figure 5. R6 and R9 should be shown as joined at pin 3 of the 1537A and R8 and R10 should be similarly joinedat pin 6.

In figure 6, the trace connecting pins 1 and 2 of IC1 is slightly
obscured by the IC outline, so take note all of you out there who are making there own PC board!

Also the titles for figures 14 and 15 are exchanged and a noninverting VCA configured as per figure 15 would have a minimum gain of unity, whereas the inverting VCA of figure 14 could attenuate to the common mode limits of the op amp used. OK?

## DISPLAYELECTRONICS

ADVERTISEMENT-MAYISSUE
Due to a printing error a photograph of the Super 77 Key Keyboard wrongly appeared under the 10 W price chassis heading. We apologise for any inconvenience caused to our customers.

## Sounds Interesting

H
ow does an extremely easy to make organ utilising "advance circuit techniques" strike you?

Aura Sounds have imported full organ kits which range in price from $£ 1499$ to $£ 7546$, but each complete organ is made up of smaller kits which can be bought individually, so that you can spread the pain of parting with your hard-earned over a
but as ever, our intrepid telephonist saved the day by ripping open the package, and there, to our surprise. . Yes, it was yet another member of the ever growing family of Casio, which has produced a new infant in the form of the fx-7100. A veritable baby, it measures $5 \mathrm{mmH} \times 55 \mathrm{mmW} \times$ 91.5 mmD and weighs only 44 gms . It incorporates a scientific calculator with 39 built-in functions, a continual display alarm clock accurate to 3 seconds a day under normal temperatures, a countdown alarm (repeater timer), a $1 / 100 \mathrm{sec}$ stopwatch and an hourly on the hour time signal a useful extra for clock-watchers (this had been the cause of the trouble that morning, and still causes the more somnambulant staff members to say 'wot dat?' every hour of the day).

The power consumption is 8 mW , which gives a life of approximately 1 year for the two sliver oxide batteries it uses. The package includes the usual data cards and a 70-page operation manual (cough). This little gem normally costs $\mathbf{f} 27.95$, or $£ 24.95$ from Tempus.
greater period of time. Aura Sounds assure us that the finished product is of superb quality, both sound and visual. Each kit comes complete with assembly manuals and they even supply the solder! The parts are in numbered containers so that the contents can be easily checked against the parts list. If you're interested contact: Aura Sounds, 14-15 Royal Oak Centre, Brighton Road, Purley, Surrey.

## Towers' Reaches New Heights

f you deal with transistors whether as a student, a hobbyist, a circuit engineer, a buyer, a teacher or a serviceman - you often want data on a specific transistor of which you know only the type number (that's what it says in the preface, anyway!)
All joking apart Towers'
International Transistor
Selector, is a veritable bible of over 20,000 British, American, European and Japanese transistors and available substitutes. All necessary infor-
mation is shown in a neat tabular form including package outline, lead info., European and Araerican equivalents etc, etc, etc. Published by W.Foulsham and Co. Ltd., this is the Revised Edition Update Two, and is well worth the outlay.
$\qquad$
$\square$

## ELECTRO-TECH COMPONENTS LTD.

## JVC-VICTOR HIGH FIDELITY STEREO CASSETTE TRANSPORT MECHANISM

ELECTRO-TECH COMPONENTS have secured a very large quantity of cassette transport mechanisms equipped with all the latest improvements, as well as 'SEN ALLOY" type 1.5 micron record/replay heads, and solenoid-controlled autostop action. These were manufactured by JVC / VICTOR of Japan to specification of TANDBERG OF NORWAY. This mechanism alone would normally cost over E50
FEATURES

* Close-tolerance, high-quality, top loading transport
* "Sen-Alloy" (SA type) R/P head
$\star$ Solenoid driven autostop circuit
* Automatic head cleaning device
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* Miniature microswitches for switching

Pre-aligned heads and calibrated motor speed regulator built in

* Three-digit tape position counter
* Six-function keyboard control

Rorward . Record Rewind. Forward. Play, "Stop/Eject Pause

* PCB connectors and cables attached
* High-mass balanced flywheel with permanent lubr cation spindle
* Full specifications for motor, heads and switches available on request



## £14.95 VAT inc.

plue £1.00 P\& P

## * CASSETTE DECK KIT BASED ON DESIGN OF MR. LINSLEY-HOOD *

We have developed an outstanding stereo cassette kit with the aid of Mr. Linsley-Hood, to complement the mproved specification and latest important advances in cassette electronics since the original design was published. The kit is ideal for use in conjunction with the JVC transport mechanism (left).
Included in the kit are iwo fibreglass PCB's, drilled and plated for jmmediate assembly, two VU meters. Dua LED Peak Meters, Variable Bias system, Power Supply over 10 micro-circuit IC's for the most up-to-date performance, as well as monitoring amplifier, test and calibration cassette, etc
Price of Kit (without transport mech.)
$£ 35.95$ VAT inc, plus $£ 1.00$ P \& P
Also available. A custom-designed case for the Kit, this is a fully screened enclosure, sloping panel, satin anodised, wood end panels, professional finish.

Price of Case $£ 9.75$ VAT Inc. plus $£ 1.00$ P\& $\mathbf{P}$
Readers will know of the original LINSLEY HOOD CASSETTE DECK Hesign, mblished in May 1976. Subse quent articles by Mr. Linsley. Huod have contirmed that the design far exceeded his original expectations, so much so that he bublished a number uf improvements moditications and additional features to the ariginal design which afe now incornorated in this Kit


BRAND NEW FROM FLUKE . NOW AVAILABLE
THE 8024A HAND HELD DMM This model incorporates all
$8020 A$ but in addition has.
A peak hold switch which can be used in AC or DC for volts and current functions
Audible continuity testing and level detection for sensing logic levels A temperature (
thermocouple. range for use with a £135

## Carriage and Insurance $£ 3$

The fowing accessories are in stock Y8008 Touch and Hold Probe ... $£ 18.00$ 81 $£ 45.00$

$\mathbf{£ 3 2 . 0 0}$ $80 \mathrm{~T}-150 \mathrm{C}$ Temperature Probe (C) $\quad$| $\mathbf{~} \mathbf{5 5} 5.00$ |
| :--- | 80 1-600 Clamp-on AC Current Probe $£ 55.00$



## HEREITIS

THE EVER POPULAR 8022A HAND-HELD DMM Consider the following features: 6 resistance ranges from 200
ohm-20 ohms. ohm-20 ohms. 8 current ranges from $2 \mathrm{~mA}-2 \mathrm{~A}$ $A C / D C$. 10 voltage ranges from 200 mv 1000 v DC- $200 \mathrm{MC}-750 \mathrm{~V}$ AC Pocket size - weighing only 370 gms. gull
Full overload protection - will withstand 6 kv spikes Rugged construction - virtually indestructable.
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\title{
FM MAINS DISTRIBUTOR
}

\title{
A system for distributing a Hi-Fi or other audio signal to any number of remotely-located speakers, using the mains wiring as the communication link.
}

This unusual project is designed to distribute an audio signal to any number of speakers that are remotelylocated throughout a house or office building, using the mains wiring as the communication link. The system has an overall audio frequency response that extends to 20 kHz , with typically less than \(0.5 \%\) total harmonic distortion and is designed to deliver a maximum of about 2 watts to each speaker. The system rejects all unwanted mains noise and has an overall audio sensitivity of about 10 mV for 2 watts output on each speaker.

The system comprises a single transmitter unit and any required number of remotely-located receiver/amplifier units. The transmitter unit generates a 200 kHz carrier signal, which is frequency modulated by the audio input signal and which the transmitter superimposes on the neutral line of the 230 volt AC mains wiring. At each receiver unit, this FM signal is picked up from the mains, is amplified, demodulated and the resulting audio signal is then fed to an external eight ohm speaker via a 2 watt power amplifier IC.

The transmitter and each receiver unit is provided with its own volume control. Each receiver unit is also provided with an automatic mute facility, which disables its audio output when the transmitter is turned off. All units are mains powered and simply plug into existing mains sockets via fused ( 1 amp ) plugs, no other interconnections being required. All units incorporate a variety of safety features, but it is essential for correct operation that the mains sockets be wired in the correct polarity: each socket should thus be tested with a neon indicator or similar device before plugging a unit into place.

The Mains-Line system can readily distribute an audio signal throughout an entire house or office building and has a variety of practical applications. In the home, it can be used to transmit the output of a music centre or other audio source to all rooms in the building. Alternatively, the transmitter can be fitted with a microphone and pre-amp and used as a baby alarm, enabling the baby to be heard from any part of the house.

In an office, the transmitter can be coupled to a mixer unit and used to distribute music signals and announcements throughout the entire building without the expense of having to fit additional wiring.

\section*{Construction:The Transmitter}

The entire transmitter unit, including the power transformer, is assembled on a single PCB. Construction should present few problems if the usual precautions are taken to ensure that all semiconductor devices and electrolytics are fitted in the correct polarity.

When construction is complete, set the core of L 2 and the slider of RV1 to mid position. If you have a 'scope, give the

unit a functional check by checking that a signal of a few hundred mV at about 200 kHz is present across the output terminals of T 2 : set the frequency to precisely 200 kHz via RV1 and trim the core of T2 for maximum output.

You can, if you wish, case the complete unit; our own prototype is uncased, as it is intended to be built into an existing audio amplifier system.

\section*{Construction:The Receiver}

Most of the recciver unit (except T1, RV2, SW1 and LED 1) is wired up on a single PCB. Construction should present few problems if the overlay is followed with care. When construction is complete, fit the PCB and remaining components into a suitable case and complete the interconnections to T1, RV2, SW1 and LED 1, as indicated on the overlay and the circuit diagram.

When construction is complete, set the core of T2 and the slider of RV1 to their mid position, connect the output of the unit to an eight ohm speaker and switch the unit on. With mute switch SW1 on, little noise should come from the speaker: with SW1 off, lots of 'white' noise should come from the speaker, indicating that the system is functional. If you have a 'scope, monitor pins 4-5 of IC1 and adjust RV1 to obtain a frequency of about 400 kHz .


Fig.1. Circuit diagram of the Line Transmitter.


Fig. 2. Circuit diagram of the Line Receiver.

\section*{HOW IT WORKS}

The system is designed to transmit an audio signal to any number of remotely-located receiver/speaker units, using the mains wiring as the communication link. The transmitter produces a low-level 200 kHz carrier signal, frequency modulated by the audio signal, which it superimposes on the neutral line of the mains wiring. At each receiver unit, the carrier signal is picked up from the mains, amplified, demodulated and the resulting audio signal is passed on to a speaker via a 2 watt audio amplifier IC. The use of an FM link ensures a good audio response and excellent noise rejection.

System operation relies on the fact that the mains wiring is highly inductive and acts as a fairly high impedance to a 200 kHz signal. At this frequency, the wiring can be regarded as an inductive potential divider, with the power sub-station at its 'low' end. This 'divider' normally produces relatively little signal attenuation between power points that are separated by scores or hundreds of metres of wiring and can be used as an excellent built-in 'data link' in any home.

\section*{The Transmitter}

IC2 is a voltage-controlled oscillator, or VCO. Its operating frequency is determined by the values of RV1-R4 and C8 and by the voltage on pin 5. With the component values shown, the VCO operates at a centre frequency of 200 kHz and produces a square wave output at pin 3. This output is used to drive common emitter amplifier Q1, which uses a standard IF transformer (T2) as its collector load; the centre frequency of T2 is shifted to 200 kHz by C3 and its ' \(Q\) ' is reduced to a fairly low value (to give a broad-band response) by R2. The output signal on T2 secondary (pins 4 and 5) has an amplitude of a few hundred \(m \vee\) rms.

Audio input signals to the unit are fed to volume control RV2 via C11 and then subjected to about 20 dB of amplification via Q2. The output of Q2 is used to frequency modulate the VCO via C9 and pin 5. Consequently, the output of T2 is a 200 kHz 'carrier' signal frequency modulated by the audio signal. This output is coupled into the neutral line of the mains wiring via low-value capacitor C2 and current-limiting 'fuse' LP1. Note that one side of T 2 output is wired to the Earth line of the mains, thereby ensuring that standing DC potentials of only a few volts exist between the primary and secondary windings of the transformer. C2 and LP1 ensure that the system will not be damaged if the output signal is accidentally fed to the live, rather than the neutral, side of the mains.

Q2 and IC2 are powered from a stabilised supply via IC1, a 12 volt regulator.

\section*{The Receiver}

The 200 kHz frequency-modulated mains signal is picked up on the input of T2 via C2 and current-limiting 'fuse' LP1; D3 and D4 are used to limit the T2 signal amplitudes to a few hundred millivolts. T2 is tuned to 200 kHz via C3 and has its ' Q ' reduced to a fairly low value via \(R 4\), to give a broad-band response. The isolated output signal of T2 is fed to the base of common emitter amplifier Q1 via current-limiting resist or R5.

The base of Q1 is biased to \(4 V 5\) via the R2-R3 divider network. Q1 is overdriven by the input signal and has its output clipped at about 6 volts peak-to-peak. The output of Q 1 is fed to the pin 3 input terminal of IC1 via R8-C6-R9. IC1 is a phase locked loop and is used to demodulate the 200 kHz FM carrier signal. This IC contains a reference oscillator, which is set to the same centre frequency as the carrier via RV1-R13 and C11. The demodulated audio signal appears at pin 7 of IC1. C12-R14-C13-R15-C14 are used to filter out any vestiges of the carrier and the resulting 'clean' audio signal is passed on to volume control RV2 via C15. The output of the volume control is fed to 2-watt audio amplifier IC3 and is then passed on to an external eight ohm speaker via C17. Most of the circuit (other than IC3) is powered from a stabilised supply via IC2, a 12 volt regulator.

The receiver unit is provided with an automatic 'mute' facility, which kills the audio output in the absence of a carrier signal, via Q2 and its associated network. Q2 is wired across the input to the volume control and kills the audio signal when biased on. Q2 is biased from two independent sources. It is positively biased (biased on) via R11 and the R2-R3 potential divider and call also be negatively biased (biased off) from the output of Q1 via the C7-D5-D6-C8-R12 rectifier network. The values of R11 and R12 are chosen so that the negative bias is predominant and Q2 is turned off in the presence of a carrier signal that has sufficient strngth to produce a peak-to-peak signal in excess of about 1 V 5 at Q1 collector. In the absence of a suitable carrier signal the negative bias falls to a negligible value and Q2 is turned on via R11.

The automatic mute circuit can be disabled by closing SW1, in which case the phase-locked loop tries to lock on to noise signals in the absence of a carrier and consequently produces very high noise levels at the output of IC3.

\section*{BUYLINES}

The Denco IF transformer used in this project is available from Watford Electronics. The other components should be readily obtainable.

\section*{Setting Up The System}

Access to a 'scope is needed when initially setting up the system, as follows.

Switch on both units and apply a suitable audio (music) signal to the input of the transmitter. Turn the transmitter volume control to zero, use the 'scope to monitor pin 2 of T2 in the receiver and adjust T2 core for maximum signal. Next, monitor pins 4-5 of IC1 in the receiver and set RV1 to the mid position at which locking to the 200 kHz carrier occurs. Finally, set the receiver volume control to mid value and adjust the transmitter volume control so that the music signal is heard at the receiver without apparent clipping. The system is then complete and ready for use throughout the house or office.

Right:a fully assembled line receiver PCB. Note the polarity of the ICs and polarised components.



Fig.3. Component overlay for the transmitter board.


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\title{
HOUSE WIRING
}

\section*{Ray Marston discusses house wiring systems of the past, present and future, presents some useful 're-wiring' aids and talks about some facinating line-based gadgets for the ' 80 s .}

Modern house wiring circuits are designed to conform to regulations laid down in 1947, that far-distant time when valves were in vogue and the word 'electronics' was used only in Sci-Fi movies. Consequently, modern house wiring works fine when used to power simple devices like flourescent lamps and electric toasters, but presents distinct problems if you want to use modern electronic lamp dimmers, FM power-line audio distribution systems, power-line remote control systems, or similar '1980s' devices.

If you happen to live in a house built before 1947, when 'modern' wiring was first introduced, it's a fair bet that your wiring is not only highly inefficient but is downright dangerous, with its rubber insulation perished to the point where total breakdown is imminent and the whole shambles is in danger of bursting into flames! So you'd better think about a rewire. And if you are going to rewire, you may as well rewire for the ' 80 s.

In the next few pages we'll tell you how 'modern' wiring systems work, explain the wiring needs of the ' 80 s, give a few hints on how to conduct a rewiring job and tell you about some of the wiring-based electronic control and data distribution systems that you are likely to see in the next year or so.

\section*{Conventional Power Wiring Systems}

Electric power is fed into the house from the outside mains and passes to the building's electricity meter. It is then fed to the individual household circuits via individual fuse units or, in the latest systems, via a multi-fused 'consumer' unit.

The household circuits are, for convenience, classified as three distinct types, (a) power circuits (feeding sockets, etc), (b) lighting circuits and (c) accessory circuits (individual heavy-duty circuits feeding immersion heaters, cooker panels, etc). Let's look first at 'power' circuits.

Old-style (pre 1947) electrical systems use a 'radial' system of power wiring, as shown in Fig.1. Here, each individual power socket or small group of sockets is treated as an individual circuit and is connected to the mains via its own specific fuse; often, the live and neutral lines of each circuit are individually fused.

Sometimes, different circuits have different fuse ratings (sometimes the cable gauges may also be different), so that an electric fire (for example) may work on one socket but blow the fuses (or the wiring) when connected to another socket.

The radial wiring system is clearly inefficient and requires the use of excessive amounts of cable and an excessive number of fuses.
'Modern' (post 1947) electrical systems use a 'ring' system of power wiring, as shown in Fig.2. Here, a power cable is run from the fuse box to the first (hall) socket, then sequentially to all of the sockets on (say) the ground floor and finally back to the fuse box again, so that a 'ring' of cable is formed. The ring is treated as a single circuit and provided with a single


Fig.2. Modern-style 'ring' power wiring circuit. The 'ring' is shown here connected to the fuse unit via a junction box, but in practice the 'ring' may be connected directly to the fuse unit.
master fuse, but all socket plugs are individually fused. Most modern houses are provided with two ring circuits, one for each floor. On the upper floor, the ring may be connected to the fuse unit via a junction box and feeder cable.

The ring system is very efficient in the use of cable. Power is fed to each individual socket via both sides of the ring, which are thus effectively wired in parallel and share the socket current. This factor enables a relatively light gauge of ring cable to be used. In practice, \(2.5 \mathrm{~mm}^{2}\) PVC sheathed cable is used for ring circuits. Any number of sockets can be fitted on a ring serving a surface area of less than \(100 \mathrm{~m}^{2}\left(1000 \mathrm{ft}^{2}\right)\) : the ring must be fitted with a 30 A (max) fuse and can handle up to 7.2 kW . The feeder cable to such a ring (if used) must be \(4 \mathrm{~mm}^{2}\) type.

\section*{Power Wiring For The 80s}

The most important 'house wiring' innovation of the ' 80 s will be the widespread use of the mains wiring as a high frequency (a few tens or hundreds of kHz ) data link between different parts of the house. The live and neutral lines of the house wiring each contain very considerable lengths of cable and consequently have substantial inductance. The reactance of the wiring is negligible at 50 Hz but can be quite significant at frequencies of a few tens or hundreds of kHz .

High frequency signals can thus readily be superimposed


\section*{Ring For Roses}

A major problem with the Fig. 4 circuit is that suitable (30 A) filter inductors are not readily available at the present time. When planning a rewire for the ' 80 s , space should, however, be left in the fuse box area for the eventual fitting of such a filter when suitable components become available. Note that high-current 'accessory' circuits such as the cooker panel and immersion heater are not fed by the filter: nor are the lighting circuits, which generate a good deal of electrical noise when used with lamp dimmers, etc.


Fig.5. The basic lighting circuit (earth wiring not shown).


Fig.6. Old-style implementation of the lighting circuit (earth wiring not shown), with three wires (plus earth) running down to each switch.

In summary, then, power wiring for the ' 80 s will take the form of 'modern' (post 1947!) ring circuits except that the feed line to the rings should be fitted with RF filters.


Fig.7. Modern-style implementation of the lighting circuit (earth wiring not shown), with two wires (plus earth) running down to each switch.

\section*{Conventional Lighting Circuits}

The basic lighting circuit of a domestic system is deceptively simple, as shown in Fig.5. Note that the light switch is used to connect the lamp to the live side of the circuit, thereby ensuring that a shock cannot be received from the lamp holder (when changing a bulb) when the switch is open or off.

The physical implementation of the Fig. 5 circuit is not a simple task. Fig. 6 depicts the old-style (pre 1947) method of implementation, in which Neutral goes to one side of each lamp and the Live line is looped from one switch to the next. Note that this method requires three wires (plus Earth) to be run down to each switch. In practice, the old-style wiremen tended to disregard the 'polarity' rules and often switched the


Fig.8. Typical ground-floor lighting circuit of a medium sized house.
Neutral line, so that the lamp holder remained permanently (and dangerously) 'live'.

Once again, the system in Fig. 8 looks deceptively simple. In practice, the system may, if you are unlucky, take a full weekend to implement, particularly if you are changing the positions of light switches and have to cut new down-channels in the plaster to accommodate new cable runs.

\section*{Lighting The Way}

Figure 9 shows the circuit and implementation of 2-way light switching. In practice 2 -core, plus earth, cable is used to connect SW1 to the ceiling rose and 3-core plus earth is used to interconnect SW1 and SW2. A lot of channelling work may be required to implement the system. Note that changeover switches are required for 2 -way switching.



Fig.10. The electrical circuit that is used in 3-way light switching.

\section*{Lighting Circuits}

A major deficiency of 'modern' lighting systems is the physical difficulty that is involved in initially installing the light switch wiring or in converting the system to multi-way switching. An ideal '1980s' solution to this problem is offered by the push-button-activated lamp dimmer/on-off circuit of Fig. 11.


Note that the control (push-button) switches of the above circuit carry maximum currents of only a few mA and that any number of switches can be wired in parallel, enabling multi-way control to be readily implemented.

Ideally, this unit should be connected into the house wiring in a position that is close to the 4 -terminal ceiling rose (but readily accessible for maintenance purposes): the pushbutton control switches should then be installed in the desired 'wall switch' positions and connected to the unit via lowpower twin flex, shallowly buried in the plaster.

Note that the circuit uses components L1 and C1 for RFI suppression. All lamp dimmer circuits generate substantial RFI and should therefore incorporate suitable suppression networks: in practice, the very limited size of the conventional 'plaster-depth switch box' precludes the fitting of suitable filters, so most of todays 'manual' dimmer circuits generate unsuppressed RFI. A major advantage of the remote-controlled dimmer/on-off circuit of Fig. 11 is that its physical size is not significantly constrained, so excellent filtering can readily be incorporated.

\section*{Practical Rewiring Hints}

Electrical re-wiring is a technically simple but physically arduous and time consuming task. Floor boards have to be raised to gain access to the wiring and holes have to be drilled through joists and beams to facilitate wiring runs: plaster has to be channelled to accept new cable runs and must be remade afterwards.

Essential tools for the job include \(21 / 2^{\prime \prime}\) bolster chisels, a lump hammer and a decent power drill. Before starting the job, plan your new wiring layout with care, giving thought to the sensible positioning of new power sockets, light switches and ceiling roses. Your task may be simplified by using the conduit of the old wiring system.

Figs. 12 to 14 show some useful rewiring aids. The Fig. 12 and 13 circuits are used for tracing old wiring and conduit. The Fig. 12 wire tracer works on the magnetic-field detection principle and is used to trace 'live' wiring. The Fig. 13 circuit acts as a simple 'metal' detector and is used in conjunction with a hand-held pocket radio to trace cables, conduit and

Fig.11. This push-button-activated dimmer/on-off unit (below) can accept any number of parallel-connected inputs and offers a state-of-the-art solution to the multi-way light-switching problem. The unit can be wired into the domestic lighting circuit (left).

plumbing. These two circuits are described in greater detail in the June ' 79 issue of ETI.

Finally, the Fig. 14 'marker beacon' circuit is useful for indicating the loft or under-floor break-through positions of pilot holes drilled through ceilings when installing new feeder cable runs or when re-positioning ceiling roses.

The cable used for rewiring will be \(1.0 \mathrm{~mm} \mathrm{~T} \& E\) for the lighting circuits, 2.5 mm T \& E for power rings and 4 mm T \& E for the ring feeders. All metal switch boxes and metal conduit, etc, must be earthed; the earth cable must be connected to the earth line of the mains feeder into the house.

Fig.12. This wiring tracer works on the magnetic-field detection principle.


Fig.13. Circuit of a simple BFO-type mains and plumbing seeker; the unit is used in conjunction with a hand-held pocket radio.


Fig.14. This 'marker beacon' circuit can be used to indicate the position at which pilot holes break through into dark places.

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\title{
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\section*{Lost in a haystack full of needles (stylii?) Ron Harris presents a review of Shures new M97 cartridge range and compares two other two moving-magnets from Stanton and Ortofon.}

Ihave to start this month with two apologies. The first goes to Videotone who had two pieces of equipment in my \(£ 300\) system a while back. Seems that while the issue was going to press, they had their bright idea of going direct mailorder, with the result that their prices took a tumble. Being nice helpful people they rang me up to tell me this of course, but being the worlds worst file keeper I promptly lost the piece of paper with the facts scrawled across its tatty, crumpled face.

So, a little belatedly I admit, I have the somewhat unusual task of reporting a price FALL. GB2 loudspeakers can be purchased now for \(£ 60\) and not the \(£ 100\) or so they used to cost. The Coral 555 E cartridge also comes down, from \(£ 25\) to around £14. Good news indeed for those shopping in that area and reason enough for me to begin filing things properly.

My second apology goes to everyone, including me, who has the sense of beauty to appreciate the lovely Felicity Kendal. Last month's Audiophile was supposed to contain an excellent photograph of the lady, provided by Mr. Rickwood. Sometime between leaving my desk, bound for our printers, and reappearing in the issue, someone or something GOT to it. thing GOT to it.

When I find out who, there will be set abroad in the night such things that the miserable wretch will lie shivering and cowering in his repentance . . . . . . .

\section*{Tale Of Four Cartridges}

To hear some of the disciples speak, you could be excused for thinking that moving-coil cartridges were the only things fit to waggle a cantilever across a record. There are, however, not a few companies still producing some excellent units in the higher price brackets, whose coils remain remarkably static.

Immediate claims to such fame could be made by Shure, Goldring, Stanton, Ortofon, Empire and Grado. Units which earn such accolades might be V15 IV, 900 IGC, 881S, LM30, EDR9 and G2. Might be. That is what I determined to find out. The first two units, the Shure and Goldring, will be no strangers to Audiophile readers as both have been reviewed herein already. This month I have a report on the Stanton 881 S and the Ortofon LM30H - SME style. Empire were invited to participate but still had not supplied an EDR9 by the time this magazine went to press. Should they ever awaken down there and one appears over my horizon you'll be hearing about. Until then - a pity.

As more than adequate compensation I can offer a firstever review on two of the new Shure M97 series of pickups the top model, the 97 HE and the middle of the road M97EJ. Let's start with these Shures then.

\section*{V15's For All?}

This new range from Shure is based upon the technology of their V15 IV model. All inherit the "dynamic stabiliser" affair from their predecessor - a carbon fibre brush set in damped pivots which rides ahead of the stylus and provides a
good deal of isolation from shock - and the 97HE model even has the same stylus contour as the V15 itself.

A feature which I am positively NOT going to test is their 'side-guard'. Shure claim that a 'lateral deflection assembly' allows the cantilever to accept impact in a sideways direction without damage, with the stylus simply withdrawing into the cartridge body. This might occur, say, when the cartridge hits the side of an LP accidentally, or is knocked across a record. Shure - I'll take your word for it, my courage fails me.

These are large cartridges, which look superb set up (in any arm). As usual for Shure the packaging and presetation is magnificent and the finish on the cartridges faultless.

The HE will take its place beneath the V15 IV in Shure's range, but with the incredible number of cartridges Shure now have on the market, it is difficult to be sure - and they show

> Audiophile has acquired a new pair of reference speakers - KEF 105 Il's, shown below and (in cutaway) right. These are probably the best speakers on the market today for home use. As you can see the 'head' contains the mid-range and HF units, each in its own little enclosure. This can be tilted and tumed through a limited angle laterally, such that the stereo image can be optimised for the listener.

no signs of rationalising. More power to them if they can sell them all.

It should be said, though, that this M97 series is a significant step ahead of their other ranges in terms of sound quality and should outsell them all with ease. Originally 1 hadn't intended to include either of these two models in with the Stanton and Ortofon - after all the price is noticably lower but the HE performed well enough for me to think it worthwhile. In fact one of the surprises awaiting me amid this forest of cantilevers, was how close the M97HE came in performance to the exalted V 15 IV !

\section*{Shure-fire Test?}

Under test conditions both the M97s proved themselves worthy of their predigrees. Both are top-flight performers in their respective classes and in fact the EJ is capable of tracking higher recorded velocities than the HE - but at a gram more weight. The HE cleared all my traps at 1 g actual tracking force (the brush means that you set up for 0.5 g more) and the E) had an optimum force of 2.2 g . Have a look at the table for more details of the results.
(Throughout these ramblings, "optimum tracking force" is that downforce at the stylus above which no improvement in tracing ability is obtained for increased weight). The 97EJ gave a creditable account of itself all around. Set up in a JVC QLA5R deck it performed very competently and gave a good
solidity to the sound, with a warm balance and smooth treble. It would match most good loudspeakers in the \(£ 100-£ 200\) class that exhibit a clean top and its powerful bass could be a decided asset, especially to impercunious rock fans.

On the debit side it has a tendency to impose too much of itself upon the music at times and could be tipped over the edge into hardness (surprisingly) by very complex material. Still, these are minor effects - and more minor than you'd expect at the price. Not a serious worry and overall a good design, one which does credit to its designers.

Set up in an SME III the M97HE played very well with all types of music. It is a good cartridge by any standards, having a smooth easy-to-listen-to approach to its task, and is tolerant of material of lesser stature than itself. As 1 said earlier it is very difficult at times to distinguish this pickup from the V15 IV - it has that same confidence in its own infallible tracking ability, never putting a diamond wrong. Distortion is low and the base possesses a good punch. Detail is well portrayed, but it is here that the \(V 15\) shines through with superior mid-range quality. A more refined performance is bought with the extra cash, it seems.

It would take a good system to justify the classier performance though, a careless matching of components could easily obscure the differences. Good enough then, I thought to bear comparison with the Ortofon and Stanton and so included the M97HE in the tests; about which you'll be hearing more later. Remember the price difference though.


Above: the Shure M97E) and, below, the M97HE still reclining in its box. Both the cartridges are identical in appearance - so there was little point in showing photos of them both!

Note the dynamic stabiliser clipped down into position as a stylus guard on the El.



\section*{Stanton On It's Merits?}

The Stanton 881S. Doesn't seem so long ago that the 681 and V15 111 were considered the two best cartridges around long were the nights spent arguing over the relative merits of the pair of them.

Stanton seem to have taken something of a low profile lately and this unit has never received the publicity it deserves. Having now auditioned it at greater length, I feel it has a lot to offer, albeit with a few vices amongst its virtues.

The 881 S is also very well presented and its appearance is very striking indeed, with the silver finish and white stylus carrier. All preceded, of course, by the inevitable brush - and this I cannot refrain from condemning, both as a cleaner and an aid to the cartirdge as a whole. Thank decibels it is at least removable.

At a time when great effort is being expended to remove static, and to ground any charges present on records; listen to Stanton's own description of how the brush does its work:-
"It operates on the principle that the rubbing action of the nylon bristles against the vinyl record surface creates an electrostatic charge which attracts dust particles like a vacuum cleaner". \(\qquad\)
\(\qquad\)
I'll bet it does. And charges up the record surface nicely too. (Dust sticks to LPs very well under charge conditions.) The stylus is trailing along just behind the brush - straight into that charged patch of vinyl prepared for it. What odds on increased snap, crackle and pop? Why, why, why, why, why, when you have a pickup this good, lumber it with a built-in static generator? I despair of humanity sometimes, I really do.

This is a well engineered unit, as the test results prove. Channel balance is beautifully maintained and resonances tightly controlled. As is Stanton's way, the cantilever is amazingly short and durable. The mass, minus brush, is about average

The sound of the 881S is best described as rich and detailed. There always appeared to be a lot going on in the music, with the cartridge obscuring little of it. The bass is good but not as extended as it might be. Mid-range is sharp and clear but can be a little too sharp in the \(2 \mathrm{kHz}-5 \mathrm{kHz}\) range at times. Treble was well extended and crisp and overall the sound was well balanced and exciting to listen to.

A cartridge more than worth its asking price, but capable of being improved still further, I feel.

\section*{Ortofon/SME 30H}

Now this is something really different. Part of the new ultra-low mass range from Ortofon, the Ortofon/SME 30 H is the LM30H cartridge adapted for use with an SME Series III pickup arm. Adaptation here means 'building into'. A normal

Left: the Stanton 881 S in its plush little box. That relatively huge container holds the fixing hardware for the Stanton cartridge, and everything else you want to hold in the headshell. What looks like a police whistle, in the foreground, is in fact a screwdriver. Very nice presentation.

CA1 arm has been shorn of headshell, and the 30 H fitted as part of the new one.

The overall effect is to bring down the effective mass of cartridge and arm to 4.2 g and create the most striking pickup around. It looks superb in operation.

Low mass like this has great advantage in the bass registers. Used in the SME, the system resonance - the frequency at which it is easiest to put a peak in the response - lies at 13 Hz , which is too high to be effected by record warps, or ripples and too low to let acoustic feedback from the speakers influence it.

So much for the theory of it, in practice we have a very attractive, pencil slim, cartridge with built-in finger lift. Just about every aspect of operation has been well thought out. An alignment tool is provided for setting up the individually shaped cartridge for vertical tracing angle. Without it, it would be virtually impossible. Even the stylus guard will help with lateral balance adjustments! (Try and work that one out.)

In play the Ortofon proved to be as much of a contrast to the Stanton in sound as it had been in looks. The bass was nothing short of phenominal. The extension went way down, more importantly though the energy was controlled very well, with no sign of looseness or tendency to 'boom'. The low mass and integrated head were responsible for this, I think. The midrange was restrained but open. No sign of brightness or sharpness here. Some people would think it too bland I suppose, but then since when does 'neutral' mean 'striking'?

Overall the Ortofon presents a smoothly blended face to the world, with perhaps a slight veiling of the extreme high frequencies.

If ever there was a cartridge that was at home with a certain type of music, it is this one. On classical music of the symphonic variety, the Ortofon really soars. Things simply sound "in place" and natural. It is probably the best pickup I have ever heard on this type of material. The difference between its performance with say, Wagner and with the Floyd is very marked and not a little puzzling. On the former it is staggeringly good, on the latter - simply good.

\section*{Listen Here}

It was this which started me off on what developed into a full blown comparison session, with the resultant exponential increase in people, equipment and headaches. All though the listening so far I had been using my usual cartridge as a reference against which to measure the others, simply because I am well used to it and know its foibles well enough.

The pickup in question is a Coral MC81 moving coil, which I have been in love with ever since reviewing it in these pages many LPs ago. I consider it one of the best around at any price and as it costs only about \(£ 48\) these days, affording a head-amp is not the bank-robbing job it might be.

Anyway I digress. What transpired in the end was that I set up a listening -panel type of comparison between the Stanton, Ortofon, Shure M97HE and the Coral as reference.

I have not the space, or inclination, here to go on about the steps taken to ensure impartiality. They were taken, believe me. If you don't you're probably a PE reader anyway!

The rest of the disc playing system comprised. Technics/ SMEIII configurations feeding a Lecson amplifier and being relayed to the waiting ears by that same pair of KEF 105 II loudspeakers. Some use was also made of a Sony TCK 55 II cassette.

Right: and below is the amazing Ortofon SME 30 H . As you can see there is no real headshell, just the cartridge itself. The unit looks extremely elegant in use, but the one thing they don't tell you is that it is so light that you need to remove ALL the lead weights from the SME III to balance it -- which means that you need more spacers.

After it
was all over ! took the scores, and'normalised'the reference at 15 for everything, adjusting the other scores to create the (average) figures obtained below. (Table Two)

Material varied from Wagner to Rickie Lee Jones, via Grieg, Holst, Stravinsky, Thelma Houston, Sky, Alan Parsons and the inevitable Pink Floyd. Each listener was asked to mark the cartridge playing, out of 20, on the parameters shown in Table Two, without knowing which unit was operating.

Not much to choose really is there? The Shure comes out least well, but then its price bracket lies well below the other two and this is in reality a creditable showing indeed. As such I can confidently recommend both examples of the M97 range, secure in the knowledge that few (if any) will be disappointed with the purchase. Yet another nice one Shure.

The Stanton and the Ortofon are a different matter. Both provide ample evidence of the excellence obtainable

from moving-magnet methods, but are totally different in their sound balance.

They scored identically in this respect in the test, as you can see, so both are appealing designs. The Ortofon is to be preferred for classical material and the Stanton for rock. Perhaps that, undoubtedly over-simplified statement is as close as I'll get to defining the differences for you. Comparing the two is entertaining stuff - try it yourself if you plan to spend around \(£ 80\) on a cartridge. The time will not be wasted and neither will the money!

Back to amps next month, with a look at an offering from Quantum Electronics. Their 102 pre-amp matched to the 110W per channel 204 power amp. You can obtain the units as either kits or ready-built equipment and amplifier modules are available separately. The main question is though - what do they sound like?
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|c|}
\hline \multicolumn{11}{|c|}{Table One} \\
\hline & \[
\begin{aligned}
& \text { Stanton } \\
& 8815
\end{aligned}
\] & \begin{tabular}{l}
Ortafon/ \\
SME 30H
\end{tabular} & \multicolumn{2}{|l|}{Shure M97HE} & \begin{tabular}{l}
Shure \\
M97E J
\end{tabular} & \multicolumn{5}{|l|}{Table One: objective test resuits. Note the Ortofon specified load is a good deal higher than normal, and a padding capacitor could be used to advantage} \\
\hline Output: \(1 \mathrm{kHz} \mathrm{5cm/sec}\) & 5 mV & 3.2 mV & \multicolumn{2}{|l|}{4.5 mV} & 5 mV & \multicolumn{2}{|l|}{\multirow[t]{2}{*}{the pickup arm to 4 g , well under pickups.}} & \multicolumn{3}{|l|}{\multirow[t]{2}{*}{effective mass is actually dose the figures for the rest of the}} \\
\hline Channel Balance & \(<1.5 \mathrm{~dB}\) & \(<2 \mathrm{~dB}\) & \multicolumn{2}{|l|}{\(<1.5 \mathrm{~dB}\)} & \(<2 \mathrm{~dB}\) & & & & & \\
\hline Optimum tracking force & 1.1g & 1.3 g & \multicolumn{2}{|l|}{1 g} & 2.2 g & \multirow[t]{2}{*}{} & & & & \\
\hline \begin{tabular}{l}
Frequency Response \\
Limits, \(20 \mathrm{~Hz}-20 \mathrm{kHz}\)
\end{tabular} & \(\pm 1 \mathrm{~dB}\) & \(\pm 2 \mathrm{~dB}\) & \multicolumn{2}{|l|}{\(\pm 2 \mathrm{~dB}\)} & \(\pm 2 \mathrm{~dB}\) & & & & & \\
\hline Separation (LonR) 1 kHz & 32 dB & 30 dB & \multicolumn{2}{|l|}{35 dB} & 28 dB & & & & & \\
\hline Cartridge Weight & \[
\begin{gathered}
6.7 \mathrm{~g} \\
\text { (inc brush) }
\end{gathered}
\] & \[
\begin{aligned}
& 10.5 \mathrm{~g} \\
& (\text { inc arm) }
\end{aligned}
\] & \multicolumn{2}{|l|}{6.4 g} & 6.4 g & & & & & \\
\hline Recommended Loading & 47k // 275p & \(47 \mathrm{k} / / 400 \mathrm{p}\) & \multicolumn{2}{|l|}{p \(47 \mathrm{k} / / / 250 \mathrm{p}\)} & 47k // 250p & & & & & \\
\hline Typical selling price & \multirow[t]{2}{*}{£80} & £85 & \multicolumn{2}{|l|}{£45} & £27 & & & & & \\
\hline \multirow{6}{*}{Table Two : subjective These figures are the responses gleaned from the panels individual markings.} & & & & & Tabl & Two & & & & \\
\hline & esuits. anged tening & & \[
\begin{aligned}
& \text { Bass } \\
& \text { Extension }
\end{aligned}
\] & \[
\begin{aligned}
& \text { Bass } \\
& \text { Quality }
\end{aligned}
\] & Mid-range Quality & Rendition of Detail & Balance of Sound & Treble Extension & Treble Quality & Neutrality \\
\hline & \multicolumn{2}{|l|}{CORAL. MC81} & 15 & 15 & 15 & 15 & 15 & 15 & 15 & 15 \\
\hline & \multicolumn{2}{|r|}{STANTON 881S} & 17 & 14 & 12 & 14 & 14 & 14 & 13 & 13 \\
\hline & \multicolumn{2}{|r|}{ORTOFON 30H} & 18 & 15 & 14 & 14 & 14 & 10 & 12 & 15 \\
\hline & \multicolumn{2}{|r|}{SHURE M97HE} & 18 & 13 & 12 & 13 & 13 & 14 & 13 & 13 \\
\hline ETI JUNE 1980 & \multicolumn{4}{|c|}{.} & & & & & & \\
\hline
\end{tabular}

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\title{
A complete personal computer for a third of the price of a bare board.
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\section*{Also available ready assembled for \(£ 9995\)}

\section*{The Sinclair ZX80.}

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\section*{valuable components of the}

\section*{Sinclair ZX80.}

The Sinclair \(\%\) K 80 is not iust another personal computer. (Quite apart from its exceptionally low price, the ZX80 has two uniquely advanced components: the Sinclair BASIC interpreter: and the Sinclair teach-yourself BASIC manual.
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offers remarkable programming advantages:
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- Unique syntas check. Only liner 1 ith correet Emtas are aceepted into programs. Acuroor dentaties errors immediately. This prevent contry of long and complicated programs with fault. only discowered when you try to run them
- Excellent string-handling capahilty - taker up to 26 suing variables of any length. AH -trings can undergo all retational tests e.g. comparison. The / X80 also haw otring inputto request a line of text when necebary Stringe do mon need to be dimensioned.
- Un to 26 angle dimenson arrays

- Cariable name of any length.
- BASIC: Language also handmes tull Boobcan arithmetic. condtional exprontorn, cti
- Excentionally ponerful edatacilttes, allowmodilication of existing program lines.
- Randomse function uncful for gamen and necret codor, a 11 ell a more serious applicathon-
- Timer under program conted
- IlBLK and POKl: cnahle entry ot mathine code in-tructions, LSR caucco bump to a uerimatione language var-roumbe
- lligh-resolution graphics with 22 standard graphic umbols.
- All characters printable in reverse under program control.
- Linc of unlmited length.

\section*{and the Sinclair teach-yourself} BASIC manual.
If the features of the Sinclair interpreter listed alongside mean little to you-don't worry Thev're all explained in the specially-written 128-page book frow with every kit! The book makes learning easy, exciting and enioyable, and represents a complete course in BASIC programming - from first principles to complex programs. Available separately-purchase price refunded if you buy a \(Z \mathrm{X} 80\) later.) A hardware manual is also meluded "th erers kit or built machine.


\section*{lete computer kit. \\ }

Fewer chips,
compact design,
volume production-
more power per pound!
I he \(/ \mathrm{X} 80\) owes its remarkable
low price to its remarkable
design: the whole system is packed on to
dwer. newer, more nowerfut and adranced i.S
chips. A single ST Pl:R R ()M, for instance, contains
the BidSlC interpteter, the character set, operating sistem. and monitor And the \(/ \mathrm{N} 80\) 's ik bete RA. 1 is roughly equitalent to +K betes in a contentional computer-typically storing 100 lines of BASIC. Key wordancupy only a single byte.

The display shows 32 characters by \(2+\) lines
And Benchmark tents show that the Z 880 is faster than all other personal computers.

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\title{
LINEAR OHMMETER
}

\section*{Well suited to either the lab or hobbist bench this accurate little project will provide an inexpensive answer to many resistive problems.}

This instrument is an inexpensive semiprecision ohm meter that can be used to give accurate readings of resistance from a few tens of ohms to one megohm. The unit has four decade ranges covering 1 k to 1 M full scale and has a full scale accuracy of \(2 \%\) if low tolerance range resistors are used.

Conventional moving coil ohmmeters have non-linear scales which typically cover two to four decade ranges of resistance value on a single scale. With such a range of resistance it is impossible to obtain an accurate read ing, especially at the higher values. To measure resistance values with reasonable accuracy, the usual method is to use a Wheatstone Bridge, often very expensive and time consuming.

By contrast, this ohmmeter gives resistance readings on a linearly calibrated scale and covers only a single decade of resistance on each switched range. The instrument thus gives inherently more accurate readings of resistance than multimeter type ohmmeters.

\section*{Construction}

The ohmmeter can either be constructed as a completely contained unit, with its own moving-coil meter, as we have done, or it can be built as an add-on to an existing multimeter having a 1 mADC range.

Take care with the polarity of the zener diode. The 301 op-amp cannot be substituted by a 741 as it has been selected for its low input current. The overall accuracy of the instrument is determined by the tolerance of the range resistors (R3 to R6) and the accuracy of the meter. If \(1 \%\) or \(2 \%\) resistors are used the accuracy of the instrument will be about two percent.

When the board assembly is complete, fit into the box and complete the wiring to the major components. If you are making an add-on version of the meter, fit a couple of screw terminals in place of the meter for connection to your multimeter.

\section*{Calibration}

When construction is complete, switch the unit on and check that the LED lights up. If it doesn't, check the wiring and the polarity of the LED. When all is well connect an accurately known resistor (having a value within the range of the instrument) across the terminals and adjust the trimpot for the correct reading. The unit is then ready for use and should not require further calibration. You could purchase a \(1 \mathrm{k}, 1 \%\) resistor specifically for this purpose.

\section*{BUYLINES}

There are no components here which will prove difficult to obtain. Casing is not critical in the slightest, and all the mailorder advertisers within this issue should be able to provide all the bits and pieces required.

PARTS LIST
\begin{tabular}{ll}
\begin{tabular}{l} 
Resistors All \(1 / 2 \mathrm{~W}\) \\
(*see text)
\end{tabular} & \\
R1 & \(2 k 75 \%\) \\
R2 & \(1 k 05 \%\) \\
R3 & \(1 k 0^{*}\) \\
R4 & \(10 k^{*}\) \\
R5 & \(100 \mathrm{k}^{*}\) \\
R6 & \(1 \mathrm{MO}^{*}\) \\
R7 & \(560 \mathrm{k} 5 \%\) \\
RV1 & \(5 \mathrm{k0}\) (minimum) vertical \\
& \\
Capacitors & \\
C1 & \\
Semiconductors & \\
LED 1 & TIL220 \\
ZD1 & \(5 V 1400 \mathrm{~mW}\) \\
Q1 & BC109, BC549 \\
IC1 & 301
\end{tabular}

Miscellaneous
SW1 DPDT toggle switch, SW2 one pole four position wafer switch, M1 1 mA FSD meter, SK1,SK2 screw terminals.



A peek inside at the PCB. Make sure it doesn't foul the range switch or meter.

The linear scale ohmmeter circuit is divided into two parts: a reference voltage generator and a readout unit that indicates the value of the resistor under test. The reference voltage generator section of the circuit comprises zener diode ZD1, transistor Q1, and resistors R1 and R2. The action of these components is such that a stable reference of about 5 V is developed across R2. This reference voltage is fed to the op-amp resistance-indicating circuit via range resistors R3 to R6.

The op-amp is wired as an inverting DC amplifier, with the 1 mA meter and R8-RV1 forming a voltmeter across its output, and with the op-amp gain determined by the relative values of ranging resistors R3 to R6 and by the negative feedback resistor Rx. RV1 is adjusted so that the meter reads full scale when Rx has the same value as the selected range resistor. Under this condition the op-amp circuit has a voltage gain of precisely unity. Since the values of the reference voltage and the ranging resistors are fixed, the reading of the meter is directly proportional to the value of \(R x\), and the circuit thus functions as a linear-scale ohmmeter and has a full scale value equal to the value of the selected range resistor.


Fig.2. Component overlay.

\section*{I.L.P's PROVEN RANGE OF HIGH}


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and staying there
}

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\begin{tabular}{|l|l|l|l|l|l|l|l|}
\hline Model & \begin{tabular}{l} 
Output \\
Powsr \\
R.M.S.
\end{tabular} & \begin{tabular}{l} 
Dis- \\
tortion \\
Typical \\
at 1KHz
\end{tabular} & \begin{tabular}{l} 
Minimum \\
Signai/ \\
Noise \\
Ratio
\end{tabular} & \begin{tabular}{l} 
Power \\
Supply \\
Voltage
\end{tabular} & \begin{tabular}{l} 
Size \\
in mm
\end{tabular} & \begin{tabular}{l} 
Weight \\
in gms
\end{tabular} & \begin{tabular}{l} 
Price + \\
V.A.T.
\end{tabular} \\
\hline HY30 & \begin{tabular}{l}
15 W \\
into \(8 \Omega\)
\end{tabular} & \(0.02 \%\) & 80 dB & \(-20-0-+20\) & \(105 \times 50 \times 25\) & 155 & \begin{tabular}{l}
\(£ 6.34\) \\
\(+95 p\)
\end{tabular} \\
\hline HY50 & \begin{tabular}{l}
30 W \\
into \(8 \Omega\)
\end{tabular} & \(0.02 \%\) & 90 dB & \(-25-0+25\) & \(105 \times 50 \times 25\) & 155 & \begin{tabular}{l}
\(£ 7.24\) \\
\(+£ 1.09\)
\end{tabular} \\
\hline HY120 & \begin{tabular}{l}
60 W \\
into \(8 \Omega\)
\end{tabular} & \(0.01 \%\) & 100 dB & \(-35-0-+35\) & \(114 \times 50 \times 85\) & 575 & \begin{tabular}{l}
\(£ 15.20\) \\
\(+£ 2.28\)
\end{tabular} \\
\hline HY200 & \begin{tabular}{l}
120 W \\
into 8 \\
\hline
\end{tabular} & \(0.01 \%\) & 100 dB & \(-45-0-+45\) & \(114 \times 50 \times 85\) & 575 & \begin{tabular}{l}
\(£ 18.44\) \\
\(+£ 2.77\)
\end{tabular} \\
\hline HY400 & \begin{tabular}{l}
240 W \\
into \(4 \Omega\)
\end{tabular} & \(0.01 \%\) & 100 dB & \(-45-0-+45\) & \(114 \times 100 \times 85\) & 1.15 Kg & \(£ 27.68\) \\
\(+£ 4.15\)
\end{tabular}

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Hobby
}

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Electronics
}

\section*{The June issue will be on sale May 16 th}

\section*{HE RADIO CONTROL}

Can it be true? Yes, of course it is, all the problems have been sorted out and next month we will be presenting what must be the last word in terms of simple to build, 2 channet proportional R/C systems.

The Tx, Rx units are based on just two, that's right, two, purpose-built ICs External circuitry has been kept to an absolute minimum, conse quently it will cost a fraction of a commercia system. Designed primarily for land-based vehicles, boats, cars etc it will enable even the most un-skilled constructor to put together a really first-class R/C combo in just a couple of relaxed evenings

More than that we're not prepared to say, we are keeping the system under close wraps. We're sure it's going to revolutionise construc tional radio control. Make sure you place your order early as the June issue is sure to be a sell-out. You have been warned

\section*{CATALOGUE SURVEY}

Do you buy components through the services of mail-order companies? If you do then you cannot afford to miss this survey into the various companies, the cost of their components, the service they offer and the quality of their catalogue. Who is the cheapest? Last year we came up with some pretty surprising results, find out if things have changed

\section*{METRONOME}

Don't miss a beat with this nifty, state-of-the-art little gadget. This revolutionary design has completely done away with cumbersome 1Cs. Yes, that's right, absolutely no Integrated Circuits. In fact we have used just four components and if that isn't state-of-the-art, what is?

\section*{POWERFETS}

Some day all power transistors will be made this way

B0512
B0522
VMP4
VN1OKM
VN64GA
VN67AF
2SJ49
2SK134 N
\begin{tabular}{r|r} 
Case & Price \\
TO202 & \(\mathbf{8 5 p}\) \\
TO202 & \(\mathbf{8 0 p}\) \\
\hline \(380-50 \mathrm{E}\) & \(\mathbf{1 2 5 0 p}\) \\
\hline TO92 \(\dagger\) & \(\mathbf{5 5 p}\) \\
\hline T03 & \(\mathbf{7 5 0 p}\) \\
\hline T0202 & \(\mathbf{7 5 p}\) \\
\hline TO3 & \(\mathbf{3 9 5 p}\) \\
TO3 & \(\mathbf{3 9 5 p}\)
\end{tabular}

M 96 -page Design Cat 20p. Heat clips TO2O2 12p. 0092 8p.

MANUFACTURERS/DESIGNERS. We will be stocking Powerfets by \(|R, T|\) and Inter MANUFACTURERS/DESIGNERS. We will be stocking Powerens by ications and type selection, supply samples and quantities
AEMEMBER Powerfets need virtually no drive current swich in nanoseconds, and are 2nd breakdown free, etc etc
\begin{tabular}{|c|c|c|}
\hline CA3026 & 70p & HI-FI ON TWO CHIPS \\
\hline CA3080E. & 70p & HA1 2017 (Preamp \(0001 \%\) distortion \\
\hline CA3140E & 38p & 83dB S N N in phono application 98 p \\
\hline DAC08 & 250p & HA1 370 (Poweramp 20 watts in 80 \\
\hline DM2502 & 555p & Both with data and circuits \\
\hline LM308 & 50p & POWERFETAMPLIFIER semicon. \\
\hline LM3900 & 43p & ductor sets High power designs ofter. \\
\hline MC3401 & 30p & ing very tow distortions \\
\hline NE 529 & 145p & 0 watt (T THD 0008 \%) E8.75 \\
\hline NE555 & 25p & 120 wall (TTHD 0004 \%) E 16.65 \\
\hline SAD1024 & 1050p & \\
\hline SD532 & 30p & frequencies \\
\hline TDA 1022 & 600 p & \\
\hline TL081
TL08C & 29p & BIPOLARS \\
\hline 2102 & 80p & \(2 \mathrm{SA} 10 \mathrm{B3}(\mathrm{P})\} 60 \mathrm{~V} 100 \mathrm{~mA}\) \\
\hline 4011 B & 17p & 2SC2545(N) \} NFO 2dB 19p \\
\hline 709 & 15p & 2SAB72(P) 90v16p \\
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\section*{CITIZENS BANNED II}

Next month is something of an anniversary for us. It will be exactly one year since we published our feature Citizens Banned. In those twelve months we have carried the campaıgn for CB (sometımes struggling) into the open. Our petition (which around half our readers signed) gained Government recognition, generated national Newspaper, TV and Radio coverage and was the catalyst for forming CB clubs up and down the country. Something like 250000 people are actively engaged in the campaign for legalisation MPs. Government Officials, Doctors, in fact everyone and anyone who wants the right for free speech.

In our second major feature we will be looking back over the past year and seeing how the campaign has fared.

\section*{EGG TIMER}

Something really different for the gadget fans next month. Our Egg Timer is a solid-state version of the sand-in-a-glass" egg timer that has been around for hundreds of years. Shake it and set it down and depending upon whether you want a hard or soft boiled egg it will warble at the appointed time No switches to worry about, is it magic? Find out next month

The items mentioned here are those planned but unforeseen circumstances may affect the actual contents

\title{
DESIGNER'S NOTEBOOK
}

\section*{Project editor Ray Marston discusses the uses and practicalities of voltage regulator circuits.}

0ne of the most common and mundane tasks facing the electronics engineer is that of designing voltage regulator circuits, ie circuits that produce a stable and well defined DC output voltage over a wide range of load current variations. These circuits may vary from simple Zener networks, designed to provide load currents up to only a few mA , to fixed-voltage high current units for powering logic boards, etc, or to variable-voltage high current units designed to act as general-purpose pieces of test gear.

\section*{Zener Based Circuits}

A Zener diode can be used to produce a fixed reference voltage by using the connections shown in Fig.1. Often, the supply voltage ( \(V_{\text {in }}\) ) may be subject to fairly wide variations, causing the Zener current to vary over a similarly large range. As long as V in is always more than a few volts greater than the Zener voltage and provided that the Zener power rating is not exceeded this variation has only a moderate influence on the output voltage of the Zener, which typically has an effective output impedance of a few tens of ohms.


Fig.1. This basic Zener 'reference' circuit is biased at about 5 mA . A current of roughly 5 mA is passed through the Zener diode from the supply line via limiting resistor \(R\).

A Zener can be used as a very simple voltage regulator, providing load currents up to a few mA , by merely selecting the value of ' \(R\) ' as shown in Fig.2.


Fig.2. This basic Zener 'regulator' circuit can supply load currents of several milliamps. When the maximum load current is being drawn only 2 mA flows through the Zener. When zero load current is being drawn the Zener passes 2 mA plus the maximum designed load current and thus dissipates maximum power.

In most practical voltage regulator applications the Zener is simply used to apply a 'reference' voltage to a high-gain noninverting buffer amplifier, which then supplies the required output power. The simplest example of this type of circuit is shown in the series-pass regulator circuit of Fig.3.


Fig.3. This series pass Zener-based regulator circuit gives an output of 11 V 4 and can supply load currents up to about 100 mA . Q1 is wired as a voltage follower, its emitter remaining at about 600 mV below its Zener-defined base voltage under all loading conditions. The Zener network provides the base drive current to Q1, this current being equal to the output load current divided by the current gain of Q1. Clearly, the higher the gain of the Q1 'buffer' stage, the better will be the output regulation of the circuit.

\section*{Op-Amp Regulators}

One way of improving the regulation of the Fig. 3 circuit would be to use a Darlington or Super-Alpha pair of transistors in place of Q1. An even better solution is to use the op-amp plus transistor buffer stage shown in Fig.4.


Fig.4. This op-amp based regulator gives an output of 12 V at currents up to 100 mA and gives excellent regulation. The op-amp and Q1 are interconnected as a unity-gain non-inverting DC amplifier with an overall current gain of about one million. The output voltage tracks within a few mV of the Zener reference value and the output impedance is less than one milli-ohm. The safe output current driving capacity of the circuit is limited to about 100 mA by the power rating of Q1; higher currents can be obtained if Q1 is replaced with a power Darlington transistor.


Fig.5. This variable-output 0-1 A circuit gives excellent regulation.
The performance of the basic op-amp circuit of Fig. 4 can be improved in a variety of ways, some of which are shown in Fig.5. The first improvement that can be made is to make the Zener reference voltage (ZD1) independent of supply voltage variations by powering ZD1 from the output of constantcurrent generator Q1-R1-ZD2-R2. Next, the Zener noise can be eliminated by feeding the reference voltage to the opamp via low-pass filter R3-C1. Thermal drift effects can be eliminated by making ZD1 a 5V6 type, with near-zero (actually about \(-0.2 \mathrm{mV} /{ }^{\circ} \mathrm{C}\) ) temperature coefficient; the op-amp output voltage can then be set to the desired value (greater than 5 V 6 ) by using feedback components RV1-R4 to set the op-amp's voltage gain at some appropriate value.


Fig.6. The output of this circuit is fully variable from zero to 20 V . The effective reference voltage is made variable from zero to 5 V6 via RV1 and the op-amp is given a fixed voltage gain of about four via R4-R5. Note that a CA3140 op-amp, which can handle input signals down to ground volts, is used in this application.


Fig. 7. This \(0-25 \mathrm{~V}, 1 \mathrm{~A}\) regulator has current limiting in its outputt \({ }^{3}\) stage with short-circuit or overload protection via. Q4 and loadsensing. resistor R8. The op-amp is protected *against excessive supplytrail voltages via R4 and ZD3.

Finally, the load current capacity of the circuit can be set to a fairly high value by using a Darlington-connected power transistor in the series-pass output stage.

\section*{Three Terminal Circuits}

Three-terminal regulators are remarkably easy to use, as shown in the basic circuits of Figs. 8 to 10 , which show the connections for making positive, negative and dual regulator circuits respectively; the 1 Cs shown in these examples are 12 V units, with current ratings of one amp. Note that a 270 n or greater disc (ceramic) capacitor should be connected close to the input terminal of the 1 C and a 10 u or greater electrolytic to the output.


Fig.8. Connections for using a 3 -terminal positive regulator IC, in this case a, \(12 \mathrm{~V}, 1\), A type.


Fig.9: Connections for using a 3-terminal negative regulator IC, in this case á \(12 \mathrm{~V}, 1 \mathrm{~A}\) type... :


Fig.10. Complete circuit of a \(12 \mathrm{~V}, 1 \mathrm{~A}\) dual power supply.


Fig.11. A very simple method of varying the output voltage of a 3 terminal regulator. The bias voltage is obtained by passing the IC's quiescent current (typically about 8 mA ) through RV1. This design is adeq̃uate in most applications, although the output voltage obviously mifts silightly with changes in quiescent current.
- ! * ? ?

The output voltage of a 3-terminal regulator is referenced eto the "common, terminal of the IC, which is normally grounded. Most regulator 1 Cs draw quiescent currents of a few mA ,
which flow to ground via the common terminal. The regulator output voltage can thus be raised above the designed value by simply biasing the 'common' terminal with a suitable voltage.


Fig.12. The output voltage of a 3-terminal regulator can be increased by a fixed amount by wiring a suitable Zener in series with the common terminal.


Fig.13. The output current capacity of a 3-terminal regulator can readily be boosted via an external transistor. This circuit can supply 5 A at 12 V . At low currents insufficient voltage is deyeloped across R1 to turn Q1 on and all of the load current is provided by the IC. At currents of 600 mA or greater sufficient voltage \((600 \mathrm{mV})\) is developed across R1 to turn Q1 on, so Q1 provides all currents in excess of 600 mA .


Fig.14. This \(5 \mathrm{~A}, 12 \mathrm{~V}\) regulator has overload protection provided via Q2.


Fig.15. This 12 V lamp regulator circuit is fully protected against excessive input supply line voltages.

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\section*{Better Bias}

This unit produces a 400 Hz and 8 kHz sinewaves of equal amplitude. By recording these using different bias settings, your system can be optimised for a maximally flat response or peaked for treble emphasis. The procedure is to record the two tones using a chosen bias setting then monitor the output levels on the VU meter. If desired, the bias can be adjusted to achieve the required response. If your deck does not feature a VU meter, you can use an oscilloscope instead. The high and low tones may be selected manually or will be produced alternately when the unit is switched to 'auto'. A frequency of about 0.3 Hz was chosen for this function. It can be simply altered by reselecting the value of C 1 .

\section*{Construction And Use}

Our PCB design offers a convenient means of building up the unit (after all you need somewhere to put all those presets don't you!). Whatever method of construction you use, there are no special precautions to take except to watch out for the polarity of the semiconductors and tantalum capacitors.

An oscilloscope is an invaluable aid when setting up the unit. However, if one is not available, connect the output to a monitor amplifier and do it by ear. Preset RV5 should be set to mid position and RV3 to maximum resistance. With power applied, RV1 may now be adjusted to produce a 4 V peak to peak triangle waveform at pin 2, IC2. Then RV3 should be adjusted for the best sine wave. Small adjustments of RV5 may now be made to further improve the waveform. You should now have a fairly good sine wave of about 2 V peak to peak at pin 2, IC2.

The frequency of the two tones is set by adjustment of RV2 and RV4. A frequency meter makes this a doddle. If you do not have one, then R7,RV2 and R8,RV4 may be replaced by fixed resistors. The calculated values using \(\mathrm{C} 4,10 \mathrm{n}\) are \(250 \mathrm{k}(400 \mathrm{~Hz})\) and \(12 \mathrm{k} 5(8 \mathrm{kHz})\).

This simple project will help you get the very best from your audio system.



PARTS LIST


Fig.1. (above) Circuit diagram. RV2 and RV4 are used to set the frequency of the two tones.

Fig. 2. (left) Component overlay. The rate of switching between the two tones is set by \(\mathrm{C} 1(0.3 \mathrm{~Hz}\) here, with \(\mathrm{C} 1,1 \mathrm{us})\).

\section*{HOW IT WORKS}

Most of the work is taken care of by IC2. This chip generates a triangle waveform which is shaped internally to produce the sine wave output. Frequency is controlled by the value of C4 and choice of resistance from pin 7 or 8 to the negative supply. Only one resistor is actively connected at any moment. Selection is achieved by controlling the voltage applied to pin 9 . When the voltage at pin 9 is above two volts, or if the pin is open circuit, then the timing resistor connected to pin 7 is selected. When the signal at pin 9 drops below one volt, control is transferred to the resistor at pin 8.

Changeover is accomplished automatically by connecting the output of IC1, an op-amp configured as an astable oscillator, to pin 9. A high or low output can be 'forced' by switching R1 to either supply rail via SW1. With SW1 in the 'centre-off' position, the op-amp will switch at slightly less than 1 Hz producing alternating tones from the unit. Frequencies are set by adjustment of RV2 and RV4.

The output signal is developed across \(\mathrm{R} 5,6\). Any convenient ratio may be chosen for these components to provide any desired output level up to a few volts peak to peak. A split supply was chosen as it facilitates circuit design. In any case IC2 needs at least a ten volt supply, precluding the use of a single battery. Current consumption is low and two PP3 type batteries provide a convenient source of power. Frequency stability with falling battery voltage is good and standard dry (Leclanche) batteries are quite adequate. Capacitors C2,3 provide overall decoupling.

\section*{BUYLINES}

The XR2206 is available from Technomatic Ltd or Stevenson Electronic Components. The other parts should be readily available.


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\hline \begin{tabular}{l}
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Next month ETI presents the definitive history of the spacecraft. Ian Graham our permanently high spaceman talks us through the hardware of the fastest man-made vehicles 10 date and takes a look at those which take mont only in our imaginations. For everyone who has looked up at the stars and longed.

Also next issue we have the long awaited Image Co-ordinator which will allow you to do things with your stereo image that your mother wouldn't approve of! Moreover Tim Orr follows up his Handbook of this month, with an artigle in similar vein, this time on his favourite subject, Active Filters. Find out how to design them yourself in the July issLe of ETI:

For the audio men there is our first look at one of the rising stars of hi-fi, the 2uantum applifier system. It can be bought as a kt, as modules, or as a fully built and working piece of equipment As an example of their range ve exathine the 102 presulp and the 204 ( 110 W per channe) power amp. Srand by your speakers.


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\title{
SARGON AND THE LCD CHESSSET!
}

\section*{The ultimate chess machine?}

Well this must come pretty close. Ron

> Harris has been getting beaten regulary this month. Recovering some confidence he reports.

Sargon is the latest in the long line of chess playing boxes. It is neatly presented, with the keyboard and piece storage telescoping out from within the board itself. As with most of these offerings, the provided chessmen are abysmal. I really do not know why they bother providing them - surely anyone who can afford a machine like this will have their own decent set anyway?

I digress. Returning to the machine, it is a development of the well known 'Boris', an opponent I crossed pawns with some time ago. Sargon inherits the ability to comment on the games, albeit with a little more reticence. However the chess playing ability of Sargon is far superior to Boris, who would be hard pressed indced to take a game from his offspring I suspect. (Response times being equal of course.)

\section*{Model Modules}

The basic concept of Sargon is a modular one. When the program is updated, changing the machine to a 'new' one means nothing more than unplugging the module and replacing it.

The keyboard is provided with different overlays to allow the machine to be used for pursuits other than chess. Backgammon and draughts are to be the first expansions, but here I shall restrict myself to the oldest wargame in history.

Features include a 'Restore' facility which allows you to replace the last move as though it had never happened handy for training and cheating. A 'Best' button which cancels any random factor in Sargon's play and leads to a totally logical opponent. Frighteningly efficient, predictable (maybe - if you're good enough). Also there is a 'Hint' mode which allows you to obtain an idea of what to do next from the machine
itself without having to listen to it if pride rises up and bites you at the last minute.

Fine thing pride. Makes you fecl noble while Sargon, cleans up your end of the board better than Domestos. Kills all known opponents. Dead. Naturally included are also full board review and alteration facilitics.

\section*{Level With Me}

Sargon is always on the level. Well some level or other, anyway. You set his response time by choosing a level from 0 (instant response) to 6 (postal chess). In between we have :-
Level one : 10 seconds
Level two : 20 seconds Level three: 45 seconds Levelfour: 2 minutes Level five : 20 minutes

At two minutes thinking time Sargon is formidable indeed and will give a club player an energetic run for his pawns. I only ever beat the infernal thing once at this level and I lost more than I won at level three.

Sargon is good. Very very good. At instant response it is better than the first generation chess machines and at level three becomes the best chess playing robot available for home use. For those who wish to trace it through I give an example game overleaf. Sargon set at Level 3 and plays Black. If you're interested in buying one, read it through - sec if you would have done any better. I got a draw!
\begin{tabular}{|c|c|c|c|c|c|}
\hline 1. & E2 --E4 & E7-E5 & 21. & C1-E3 & B6x E3 \\
\hline 2. & G1-F3 & B8-C6 & 22. & E1 \(\times\) E3 & C7-C6 \\
\hline 3. & B1-C3 & G8-F6 & 23. & A1-E1 & D6xE5 \\
\hline 4. & F1-C4 & F8-C5 & 24. & F4 \(\times\) E5 & E8-E7 \\
\hline 5. & F3-G5 & E8-G8 & 25. & G5-H3 & D7-H3 \\
\hline 6. & E1-G1 & D7- D6 & 26. & G2 x H3 & F8- D8 \\
\hline 7. & D2-D3 & C8-G4 & 27. & E5-E6 & E7 \(\times\) E6 \\
\hline 8. & D1-D2 & D8-E7 & 28. & E3 x E6 & E7x E6 \\
\hline 9. & C3-D5 & F6x D5 & 29. & E1 \(\times\) E6 & D8-C8 \\
\hline 10. & C4 \(\times\) D 5 & C5-B4 & 30. & H3--H4 & G8-F7 \\
\hline 11. & C2-C3 & B4-A5 & 31. & E6-E3 & C8-B8 \\
\hline 12. & D5 x C6 & B7 \(\times\) C6 & 32. & B2-B3 & B8 -- E8 \\
\hline 13. & F2-F3 & G4 -- D7 & 33. & E3 \(\times\) E8 & E7 \(\times\) E8 \\
\hline 14. & D3-D4 & E7-F6 & 34. & H1-G2 & E8-F7 \\
\hline 15. & D4 x E5 & A5-B6 & 35. & G2-H3 & F7-F6 \\
\hline 16. & G1-H1 & F6x E5 & 36. & H3-G4 & F6-E5 \\
\hline 17. & F3 - F4 & E5-B5 & 37. & G4-F3 & C6-C5 \\
\hline 18. & F1-E 1 & A8-E8 & 38. & \(\mathrm{H} 2-\mathrm{H} 3\) & D5-D4 \\
\hline 19. & E4-E5 & B5 - D5 & 39. & C3 \(\times\) D 4 & E5 x D 4 \\
\hline 20. & D2 x D 5 & C6 x D5 & 40. & F3-F4 & D4-C3 \\
\hline
\end{tabular}

Figure 1. Playing Sargon at Level 3. Machine plays black. At the end of forty moves it's heading for a draw - providing neither of us does anything stupid!

\section*{Summing Totals}

There is not much more to say. Sargon is a well presented games machine which is potentially expandable to better chess - or anything else a module appears for. As a player it is the best we've ever seen inside a ROM and will give any player food for thought. Its power is not to be scorned, consider it a toy and you're beat before you start. Tread carefully, oh ye of little faith, lest ye be divested of all manner of men!

\section*{Chess Champion}

Just when I thought I'd done with chess (for this month at least) and was about to retreat back to wargaming, to regain a little composure, this box of tricks was placed mid-desk with its printer and LCD board - sufficiently interesting I think to hold off the counters a while longer and raise pawns once more.

Chess Champion is a dedicated chess machine. Expansion comes in the form of a printer, LCD board and game memory. A full chess clock will be added later.

Rather than me trying to describe what it looks like, or has to offer, take a look at the photos. It features a fairly standard chess game keyboard with full board checking facilities. You can put back aught that has been removed and remove what has not.

Display of move and status is via an LCD 'clock-type' display with piece verification symbol. Strength of game played is selected by varying response time. In seconds this time, not levels. In practice you have to double the time to get any appreciable increase in ability from the box.

\section*{Board Decision}

As I can't see anyone using this unit without the LCD chessboard let me quickly add that to the consideration.

Packaged as a clip-on extra - the data bus edge connects - the board is powered from the main unit and is a complete chess set in itself. The chessmen are based around one symbol, which when displayed in its entirety is a Queen and assumes


The Chess Champion printer unit. Price : £104.95.
the guise of everything else as different segments are left unenergised. The photo shows how effective this can be.

Backlighting is available when running from the mains and the board flashes a proposed move until the ENTER key is pushed. As the game progresses the board provides a continuous updated read-out and totally eliminates the need for a separate chess set with all the attendant errors of misinterpretation and mismanagement. Sheer magic! At last a selfcontained intelligent chess set! I could forgive a lot of failings in the machine just for this beautiful facility.

As it happens there is little wrong with Chess Champion anyway. I disliked the sloppy keyboard and having to go through the involved key sequence to change level is frustrating, but so what? Sargon's board is touch-switched and an absolute pest. And you have to move men around to play it. Fair exchange?

\section*{Mating Ritual}

As a chess player, Chess Champion is no match for Sargon (at equal response). Witness the game below. Sargon is set to Level one ( 10 secs) and Chess Champion to 30 seconds response time. Although Sargon wastes what should have been a winning position later on in the conflict it still manages an honourable draw, taking \(1 / 3\) of the time!

This is the LCD board for the Chess Champion. Price: £106.95.
\begin{tabular}{|c|c|c|}
\hline 4. & \[
\begin{aligned}
& \mathrm{D} 2-\mathrm{D} 4 \\
& \mathrm{C} 2-\mathrm{C4} \\
& \mathrm{C} 1-\mathrm{CB} \\
& \mathrm{B1}-\mathrm{AB} \\
& \mathrm{E} 2-\mathrm{E} 4
\end{aligned}
\] & \[
\begin{aligned}
& \text { D7-D5 } \\
& \text { D55C4 } \\
& \text { B8-C6 } \\
& \text { C8EE6 } \\
& \text { G8-F6-F }
\end{aligned}
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\hline \multicolumn{3}{|l|}{Ya - M A} \\
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\hline \multicolumn{3}{|l|}{\multirow[t]{2}{*}{}} \\
\hline & & \\
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\end{tabular}
\begin{tabular}{|c|c|c|}
\hline 6. & E4-E5 & F6-E4 \\
\hline 7. & F1xC4 & E6xC4 \\
\hline 8. & A3xC4 & E7-E6 \\
\hline 9. & D1-D3 & F8-B4 \\
\hline 10. & C1-D2 & E4xD2 \\
\hline 11. & C4xD2 & E8-G8 \\
\hline 12. & E1-G1 & B4 -E7 \\
\hline 13. & A2-A3 & B4-E7 \\
\hline 14. & D3-C4 & D5xC4 \\
\hline 15. & D2xC4 & A8-D8 \\
\hline 16. & A1-D1 & D8-D5 \\
\hline 17. & F1-E1 & F8-D8 \\
\hline 18. & E1-E4 & F7--F5 \\
\hline \multicolumn{3}{|l|}{YKMM 3 "} \\
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\hline & & \\
\hline \multicolumn{2}{|l|}{WM} & \\
\hline & 6 & \\
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\hline & I & 3 \\
\hline & E5--F6 & E7xF6 \\
\hline 20. & E4xE6 & C6xD4 \\
\hline
\end{tabular}


\begin{tabular}{lll} 
41. & A4-B6 & F8-E8 \\
42. & H2-H3 & D6-F4 \\
43. & B6-D5 & F4-D6 \\
44. & G2-F2 & H8-G7 \\
45. & C4-C6 & E8-E6 \\
46. & C6-C4 & E6-E8 \\
47. & C4-C6 & E8-E6 \\
48. & F3-F4 & G5xF4 \\
49. & F2-F3 & H6-H5 \\
50. & G4xH5 & E6-H6 \\
51. & D5xF4 & D6xF4 \\
52. & C6-C5 & H6-F6 \\
53. & F3-E4 & G7-H6 \\
54. & C5-D5 & F4-G5
\end{tabular}

\begin{tabular}{lll} 
55. & \(\mathrm{H} 3-\mathrm{H} 4\) & G5xH4 \\
56. & D5-C5 & H4-G5 \\
57. & E4-E5 & H6xH5 \\
58. & C5-D5 & F6-C6
\end{tabular}

59. E5-D4
60. D5-F5
61. D4-D5
62. D5-C4
63. C4-C5
64. C5-D5 E6-B6
65. F5-F4 H4-H5
66. F4-C4 B6-B3
67. C4-E4 H5-G6
68. E4-F4

B3-E3

69. F4 E4

E3xE4 F6-C3

\begin{tabular}{lll} 
71. & E4-D3 & C3-E5 \\
72. & D3-E4 & G6-F6 \\
73. & E4--D3 & F6--F5 \\
74. & D3-E3 & F5-G6
\end{tabular}

Figure 2 (above) the same between Sargon at 10 second response (white) and Chess Champion at 30 seconds. A draw in the end. Sargon should Below the complete Chess Champion, with the LCD board in operation. Fascinating. The main unit will cost you £154.95 all inc. So Sargon costs about the same as the main unit plus LCD board in Chess Champion.


However, please don't think I'm decrying Chess Champion's ability. I wouldn't dare. With the possible exception of the Voice Challenger, I know of no other machine that could best it bar Sargon. Given a little longer Chess Champion will still pin you to the back rank should that be your desire.
it is just that it takes a little while to get over the advanced presentation (i.e. gadgets!) that comes as part of the system. Talking of which I haven't mentioned the printer yet, so let us rectify that immediately.

Packaged as another clip-on extra, the printer is a thermal unit with twenty characters per line capability. Shown below is the display of the full board which can be obtained, at any point during a game, by pushing LIST on the printer. Moves are recorded with a "symbol--move from--move to" sequence.

In order to give an example of the printer's output - and because I couldn't resist it - below I have given the ending from a game of Sargon vs Chess Champion at equal response times ( 20 secs). It's a massacre so don't look if you can't stand the sight of blood! (facing page).


Above: the Chess Champion master unit with its clock-type display. To the right is shown the bus connection for the slave printer-board units.
Below: Sargon ready to play.


Above: Sargon ready to play.


\section*{Which Machine?}

Choosing between the two is by no means straightforward. If you're a dedicated high-level chess player who will always use his own chess-set anyway, then Sargon will be your best choice for its superior playing ability. On the other hand the LCD board is a huge advantage (and error eliminator) and provided you don't mind waiting that extra time for equal ability Chess Champion is an attractive proposition.

The difference between the machines, in ability, diminishes as the thinking time is increased past 2 minutes, with Sargon always retaining the edge. For my own part l'd tend to go for Chess Champion as that still beats me often enough to be challenging and that board fascinates me! I dare say though Sargon will receive heavy support from the better players of this world.

My thanks to Kramer \& Co. for lending us the machines for this article. Prices of the units from them are given in the captions.


Figure 3. Sargon vs Chess Champion (black) with both machines on 20 seconds think time. The print-out is courtesy of Chess Champ's printer. ETI

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The slim but strong bracelet is fully adjustable and is available in a silver or gold finish.
M64 Mans dual time quartz alarm chronograph with 6 digits, 5 indicators and 22 functions.

For business people with overseas contacts and responsibilities this is the ideal watch.

Local time is always visible, but in addition the watch can be set, and recall, a second time zone, in either 12 or 24 hour formats, and displays a day and date for each zone.

The chronograph/stopwatch displays up to 12 hours, 59 minutes and 59.9 seconds.

On command, the stopwatch display freezes to show intermediate (split/lap)time while the stopwatch continues to run and neither function affects the normal timekeeping.

The alarm can be set to any tıme within a 24 hour period.

To complete the functions, there is also a 4 year calendar and a fully adjustable stainless steel strap.


\section*{M15 Ladies quartz \\ LCD Day Watch}

This slender watch displays hours, mins, secs, day and date and has an auto calendar and a backlight.

Only \(25 \mathrm{~mm} \times 20 \mathrm{~mm} \times 6 \mathrm{~mm}\) thick this elegant watch has a bracelet, in siver or gold finish, and is fully adjustable to suit very slim wrists.


\section*{M17 \\ Ladies quartz LCD Cocktail Watch}

Only 6 mm thick, the watch displays hours, muns, secs, day, date and has an auto calendar and backlight.

The fully adjustable bracelet has a bronze/gold or silver finish.


\section*{M30 Mans dual time melody alarm chronograph with count-down timer, 34 functions}

A very impressive new watch at a superbly low price and with so many useful functions.

There are 5 independent working modes; normal watch, count-down alarm, alarm, dual time zone, \(1 / 100\) th sec. chronograph.

In addition, the watch can display the day of the week in French, German or English.

The count-down timer can be used for a varıety of applicatıons from boiling an egg to reminding you your parking meter time has expired. Both the count-down alarm and the normal alarm have a clear musical tone.

For the businessman the time zone feature could be a real advantage. Just programme the second time zone and it will be permanently recorded for easy reference.

And as a stop-watch here's a great timepiece for sporting events and for timıng recordings.

There's the conventional stop/start counter plus a lap timer which enables first and second places to be timed.

Longer timing intervals, such as journey times can be recorded while the watch is reading its normal time.


\section*{M3 Mans quartz LCD with 6 digits 3 and 11 functions}

Only 7 mm thick and with a fully adjustable stainless steel bracelet, this watch is ideal for all ages.

The normal functions are hours, mins, secs, day, date, and day of week.

But as a stop-watch, which does not affect normal timekeeping you also have 1/100th and 1/10th secs.. split, lap and journey timing, a four year calendar and a backlight.

Also avarlable is a solar version.
This is the same watch but incorporated is a solar energy panel which converts normal daylight into electricity.

During periods of darkness the watch instantly operates by battery without losing its accuracy.



M4
Mans quartz LCD alarm with 6 digits and 9 functions
A very useful watch with ar effective, loud alarm but still only 8 mm thick.

The normal functions are hours, mins, secs, date. day of week, four year calendar and a backlight.

In addition, there is a 24 -hour alarm, a 5 -minute snooze feature and a 4 second pre-alarm conference bleep.

The conference signal is a bleep. 4 seconds before main alarm to give advance warning and the option to cancel. After the main alarm stops the snooze repeater alarm sounds 5 minutes later, unless previously cancelled.

To complete the functions, there is also a 4 year calendar and a fully adjustable stainless steel strap.


\section*{M16 Mans dual time quartz alarm chronograph with 6 digits, \\ 5 indicators and 22 functions.}

This watch has the same functions as M64 except the time is in the 24 hour format only.

A solar version is avallable.
This is the same watch but incorporated is a solar energy panel which converts normal daylight into electricity.

During periods of darkness the watch instantly operates by battery without losing its accuracy.

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\hline & 10p & BFY50 & 23p & 2N3702 & \\
\hline \({ }^{\text {BC109 }}\) & 1 & BFY5 & 23p & 2N3 & \\
\hline BC109C & 12 p & BFY52 & 23p & 2 N & \\
\hline BC147 & 90 & & 100p & & \\
\hline 148 & \(9{ }_{90}\) & & & & \\
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BC184 & 10 & DIODES & & & \\
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\hline 212L & \% & 1N4002 & 5p & & \\
\hline 14. & 10p & 1 N 4148 & 50 & & \\
\hline
\end{tabular}

\section*{PCBS}

VEROBOARD

\section*{\(\begin{array}{llll}25 \times 1 & 16 \mathrm{p} & - & \text { Vero } \\ 25 \times 3.75 & 60 \mathrm{p} & 5 \mathrm{p} & \text { Cutter 110p. }\end{array}\)}
\(2.5 \times 5.5\)
\(3.75 \times 5\)
\(3.75 \times 17\)
\begin{tabular}{lll}
\(75 \times 5\) & 75 p & 65 p \\
\hline \(75 \times 17\) & 75 p
\end{tabular}
SS pins/100 275p 240p
Fibreglass board, \(203 \times 95 \mathrm{~mm}\) : 80p each

\section*{RESISTORS} E12 series. 4.7 ohms to 10 M . Any mix: \(0.25 \mathrm{~W} \quad \begin{array}{llll}\text { each } & 100+ & 1000+\end{array}\) \(\begin{array}{llll}0.5 \mathrm{~W} & 2 \mathrm{p} & 1.9 \mathrm{p} & 0.85 \mathrm{p}\end{array}\) Special development packs consisting of ohm ( 650 res) 0.5 W £8.50. 0.25 W £5.30. METAL FILM RESISTORS
\% Available from 510 hms to 330 k 1\%. Availabie from 510 hms to 330 k in \(\begin{array}{llll}0.25 \mathrm{~W} & \left.\begin{array}{lll}\text { each } & 100+ & 1000+ \\ 4 \mathrm{p} & 3.7 \mathrm{p} & \\ 3.5 \mathrm{p}\end{array}\right)\end{array}\) POTENTIOMETERS
Preset vertical or horizontal 100 ohms
Rotary 5K-2M2 Log or Lin single. 30 p Rotary 5K-2M2 Log or Lin double 90 p lide 60 mm travel \(5 k-500 \mathrm{k}\) Log
or Lin, single
aps in blue, above with coloured black. Rotary controls \(16 p\) each. Slide

\section*{MSC.}

Murata Ultrasonic Transducers 350p pair 64 mm 64 ohmspeakers SRB 17W soldering iron Reel of 22swg solder ( 39.6 m ) Desoldering tool \(\begin{array}{ll}\text { Precision screwdriver set } & 510 \mathrm{p} \text { each }\end{array}\) Titan Electric drill 170p each Minaiture 606 and 909

\section*{SWITCHES}

TOGGLE \(\begin{array}{lll}\text { Standard } & \text { SPST 36p } \\ \text { Miniature } & \text { SPDT } 75 \text { DPDT } 50 p\end{array}\) Subminiature SPST 58p SLIDE Standard
Miniature
ROCKER (10A rating)

\section*{ROTARY}

1P12W 2P6 Key operated DPDT (Yalekey) 595 peach PUSH
Nonlocking push to make \(16 p\) each push to break
SPST
Locking SPST

\section*{RECULATORS \\ LM309K 140 LM317T 220p LM323K 480p}


\section*{76 College Road, Bromley, Kent BR1 1DE.}

\section*{ETI}

\section*{CIRCUIT DESIGN HANBOOK}

\author{
NO. 1 : AUDIO AMPLIFICATION AND OSCILLATORS.
}


A step by step guide to doing it ALL yourself - by Tim Orr. This is the first of what will become an occasional series of easy to read reference works. Mathematics will be kept to a minimum with the emphasis upon producing practical circuits - quickly. Just the thing you always wanted, but thought no-one was ever going to produce! Future subjects will include radio circuitry, digital logic and signal processing.

\section*{SECTION ONE :}
small signal and pre-amplifiers
SECTION TWO:
large signal, or power, amplifiers
SECTION THREE:
audio frequency oscillators

\section*{1. SMALL SIGNAL AND PRE~AMPLIFIERS}

Preamplifiers are used to convert low level signals into higher level signals with low output impedances. The primary design considerations for preamplifiers are input impedance, signal gain, equalisation, noise performance and distortion. It is now possible to buy integrated circuits that will perform virtually all common preamplifier functions. Only rarely, (and with a lot of skill), will one be able to improve upon a monolithic 'best' solution with a discreet component design. However, it is necessary to fully understand the operation of the IC if optimum results are to be obtained.

\section*{The Op Amp Building Block}

Most IC preamplifiers operate as op amps. They have a single or differential input, a low impedance output and a large frequency dependent voltage gain, (Fig.1). Note that the


Fig.1. Typical frequency response for the 741 op amp.
open loop voltage gain rolls off at -6 dB per octave. By applying feedback around the op amp (closed loop), the gain is stabilised and is held constant by the resistor ratio until the device runs out of bandwidth. The difference between the open and closed loop gain is known as the surplus loop gain. This surplus loop gain is the negative feedback that is used to iron out non-linearities in the op amp. As the size of the surplus loop gain decreases with increasing frequency, the distortion and output impedance increase. Fig. 2 compares the performance of inverting versus non-inverting configurations.
inverting mooe
\(\left.\begin{array}{l}\text { (CLOSED LOOP } \\ \text { VOLTAGEGAIN) }\end{array}\right)=\frac{\text { RA }}{\text { RE }}\)
(INPUT IMPEDANCE) ZIN = RB
(OUTPUT IMPEDANCE) ZO \(=\frac{R_{0}}{1+L}\)
CLOSED LOOP.
OUTPUT THD
Closed loop
BANDWIDTH = GBV

non inverting mode
\[
\begin{aligned}
& \begin{array}{l}
\text { COMPARED TO THE INTERNAL } \\
\text { INPUT RESISTANCE OF THE OP AM }
\end{array} \\
& Z_{o}=\frac{R o}{1+L} \\
& \begin{array}{l}
\text { CLOSED LOOP } \\
\text { OUTPUT THD }
\end{array}=\text { THD } \\
& \underset{\text { BANDWIDTH }}{\text { CLOSED LOOP }}=\frac{\text { GBM }}{\text { AY }}
\end{aligned}
\]

L SURPLUS LOOP GAIN
RO = OPEN LOOP OUTPUTIMPEDANCE
THD \(=\) OPEN LOOP THD
GBW - GAN BANOWIDTH - FREOUENCY AT WHICH
OPEN LOOP GAIN IS UNITY

Note that for unity gain the non-inverting mode has twice the closed loop bandwidth of the inverting mode. Also note that the output impedance rises as the surplus loop gain decreases. This can cause a sharp increase in distortion when the op amp is driving a low impedance load at high frequency.

\section*{Design Example}
Q. Design an amplifier with a gain of 60 dB , a closed loop bandwidth of at least 20 kHz and input impedance of 10 k .
A. First, try the inverting mode as shown in Fig.2.
\(\mathrm{Zin}=10 \mathrm{k}=\mathrm{RB}\).
\[
A v=60 \mathrm{~dB}=X 1000=\frac{R A}{R B}
\]

Therefore, \(\mathrm{RA}=10 \mathrm{k} \times 1000=10 \mathrm{M}\)
If we use a 741 then the input offset voltage will be multiplied by the closed loop gain. The offset is typically \(\pm 1\) to 5 mV . Therefore, the output offset will be \(\pm 1\) to 5 V ! It is possible to null out the input offset (Fig.3a) with a preset. This circuit will not be very satisfactory.


Fig.3a. The input offset can be nulled with a preset.

Its DC output offset will probably drift with temperature and time. If stable high DC gains are required then a 741 should not be used. A high performance instrument op amp should be selected in its place. Another problem in using the 741 is its 1 MHz gain bandwidth product. A closed loop gain of 60 dB will result in a closed loop bandwidth of 1 kHz , and not the 20 kHz needed. An op amp capable of giving 60 dB of gain at 20 kHz would need a gain bandwidth product of 20 MHz .

Although there are some op amps with this performance, they are generally difficult to stabilise and are relatively expensive. A cheap solution is to use two 741s, both with gains of 30 dB ( x 33 ), (Fig.3b). The 741 has a bandwidth of 30 kHz at


Fig.3b. A cheaper way to achieve higher gain at, say, 20 kHz without incurring a huge bandwidth is to use two 741 s .
a closed loop gain of 30 dB . The DC offset still remains a problem, but it could be removed with a nulling preset on the first op amp. However, if the amplifier is to be used for audio then a DC response is not needed and so AC coupling can be used to reduce the final DC offset, Fig.3c. Yet another problem still exists. With the input short circuited the circuit would probably produce about 10 mV of noise at its output. The subject of noise will be dealt with later; suffice it to say that the 741 is not a low noise device. Low noise operation can be obtained by using one of the low noise op amps that are now available.


Fig.3c. AC coupling can be used to produce the final offset in audio applications.

\section*{Input Offset Voltage And Bias Current}

When using op amps as DC amplifiers there are several sources of errors, Fig.4. The input to an op amp is usually an NPN differential pair. To make the device operate, a base current must be supplied (input bias current). Also, to balance the op amp the current through both transistors must be


Fig.4. Typical differential op amp input.
equal. The transistor pair is 'matched' for parameters such as Hfe and Vbe versus ICE. However, small differences are caused by the manufacturing process, resulting in the base currents being different (input offset current) and also the base-emitter voltage parameter (input offset voltage). The input offset


Fig.5. The effect of \(\mathrm{V}_{10}\).
voltage is multiplied by the closed loop DC gain of the op amp (Fig.5) and the input bias current sets up a DC offset across any resistors it flows through (Fig.6). Typical parameters for the 741 op amp are; \(2 \mathrm{mV}\left(\mathrm{V}_{\mathrm{IO}}\right), 80 \mathrm{nA}(\mathrm{IB})\) and 20 nA (IB1-IB2). These parameters vary from device to device and from manufacturer to manufacturer. The purpose of successful design is to produce circuits that are insensitive to these


Fig.6. The effect of \(I_{B}\).
variations. Generally, for audio designs, the DC offsets may be eliminated by AC coupling and other methods (Fig.7). Note that the DC output offset may be reduced by inserting a resistor from the non-inverting input to ground. Without that resistor the DC offset may well have been \(\pm 26 \mathrm{mV}\) (IB2 \(\times\) RA ) as opposed to \(\pm 6.6 \mathrm{mV}\) ( \((\mathrm{IB} 1-\mathrm{IB} 2) \times R A)\). A DC voltage on the output would generate a disturbing crackle when the level pot is adjusted.


\section*{Voltage Swing, Power, \& Bandwidth}

The voltage swing at the output of an op amp is limited in many ways, Fig.8. Most op amps can only swing within a few volts of either supply rail. Also, the speed at which the output voltage can move is limited by the slew rate of the device, which is typically \(0 V 5\) per microsecond for a 741. This is the limiting factor in designing amplifiers for high level large signal voltages.

Fig. 8. Typical power bandwidth for a 741 op amp .


\section*{Design Example}
Q. Design an amplifier with a gain of 4 to amplify a 50 kHz 5 V square wave.
A. First try a 741, Fig.9. The required output swing is \(\pm 10 \mathrm{~V}\). The 741 can only move at \(0 \mathrm{~V} 5 / \mathrm{uS}\) and so in the half period of the square wave, it can only move 5 V . If the 741 is replaced with a faster device, the TL081 ( \(13 \mathrm{~V} / \mathrm{uS}\) ) then a 'square' wave is produced. The TL081 would take approximately 1.5 uS to travel the 20 V distance, thus generating a


Fig.9. The difference in slew rate between a 741 and a TL081.
rise and fall time of 1.5 uS . Note, that if the resistors were increased in value to say 250 k and 1 M 0 , then the squarewave output would ring. This is because the feedback would have to charge up the stray capacitance at the inverting input, thus generating a lag between the output and the feedback, which in turn would generate an overshoot.

\section*{Noise}

Noise is always a problem in electronics. The presence of noise degrades the quality of the signal we are interested in. Everytime we amplify, process, transmit, record or replay a signal, noise is introduced thus worsening the signal to noise ratio. Some common signal to noise ratios are shown below.
Telephone 20 to 40 dB
Cheap cassette player 30 dB
Good tape recorder 60 dB
Professional studio equipment 80 dB
The calculations of noise produced by electronics is complex, but with a few short cuts it is possible to get some useable calculations.


Fig.10. Thermal noise generated by a resistor.

All resistors generate noise due to thermal agitation (Fig.10). Noise is also generated when a voltage is applied to them. Manufacturers generally express this latter noise in \(\mathrm{uV} / \mathrm{V}\) typically \(0.1 \mathrm{uV} / \mathrm{V}\) for metal film devices. For most purposes resistor noise is not a dominating noise source although low level amplifiers perform slightly better with metal film devices. Keeping the resistor values low, helps to obtain low noise operation.

An op amp has several sources of noise generation, Fig.11. there are two noise current generators which both generate noise by flowing through the resistors in the circuit. The resistors themselves generate noise and there is an input voltage noise generator. The total output voltage Eo is given by

(noise from \(\ln\)-source) \({ }^{2}+(\) noise from RC) + (noise from RA//RB \(n \vee \sqrt{\mathrm{~Hz}}\)


Fig.11. Model of op amp noise generation.

The noise performance curves for a low noise op amp, the SE5534, are shown in Fig.12a,b,c. Graph a shows the input noise voltage density, En (ie total RMS noise in a 1 Hz bandwidth at that particular frequency), as a function of frequency. To convert this input noise voltage, \((4 n \mathrm{~V} / \sqrt{\mathrm{Hz}})\) into an equivalent input noise generator, we must define the bandwidth of interest. As the noise spectrum is relatively flat above 100 Hz then we can say,

Fig. 12a. The SE5534 low noise op amp input noise voltage density.


Fig. 12 b . The variation in total input noise density with source resistance for two frequencies.


Fig.12c. The equivalent input noise voltage for two bandwidths as a function of frequency.


The equivalent input noise voltage E in \(=\sqrt{\left(E n^{2} \times \text { bandwidth }{ }^{2}\right)}\) For 20 kHz bandwidth
\[
\begin{aligned}
& \text { Ein }=\sqrt{\left(E n^{2} \times 20,000^{2}\right)} \\
& \text { Ein }=(E n \times 141) n V_{\text {RMS }} \\
& \text { But En }=4 n V \sqrt{H z}
\end{aligned}
\]
\[
\text { Therefore Ein }=4 \times 141^{\circ}=0.564 \mathrm{uV}_{\mathrm{RMS}}(20 \mathrm{kHz})
\]

\section*{Design Example}
Q. Calculate the output noise in a 20 kHz bandwidth for the circuit in Fig.13. Assume the voltage and current densities have a flat spectrum (which is not too far from the truth!).


Fig.13. A low noise amplifier.
A. Calculate the individual noise sources.

\section*{Resistor Noise}

Effective resistor is \(\mathrm{RA} / /(\mathrm{RB}+\mathrm{RC}) \quad 1 \mathrm{k} 0\)
Therefore thermal noise (from Fig.13b) \(=3 \mathrm{nV} / \sqrt{\mathrm{Hz}}\)
Noise Voltage
\(\mathrm{a}=4 \mathrm{nV} / \sqrt{\mathrm{H}_{7}}\)
Noise Current
\(\mathrm{c}=0.5 \mathrm{pA} / \sqrt{\mathrm{Hz}}\)
which sets up a noise voltage through ( \(R B+R C\) ). This noise voltage is \(0.5 \mathrm{pA} \times 1 \mathrm{kO}=0.5 \mathrm{nV} / \sqrt{\mathrm{Hz}}\)
Therefore the total noise voltage
\(E_{0}=\left(-\frac{R A+R B+R C}{R A+R B}\right) \times \sqrt{(4)^{2}+(0.5)^{2}+(3)^{2}}\)
\(=101 \times \sqrt{16+0.25+9}\)
\(=101 \times \sqrt{25.25}\)
\(500 \mathrm{nV} / \sqrt{\mathrm{Hz}}\)
For 20 kHz bandwidth, the output noise \(=500 \times 141\)
\[
=70,500 \mathrm{nV} \mathrm{RMS}
\]
\[
=70.5 \mathrm{u} \mathrm{~V}_{\mathrm{RMS}}
\]

A 7 mV RMS input signal from, say, a low impedance microphone would result in a 700 mV RMS output signal and give a \(\mathrm{S} / \mathrm{N}\) ratio of \(20 \log \left(\frac{700}{0.0705}\right)=80 \mathrm{~dB}\)

Note that most dominant source in this circuit is the noise generator En. As long as the input impedance levels are kept low, then it is the noise generator En on its own that can be used as a rule of thumb for calculating absolute and comparative noise performance. For high input impedance applications a FET op amp (with virtually no input noise current) should be used.

\section*{Noise Measurements}

The noise current voltage psectrums of Fig. 12 were measured using a mobile analysing filter ( 1 Hz bandwidth) plus an RMS meter. A simpler measurement can be performed using the system shown in Fig.14. This will measure the


Fig.14. Noise measurement.
equivalent input noise in a specified bandwidth. The low pass filter should be high order device with a steep roll off slope. If a single pole low pass filter is used, then the RMS reading should be corrected by the following equation,
'True' RMS noise =
(for a one pole lowpass filter)
\(\frac{\sqrt{\text { measured RMS noise }}}{1.57}\)
(An RC 20 kHz low pass filter would be made from an 820 ohms resistor with a 10 n capacitor to ground).

Sometimes the signal to noise ratio is quoted in dBA. This means that the noise measurement has been modified by an A weighted curved.

A short chart of op amp performance has been drawn up in Fig.17. It is difficult to compare device performance merely from the noise voltage at one frequency in the spectrum, as the noise spectrum shapes are different from device to device. It is best to refer to the manufacturing data sheet and then to actually breadboard the devices.
\begin{tabular}{|c|c|c|c|}
\hline Device & \begin{tabular}{l}
NOISE VOLTAGE \\
AT 1 kHz \\
\(\mathrm{nV} / \sqrt{ } \mathrm{Hz}\)
\end{tabular} & \[
\begin{aligned}
& \text { UNITY GAIN } \\
& \text { BANDWIDTH } \\
& M H z
\end{aligned}
\] & \[
\begin{aligned}
& \text { SLEW } \\
& \text { RATE } \\
& \text { V/US }
\end{aligned}
\] \\
\hline \begin{tabular}{l}
NATIONAL \\
SEMICONDUCTORS IM381A
\end{tabular} & \[
\begin{aligned}
& 50 \\
& \text { NOT OPTMMISED }
\end{aligned}
\] & 15 & 47 \\
\hline \begin{tabular}{l}
SIGNETICS
SE5534 \\
SE5534
\end{tabular} & 40 & 10 & 13 \\
\hline SIGNETICS SE5534A & 35 & 10 & 13 \\
\hline 741 & 20 to 50 NOT USUALLY SPECIFIED & 1 to 1.5 & 0.5 \\
\hline \[
\begin{aligned}
& \text { RAYTHEON } \\
& \text { RC4136 }
\end{aligned}
\] & 10 & . 3 & 0.5 \\
\hline RAYTHEON RC4558 & 10 & 3 & 0.5 \\
\hline \[
\begin{array}{|l|l|}
\text { TEXAS } \\
\text { TL071 }
\end{array}
\] & \[
\begin{aligned}
& 18 \\
& \text { - FET INPUT VERY } \\
& \text { LOW INPUT NOISE } \\
& \text { CURRENT } \\
& \text { OOM PA } \\
& \hline
\end{aligned}
\] & 3 & 13 \\
\hline FERRANTI 2N45ST & 4.5 (Rs \(=510 \mathrm{R})\) & 15 & - \\
\hline
\end{tabular}

Fig.15. Op amp performance.

Biasing


Fig.16. Biasing the LM381 (differential mode).
The base of Q1 is held at +1 V 3 by a pair of diodes. This preamplifier is often run from a single supply rail and a simple resistor network can be used to bias the output voltage to \(1 / 2 \mathrm{Vcc}\) (Fig.16). Also a single ended amplifier can be constructed (Fig.17). The resistor pair RA, RB determines the DC output level and gain. To increase the AC gain resistor \(R B\) can be shorted to ground with a series \(R, C\) network.


Fig.17. Single-ended biasing.

\section*{Design Example}
Q. Design a preamplifier using the LM381 with a gain of 30 dB and a low frequency roll off of 20 Hz running from a +24 V power supply.

\section*{A. The design calculations are shown in Fig.18.}

\section*{Record Preamplifier}

When replaying a record from a magnetic cartridge it is necessary to have a preamplifier with an RIAA playback equalisation (Fig.19). A magnetic pick up generates a voltage


Fig.18. A 30 dB amplifier.
that is proportional to the velocity of the sideways movement of the stylus. So high frequencies produce large outputs and vice versa. Also, to assist replay electronics, the recording is given a 12 dB de-emphasis from 500 Hz to 2120 Hz . Thus, to restore a flat output it is necessary to equalise the signal from the pick up with an RIAA curve. As a rule of thumb,


Fig.19. RIAA equalisation.
a typical magnetic pick up will generate 5 mV RMS at 1 kHz , although the recording level and make of pick up will effect this figure.


Fig.20. An RIAA-equalised preamplifier.

Low frequency gain \(=\frac{R 2}{R 4}=60 \mathrm{~dB}\)
Low frequency rolloff \(=\frac{1}{2 \pi \mathrm{R} 4 \mathrm{C} 3}=15 \mathrm{~Hz}\)
50 Hz breakpoint
\[
\frac{1}{2 \pi \mathrm{R} 2 \mathrm{C} 1}
\]

The gain drops at \(-6 \mathrm{~dB} /\) octave beyond this point 500 Hz breakpoint
\[
2 \pi \mathrm{R} 3 \mathrm{C} 1
\]

Now the gain remains constant until the next breakpoint AC gain at \(1 \mathrm{kHz}=\underline{R} 3=40 \mathrm{~dB}\)
2120 Hz breakpoint \(\frac{1}{2 \pi \mathrm{R} 3 \mathrm{C} 2}\)
The gain now falls at -6 dB /octave beyond this frequency.
A 5 mV RMS signal at 1 kHz will result in a 500 mV RMS
( 1 V 4 pp ) at the preamplifier output. If the amplifier is powered from \(\pm 12 \mathrm{~V}\), then there is an overhead margin of
\[
\left(\frac{\text { maximum output swing }}{\text { typical swing }=1 \mathrm{~V} 4}\right)=14 \text {, }
\]
which is 23 dB . The noise spectrum of the op amp will be multiplied by the RIAA curve which would complicate any noise performance calculations. However, an op amp with an equivalent input noise of 0.5 uV should give a signal to noise performance of better than 76 dB which is superior than that of the disc itself. Because of the large low frequency gain care must be taken to avoid mains hum pick up. Keep the input wiring away from the mains cables and transformers, use low noise screened cable and wire this cable as close as possible to the preamplifiers.

\section*{Problems}

Often a preamplifier will pick up radio signals. Usually, the radio signal is picked up by the input wiring to the preamplifier and is rectified by the transistor input stage. Then it is amplified by the rest of the audio amplifier and you end up with permanent broad band radio reception. There are several solutions that can be tried, Fig.21. A low pass filter made from an LC or an RC section will attenuate the 'pick up' interference. These devices must be physically close to the op amp. If possible use a PCB ground plane. Also, a conductive metal screen (metal foil is often used) surrounding the preamplifier will help.


Fig.21. Removing RF interference.
Hum can also be a problem. If the hum is at 50 Hz then the source of it is probably magnetic. Check the wiring to see if any signals pass near to the mains section. Magnetic screening is difficult to implement. The best design solution is to put as much distance between the sensitive input and the mains
section as possible. If it is possible try rotating the mains transformer (using a gloved hand, the other hand in your pocket). Often the size of the hum can be reduced by reorientating the transformer. If the hum is 100 Hz , then the source is either the supply rails or the power supply layout. A larger smoothing capacitor will reduce the power supply ripple. If the hum has a sharp buzz then the problem is probably the charging current pulses in the power supply. If the layout is bad, these current pulses generate voltage pulses that get added into the ground reference voltage, thus causing the hum.

\section*{Gain}

When designing an audio system it is necessary to know what the normal signal level at any point will be and also the signal gains and attenuations of various units. It has been found that the most useful way to describe levels and gains is with the logarithm decibel, Fig.22. Signal gains in dB are additive. That is, a signal passing through a series of gains of \(+10,+20,-30,+6 \mathrm{~dB}\) will end up with an overall gain of +6 dB .

dBm IS THE UNIT OF VOL TAGE LEVEL
OdBm IS 1 mW OF POWER INTO A G00R
\(\underset{\text { LOAO }}{0.08 \mathrm{~m}}\)

Fig.22. The \(d B\) and \(d B m\) story.
A typical audio system is shown in Fig.23. A low impedance microphone might typically give a -50 dBm output signal which will have to be given a \(56 \mathrm{~dB}(\mathrm{x} 600)\) gain to bring it up to line level (about +6 dBm ). The line driver should


Fig.23. One channel of a mixing desk.
be capable of driving +20 dBm into 600 ohms at 20 kHz without generating significant distortion. Some line drivers are, in fact, capable of driving 30 ohm loads, but these units are small high quality power amplifiers.

\section*{2. LARGE SIGNAL, OR POWER, AMPLIFIERS}

Apower amplifier must deliver power into a load without generating significant distortion or bursting into oscillation or burning itself out. Power amplifiers are, however, prone to all these effects and great care is needed during their design.

\section*{Power}

Power is measured in watts and is defined as the product of VRMS \(\times\) IRMS (Fig.1c), where RMS is the equivalent DC value. That is, a 2 Vpp sinewave has the DC value of 0 V 7 . The 2 Vpp sinewave will generate as much heat in a load as a 0 V 7


Fig. 1 a. (above) Graph of voltage against power.
\begin{tabular}{|c|c|c|c|}
\hline & 4R & 8R & 158 \\
\hline Iv & 0.031 & 0.015 & 0.008 \\
\hline 3 V & 0.28 & 0.140 & 0.075 \\
\hline 10V & 3.125 & 1.562 & 0.833 \\
\hline 30 V & 28.15 & 14.062 & 7.50 \\
\hline 100 V & 312.5 & 156.25 & 83.33 \\
\hline \begin{tabular}{l}
Vpp \\
ACRO \\
RL
\end{tabular} & \multicolumn{3}{|r|}{POWER IN RL} \\
\hline
\end{tabular}

Fig.1b. (left) The power dissipated in a load against drive voltage.

Fig.1c. (left) The measurement of power.

DC voltage. The chart in figure 1 b shows the power dissipated in a load against drive voltage. If you have an amplifier that has a maximum output voltage swing of \(\pm 10 \mathrm{~V}\), then the maximum power output will be 12.5 watts into a 4 ohm load (from Fig.1a). Note that the amplifier must be able to deliver a peak current of 2.5 Amps. Whilst dumping power into the load, the amplifier will be dissipating heat itself. Most monolithic devices are documented with design graphs of output power versus amplifier dissipation of power efficiency. These will enable you to determine the amplifier's maximum power dissipation. As a rule of thumb, this equals the maximum sinewave power that can be dumped into the load. A 10 watt amplifier may have to dissipate a maximum of 10 watts of heat, although this level of dissipation would not be normal in general use. Manufacturers information usually gives the thermal resistance of the junction to case. If this was say \(3^{\circ} \mathrm{C} /\) watt then a 10 watt dissipation would raise the junction temperature by \(30^{\circ}\) above ambient \(\left(25^{\circ}\right.\) raising to \(55^{\circ} \mathrm{C}\) ). This is only true if the case temperature remains at ambient temperature, that is if the case is contact with an infinite heat sink. The heatsink may be anything from nothing (free air dissipation) to near infinite. It is important that the amplifier chip junction does not get very hot (above \(100^{\circ} \mathrm{C}\) ). The power chips of the amplifier age very quickly at elevated temperatures suffering from deteriorating characteristics and a short life time. This is why power amplifiers and power supplies are common failures in equipment. When the chip is heated up it expands. The chip is glued to its case and so by expanding it stresses the glue and eventually causes it to fracture. This thermal cycling increases the thermal resistance of the chip to the case and so the chip ends up operating at an even higher temperature.

Other heatsinking materials are used in the construction of power devices such as heat conducting plastics and pastes (Beryllium oxide). Manufacturers often provide design graphs of maximum dissipation versus temperature for various heatsink thermal resistances. These help to select an acceptable heatsink. Often if you are using the chassis as a heatsink it is impossible to calculate the temperature rise and it has to be done by trial and error. (As a rule of thumb 1 am satisfied if can place my finger on the device for 5 seconds indicating that case temperature is no more than \(80^{\circ} \mathrm{C}\) ).

\section*{Distortion}

A simple power amplifier is shown in figure 2. An op amp provides the voltage gain and a NPN, PNP transistor pair forms a current amplifier. Any distortions or nonlinearities are ironed out by the surplus loop gain of the op amp. The transfer characteristic of Q1,Q2 shows that there is a dead zone of


Fig.2. A simple power amplifier.
\(\pm 0 \mathrm{~V} 6\) where neither transistor is ON. If a low frequency sinewave is connected to the input (the op amp having a surplus loop gain of 1000 at this frequency) then the output will be a sinewave with a small amount of crossover distortion. The distortion level will be
\[
\frac{ \pm 0 \mathrm{~V}}{100}= \pm 0.6 \mathrm{mV} .
\]

However, as the frequency is increased, the surplus loop gain will decrease causing the distortion to rise. At higher frequencies the slew rate of the op amp becomes noticeable (Fig.3). When the input signal crosses 0 V the output of the op amp has to change from +0 V 6 to -0 V 6 . If the slew rate is \(0 \mathrm{~V} 5 / \mathrm{uS}\) then the time taken to travel the 1 V 2 distance is 2.6 uS. Thus a 2.6 uS chunk of the signal is missing out of each half cycle. The problem may be overcome by biasing the


CROSS OVER DISTORTION FOR CIRCUIT IN FIG 2
OpAmp SLEW RATE \(=\frac{\Delta V}{\Delta T}\)
THEREFORE \(\Delta T=\triangle V=(2\) DIODE VOLTAGES \()\)
SLEW SLEW RATE
IF SLEWRATE \(=0 \mathrm{~V} 5 / \mathrm{uS}\)
THEN \(\triangle T=\frac{1.3}{0.5 \times 10^{6}}=2.6 \mathrm{uS}\)
Fig.3. The effect of slew rate at higher frequencies.
two transistors so that they are both conducting. Then the crossover distortion becomes reduced to a reasonable level. The slew rate still needs to be considered. An amplifier delivering a 40 Vpp sinewave at 20 kHz has a fastest slew rate of \(2 \mathrm{~V} 5 / \mathrm{uS}\) (this represents a power of 25 watts into 8 ohms). If the amplifier has not enough slew rate the output will become distorted. Manufacturers generally provide graphs of distortion (THD) versus power output and frequency (Fig. 4). For the power curve, the onset of distortion is caused by the amplifier clipping at its power rails, whereas for the frequency curve the distortion rises as the surplus loop gain falls.



Fig.4. THD versus power and frequency.
Distortion is measured at various power levels and frequencies using the equipment shown in figure 5. A deep notch removes
the test sinewave leaving behind the distortion products. Generally \(0.1 \%\) THD is common for monolithic amplifiers.

\section*{Stability}

Power amplifier performance is very similar to that of op amps. They have a large open loop gain that is stabilised by resistive feedback (Fig.6). Note that the amplifier described in this graph is normally inverting ( \(180^{\circ}\) DC phase shift) but that it suffers a phase shift as the frequency increases. The phase shift at the unity gain frequency is shown as the phase margin. If the phase margin falls to zero anywhere before the unity gain frequency then the amplifier will oscillate. This is simply because the loop phase shift will be zero at a loop gain of greater than unity, which are the conditions for an oscillation. A large phase margin is desireable.


Fig.6. Gain and phase response.
Various techniques are available for preventing instability. Often a series RC network is connected from the amplifiers output to ground. This reduces the high frequency gain and thus reduces the unity gain frequency. Local power supply decoupling should be used. Current loops, whereby the output current generates a voltage in the signal ground wire which gets fed back to the input can cause bursts of high frequency oscillation. Also high input impedances can capacitively pick up the output signal and burst into oscillation. Increasing the closed loop gain may prevent some forms of instability, swearing will not! Figure 7 shows some typical instability problems.

- DENOTES VERY HIGH FREQUENCY OSCILLATION (INSTABILITY)

Fig.7. Instability; A, on one half cycle; B , at crossover; C , at all points.
(a) The sinewave oscillates on one half cycle. Really a power amplifier is two amplifiers, one half handling positive signals, the other, negative signals. Thus it is quite possible that the amplifier can be stable for negative signals but not positive ones.

Fig.5. THD measurement.

(b) The sinewave is unstable at crossover. This may be caused by the loss of feedback at crossover. Increasing the bias current may eliminate it. Alternatively it might be caused by slew limiting manifesting itself as an extra phase shift.
(c) The amplifier is never stable. Check the layout for current loops, increase the gain, increase the output CR loading, even try removing it, reduce the impedance levels.
You may not hear the effects of high frequency oscillation but it does cause RF interference and generates waste power. It


Fig.9. Medium power audio amplifier. The LM380 will work with a supply voltage range of 8 to 22 V . It can deliver 4 watts of power into 8 ohms at 20 V , although a good heatsink is needed for this level. The inputs are ground referenced and the output is automatically biased to \(1 / 2 \mathrm{Vcc}\). The voltage gain is fixed at 34 dB . It also has a short circuit proof output and internal thermal limiting.

can burn out output stages and even loudspeaker crossovers.
The following five design examples demonstrate how to produce a solution to an amplifier problem. It is now possible to buy an amplifier for most general purpose uses. A wide selection of monolithic devices and modules cover the 0.25 to 100 watt power range. It is rare to have the time or the ability to improve upon this range. The art of designing is to select the most suitable solution on the basis of size, cost and performance.


LM386 DEVICE DISSIPATION VERUS OUTPUT POWER INTO AN 8R LOAD
Fig. 8. Low voltage, low power battery operated amplifier. The LM386N Fig. 8. Low vol tage, low power battery operated amp of 4 to 12 V . It can deliver 0.7 watts into 8 ohms at 12 V , although, at this level, some heatsinking would be advisable. The typical battery drain is 4 mA . The voltage can be varied from 20 to 200 , as shown it is 20 . An AC short across pins 1 and 8 will increase the gain to 200 . With a resistor in series the gain can be set to any thing from 20 to 200 . For gains greater than 20 , a bypass capacitor ( 100 n to ground from pin 7 ) should be used. Even with a supply voltage of only 4 V , there is an output voltage swing of greater than 2 V .


Fig.10. 9 to 14 watt amplifier. The TDA2030 is a Hi -Fi audio amplifier which has short circuit protection and thermal shutdown. It can operate from supply rails of \(\pm 6\) to \(\pm 18 \mathrm{~V}\). At a \(\pm 14 \mathrm{~V}\) supply the guaranteed output power is 12 watts into 4 ohms and 8 watts into 8 ohms. Harmonic and crossover distortion is low being typically \(0.05 \%\) at 1 kHz for 7 watts of power output. The recommended closed loop gain is 30 dB . The two diodes protect the amplifier from back EMF voltages from the speaker.

\section*{3. OSCILLATORS}
t seems to be a fact of life that amplifiers oscillate and oscillators won't! Generally there is little difference between the two. Both devices are amplifiers with feedback. The conditions for stable sinusoidal oscillation are shown in Fig.1. The higher the Q of the resonator the more stable is the resonant frequency, and the purer the sine wave. To stabilise


CONDITIONS FOR OSCILLATION
- PHASE SHIFT AROUND LOOP \(=0^{\circ}\)
- LOOP GAIN = UNITY
- IF SINEWAVE FALLS BELOW SET

AMPLITUDE, GAIN INCREASES
* if SINEWAVE increases above

SET AMPLITUDE, GAIN DECREASES
Fig.1. Conditions for a stable sine wave osciliator.
the signal level an automatic gain control circuit is used. This can be anything from simple diodes or thermistors to elaborate AGC systems. The smoothness with which the AGC works will determine the sine wave purity. A thermistor circuit might well introduce distortion at low frequencies by changing its resistance during one half cycle of oscillation. Very pure sinewave oscillators (better than \(0.001 \%\) distortion) employ slow acting AGC systems to control the loop gain.

\section*{Wien Bridge}

The well known Wien Bridge oscillator is shown in Fig.2a. A frequency sensitive feedback network is constructed from R1, C1 and R2, C2. This network has a peak in its amplitude response which also corresponds to zero phase shift. At this frequency the attenuation is \(\times 1 / 3\) and so to ensure oscillation


Fig.2a. A Wien Bridge oscillator.
the amplifier must have a voltage gain of at least \(\times 3\). To stabilise the amplitude a thermistor is used in the feedback


Fig.2b. To stabilise the amplifier a thermistor is used in the op amp feedback loop.
loop of the op amp. As the oscillation amplitude increases, the thermistor heats up, drops in resistance and so reduces the gain. The circuit suffers from amplitude bounce when the frequency is altered. Also, the op amp phase shift, which increases with increasing frequency, must be taken into consideration when designing this oscillator. Another sine wave oscillator is shown in Fig.3. This generates both sine and cosine outputs. The circuit is a state variable filter with posi-


Fig.3. A state variable sine/cosine oscillator.
tive feedback (R2) to ensure oscillation and amplitude limiting (the diode bridge) to stabilise the sine wave level. The distortion may be trimmed by adjusting the amount of positive feedback. The oscillation frequency is set by RA and C.

A triangle/square wave oscillator may be constructed from a pair of op amps (Fig.4). IC1 is an integrator, the output of which ramps up and down between the hysteresis levels set by the Schmitt trigger, IC2. If the output of IC2 can swing to \(\pm 10 \mathrm{~V}\) then the hysteresis level will be \(\pm \frac{10 \times R A}{R B}\) volts

The oscillation frequency and triangle symmetry is linearly proportional to the output swing of IC2. If a variable frequency oscillator is wanted, then resistor R can be connected to the wiper of a potentiometer fed from IC2 output.

\section*{\(\Delta V\)}

Note that \(\bar{\Delta} \bar{T}\) is \(4000 \mathrm{~V} / \mathrm{sec}\). When designing this type of oscillator the slew rate of the integrator and Schmitt trigger need to be considered, although tin this case virtually any op amp will be OK.

\section*{Design Example}
Q. Design a triangle oscillator with a 2 Vpp triangle output, oscillation frequency of 1 kHz , operating from \(\pm 12 \mathrm{~V}\) power supplies, using circuit in Fig.4.


Fig.4. A triangle/square wave oscillator.
A. Assume an output voltage swing at IC 2 of \(\pm 10 \mathrm{~V}\).

For \(\pm 1 \vee\) Hysteresis,
\[
R A=R B
\]

Let \(R B=100 k\), then \(R A=10 k\)
\(F_{O}=1 \mathrm{kHz}=\frac{1}{\Delta T}=\frac{i}{i \Delta v}=\frac{10}{C \times R \times 4}\)

Thercfore CR \(=\frac{10}{4 \times 1000}=2.5 \times 10^{-3}\)
Let \(C=100 n\)
Then \(R=\frac{2.5 \times 10^{-3}}{10^{-7}}=25 \mathrm{k}\)

\section*{Linear VCO}

A linear voltage controlled oscillator (VCO) is shown in Fig.5. This again is a triangle square wave oscillator although the squarewave is the only buffered output. The CA3080 is used as a current source for charging and discharging \(C\). The charging current is equal to \({ }^{\mathrm{ABC}}\), which is true for several

\(\begin{aligned} & \text { CURRENT IHAT CHARGES C }=+1 A B C \\ & \text { VOLTAGE ATPIN } 3 \text { IC2 IS A } 6.5 \mathrm{~V} \text { SQ SQUA }\end{aligned}\)
VOLTAGE AT PIN 3IC2 IS A \(6.5 V\) pp SQUAREWAVE
THEREFORE, THE TRIANGLE WAVEFORM IS ALSO \(6.5 V_{p p}\)
\(\frac{\Delta V}{J T}=\frac{i}{C}=\frac{A B C}{C}\)
\(F o=\frac{1}{\Delta T}=\frac{I A B C}{C \Delta V}=\frac{I A B C}{C \times 6.5 \times 2}-2^{H z}\)
- IF \(\mathrm{C}=680 \mathrm{p}, \mathrm{IABC}=250 \mathrm{uA}\),
\(\begin{aligned} & \text { THEN Fo }=250 \times 39^{-9} \\ & 680 \times 10^{-12} \times 6.5 \times 2\end{aligned}=28.28 \mathrm{kHz}\)

Fig.5. A linear VCO.
decades of current. The Schmitt trigger uses a TL081 which has a slew rate of \(13 \mathrm{~V} / \mathrm{uS}\). As the squarewave output voltage is 13 V then the rise and fall times are 1 uS each. This enables the VCO to run at frequencies up to 100 kHz . As this frequency is approached the VCO loses its linearity, due to time delays in the circuits.

Another VCO is shown in Fig.6. This has two buffered outputs, a triangle and a square wave. Again, the oscillation frequency is dependent on the output voltage swing of the Schmitt trigger, IC2. However, if a stabilised power supply is used this circuit behaves very well. Superior performance can be obtained by replacing Q1 with a switching FET. The abberations caused by saturation voltage and storage time are then removed. Also fast FET op amps will improve high frequency performance.
```

* ASSUME OUTPUT SWING OF IC2 IS * YOV
DURING HALF CYCLE A.
IA = IV,M 1/3Vin
A = (Vin Il/3Vin!
IA = = \ing
DURING HALFCYCLE B,
OI IS ON AND SO THE JUNCTION
OF R1,R2 IS SHORTED TO GROUN
AB=1/3 Vin = - V Vm,
R2 300k
THEREFORE, THE CURRENT THAT CHARGES AND
DISCHARGES CIS THE SAME MAGNITUDE INBOTH
ALVES OF THE CYCL.
THEREFORE \
OSCILLATIONFREOUENCYFO = 1, M
Fo = (VMO

```


Fig.6. A linear triangle/square wave VCO.

\section*{The 555}

The 555 timer chip (Fig.7) can be used as an oscillator (Fig.8). Capacitor C is charged up via RA and RB. When the voltage at pin 6,2 reaches \(2 / 3 \mathrm{VCc}\) the discharge transistor is turned ON. When the voltage falls to \(1 / 3 \mathrm{Vcc}\) the discharge


Fig. 7. The timer chip.
transistor is turned OFF and the charging process repeats itself. As power supply voltage terms appear in both the numerator and demoninator of the charging equation, it drops out and so the oscillation frequency is hardly effected


Fig.8. A simple oscillator based on the 555.
by supply voltage changes (typically \(0.3 \% \mathrm{~V}\) ). Also the temperature stability is good, typically \(50 \mathrm{ppm} /{ }^{\circ} \mathrm{C}\).

\(\mathrm{T} 1=0.693(\mathrm{RA}+\mathrm{RB}) \mathrm{C}\)
\(\mathrm{T} 2=0.693(\mathrm{RB}) \mathrm{C}\)
T2 \(2=0.693\) (RB) C
TOTALPERIOO \(=T 1+T 2=0.693\) (RA \(+2 R B) C\)
FREQUENCYFO - \(1-1+\frac{1}{1-443}\)

A low power 555 oscillator is shown in Fig.9. This employs a CMOS version of the chip which consumes a mere 120 uA. Capacitor C is slowly charged by current i and rapidly discharged by Q1.


Fig.9. A linear VCO built around the ICM7555, the CMOS 555. ETI

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\title{
INFRA-RED REMOTE CONTROL
}

This concluding part of our IR60 remote control project covers construction of the transmitter and setting up the system.

The transmitter circuit is constructed on two PCBs, a single-sided board being used to hold most of the electronic components and a double-sided board being used to hold the matrix of 16 keypad switches. The double-sided board is best tackled first.

The double-sided PCB has 16 pin-through connections, which are used to connect the tracks on different sides of the board and to make external connections. Start construction by fitting Veropins through these 16 positions, remembering to solder the pins on both sides of the board where appropriate. Next, solder diodes D1 to D4 into position on the PCB and then solder the bodies of the 16 keypad switches into place: the switch caps and bezels can now be snapped on to the switch bodies.

The completed keypad assembly can be mounted to the front panel of the transmitter case (see Buylines) via four \(12 \mathrm{~mm} \times 6\) BA-tapped stand-off pillars, after first providing a suitable cut out in the front panel. Use \(1 / 4\) inch 6BA screws to fix the four pillars to the PCB, then pass the keypad through
the cutout so that the switch tops protrude slightly and finally epoxy the four pillars to the back of the front panel.

The single-sided PCB can be built next. First, insert all Veropins and the single wire link. Next, fit the resistors, IC socket, semiconductors, capacitors and L1. Note that C1 is a PCB-mounting capacitor with its legs bent at right angles so that it lies flush on the PCB. The completed board can be fitted in the case with stickypads.

The two infra-red transmitter diodes can be fitted next. They are mounted through the back of the case, approximately 32 mms apart. Take special care to fit these diodes in the correct polarity.

The final stage of construction is the inerwiring of the two boards and the LEDs, etc. Take special care here, particularly when wiring the switch board to the main circuit. The battery is wired directly to the transmitter circuitry and can be fitted into the case with stickypads.

When construction is complete, activate each of the 16 keypad switches in turn and check in each case that the front-


Fig.1. Circuit diagram of the IR60 transmitter unit.

\section*{HOW IT WORKS}

The heart of the transmitter is IC1, a highly sophisticated \(\mathbf{P}\) MOS LSI chip. This chip receives input 'instructions' via an 8 -row (pins 9 to 16) by 4 -column (pins 2 to 5) matrix that can be activated via contact 'key' switches. The circuit is 'clocked at about 60 kHz via the R9-L1-C2-C3 oscillator when the IC is active.

When the transmitter is in the quiescent state the IC is disconnected from the battery via turn-on transistor Q3 and the complete circuit (including the clock oscillator) is de-energised. Under this condition the entire circuit draws a total leakage current of only a few microamps from the supply battery. When any of the key switches are actuated, negative potential s applied to one of the 'row' pins via one of the R4 to R7 resistors and pin 7 goes high and turns Q3 on, thus energising the IC and its clock oscillator.

Whenever the IC is energised via a key-switch operation a keyboard scanner comes into operation, detects the 'code' of the actuated key and converts this information into a clockrelated serial output code that appears on pin 8. This serial code signal is fed to the infra-red transmitter LEDs via Q2 and Q1.

The transmitter serial code is rather unusual. It consists of a start bit, followed by six information bits, which are read out in biphase code at half the clock frequency. 'Biphase' in this case means that a 'bit' prior to a clock reference point is read as a ' 0 ' and a 'bit' after a clock reference point is read as a ' 1 '. The seven-bit serial code signal has a total 'frame'time of about 11 mS and is repeated at a time-base rate of about 130 mS throughout the duration of a key press. When the instruction key is released a single seven-bit 'end of signal' code frame is transmitted and the transmitter is then automatically deactivated again via Q3.

The serial output code from pin 8 is amplified by Q2 and is used to pulse constant-current generator Q 1 on and off via R2 and LED 1. Q1 feeds 'on' pulses of several hundred milliamps to the two series-connected infra-red transmitter LEDs, this high current being supplied via storage capacitor C1. Although the PEAK IR LED currents are very high (thus ensuring a good operating range), the MEAN IR LED currents (averaged over one time-base period) amount to only 5 mA or so.

Considering that the transmitter will normally only be required to operate for about half a second per instruction, it can be seen that roughly 100,000 instructions can be transmitted from a single PP3 can be expected to transmit 250 instructions per day for roughly a year. Clever?
panel LED illuminates, indicating that a code signal is being transmitted. If the LED does not illuminate, re-check the circuit wiring.

\section*{Setting Up The IR60 System}

When construction is complete, set the adjustable core of L1 in the transmitter and in the receiver to mid-position, place the transmitter a metre or so from the receiver and alternatively operate transmitter buttons 1 and 2 . With luck, receiver relay RLA will switch alternately on and off, indicating that the system is functioning correctly. If this action is not obtained, try twiddling the core of L1 in the receiver. If you still have no luck, use a 'scope to see if a coded signal is reaching the output of Q1 in the receiver: if not, recheck the transmitter circuitry and the polarity of IRD1 in the receiver.

Once you've got the system working, adjust LT's core in the receiver to find the extreme positions at which control is lost, then reset the core to half way between these two positions. You can then adjust RV1 in the receiver to obtain maximum possible range consistent with reliable operation: our prototype system gives a range of about 15 metres.

Finally, you can use a 'scope or voltmeter to monitor the individual outputs of the receiver while you check that they can be controlled via the transmitter buttons in accordance with the information given in Tables 1 and 2 last month. Your system is now complete and ready for use.

\section*{BUYLINES}

The case for this project was chosen from the BIM Console range supplied by Boss Industrial Mouldings Ltd. (order code BIM6005 Black).

A full kit of parts including the Mec switches (order SRM plus switch cap colour) can be obtained from Watford Electronics.

Ambit International are suppliers for L1, order as 87 BN , 22 mH .

The SAB3210 transmitter IC is avaifable from Electrovalue and Watford.


Fig.2. (left) Component overlay for the control board.
Fig.3. (above) Component overlay for the second board.
Fig.4. (below) The mounting positions of the controls on the double sided control board.
e.g. GREEN INDICATES COLOUR OF SWITCH CAP
- = PIN THROUGH

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\title{
RAVEN ON
}

\section*{Dave Raven takes the lid off his domestic computer scene and sounds alarm bells for the British computer scene.}

Towards the close of 1979 it was announced in China that they had developed high speed emitter-coupled logic circuits that will permit construction of a super computer capable of 20 million operations per second. This is equivalent to ten times faster than any device they have produced to date. It was also announced that they would be exporting computers in the future.

Since this piece of breathtaking information must, by now, have brought you to the edge of your chair I will concentrate the mind further. The significance of China's declaration to enter the international computer market would be lessened if viewed in complete isolation and certainly does not pose any immediate threat to the western computer manufacturers. When, however, it is considered along with that of other emerging nations like Brazil, India and South Africa, who are all eager to develop independent computer industries, it serves to illustrate how different the international computer market will look at the end of the 1980's.

The USA, Europe, Japan, USSR and China will all be aiming to produce computer equipment for their 'in-house' requirements and also capture export markets.

The potential military role of computers is of major significance. However, other sectors of high technology such as telecommunications, aircraft, satellites and nuclear industry are all critical to the maintenance of an industrially based military complex.

\section*{Backing Britain}

The ability of Britain to maintain our industries in all the above technological areas is vital if we wish to remain independent and it would surely be crazy if we were to waste the years of experience built up in this country in high technology only to import computers made in Brazil or China. Japanese computer manufacturers are already embarking on a long term programme to penetrate the USA computer market. This will be accomplished in much the same way as the establishment of cars in the UK; with good service centres and software requirements fully catered for.

In Britain, after seeing the end to our industry for manufacturing small motorbikes, we are now witnessing a slow takeover of the (cheap) family saloon market. Consumer electronic goods is of course well underway with virtually all the UK manufacturers killed off. Remaining are a few TV producers that will be fighting for their lives now that the PAL patents protection is soon to be lost.

\section*{The Video Story}

Video Recorders could well reach the sort of sales levels which have been achieved by Colour TVs during the next ten years, since everyone with a TV has an application for a recorder. Guess how many of these quite straightforward pieces of hardware will be made in Britain, 12 million? 5 million? 1,000 ? How about 100 ? Sorry, not ONE. With the exception of a few home made models built in garden sheds and by lost souls in university development labs.

\section*{Watch This Space}

Having debated involving myself in small computers for the last two years, I have at last purchased a home computer. The significance of this is that it is intended primarily for home use and, therefore, had to compete with other domestic demands on my home budget, as distinct from a business expense.

The decision to buy a home computer is not to be taken lightly, even at the knock down price of under \(£ 400\), since this must be compared against other competing products which are just as attractive. My desire to buy a video recorder has not receded and the demands made by my wife for \(£ 400\) worth of (quite unnecessary) furniture still continue. So what was the final overriding reason that made me rush out and buy a small computer?

Like most enthusiasts of electronics I usually desire new electronic goodies quite early in their evolution and home computers were to be no exception. All the products I have bought to-date such as TV games, digital watches, calculators etc, have all had clearly defined uses. However, a computer takes just a little more justifying as the following script shows:

Picture this domestic scene
Freak "Darling I have decided finally to buy a home computer".
Wife "That will be nice dear".
Freak "I have come to this decision after many months of careful thought and feel it will bring a greater understanding between man and machine. The involvement of the human brain with a computer will expand our memory capacity allowing us to be more creative thinkers".
Wife "That will be nice dear".
Freak "Through the tips of my fingers will be unleashed a storm of interlectual and statistical power man has not previously enjoyed. It can be incorporated with art, music, science, finance and with imagination it will probably iron my shirts".
Wife (looking slightly more interested) "That will be nice dear".
Freak (now standing looking out of the window with a glazed look on his face) "With the right level of software and peripherals it could organise many of our daily needs. A telephone link would enable it to order the shopping. Cooking, cleaning and remembering birthdays could all be carried out with the aid of a little robotics".
"Darling is everything alright?"
Wife
Freak
(not hearing) "With the right robotic design it could develop a human form. Feelings of compassion and warmth could be available to me at the press of a button. Love and understanding always there to satisfy my every whim".
Wife "But if the computer can be made to do all these things what will be my place in your life?".
Freak (now facing wife with manic expression) "And it all costs less than \(£ 400\) !"

The most frequent question asked by the few remaining people that have not yet bought a computer (sic) is - "What does one use it for?". Well, after going around the houses a few times, I can - with a little arm waving - come up with quite a convincing answer.

Life will of course continue without small computers. However, I doubt if small businesses will after a few more years. The pressures from larger competitors who use all the latest tools to beef-up their profit margins will force smaller competitors to follow suit. Don't ever kid yourselves that small companies are cheaper to operate. It requires nearly the same sized operation to print this one magazine as it does to print half a dozen. Ask the Managing Director of Modmags, if you don't believe me. Small computers can be used to speed the flow of management information required on a daily basis. They can put off the day when it is necessary to increase the size of office premises and produce more output without increasing staff numbers (not a bad objective when one considers that the birth rate is declining in Britain).

\section*{Joining The Revolution}

Having extolled the virtues of computers and my fears that Britain may not enjoy the full fruits of their manufacture, I am rather excited by the future prospects of our own Prestel system. For once this very British innovation cannot easily be pinched and sold back to us at a cheaper price since it consists of a system rather than a single manufactured product.

My grateful thanks to Rediffusion Manager Tim Jaggard for allowing me to be present at a demonstration of both the Teletext and Viewdata systems. I must openly confess that although I am aware that much has already been written about these new systems, I have previously found it difficult to muster any interest. Perhaps this is because I am more familiar with Teletext, which interesting and useful as it is, remains an extention of the more traditional information services.

Clearly consumers in the next few years will demand Teletext as a standard on their TV sets in the same way that colour is now required. Viewdata (or Prestel), however, is a different ball game which links together a domestic telephone with the television and converts this to a traditional video display unit as used with a computer. At the press of a button connection is made through the GPO exchange to indpendent organisations who contribute information directly from their own offices.

The Post Office, who provides the Prestel computer and exchange equipment are not involved in editing or interfering in any way with the material supplied to the subscriber. The computer is capable of providing over one million pages of information which can also be of a highly confidential nature and only available to subscribers who have access to a certain code -- for example, private company information to members of staff, bank statements, credit checks on potential customers for loans. On the direct selling side it is possible for subscribers to book tickets on planes, ships and trains using their credit cards. The possibilities for mail order are endless with customers buying directly after seeing TV adverts and not even leaving their front room.

Small Viewdata printers are available producing a hard copy of what you see on the screen. This is all British, you have to remind yourself, and according to the Post Office by 1986 Prestel services would be called on by 95 per cent of telephone users. One other interesting observation is of the uses which may be made of the three as yet unused Viewdata channels. I cannot see the problem in providing software and memory for use by the consumer - which would rapidly make redundant all the small home computers.

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Fig.1. Ceefax and Oracle are broadcast in the same way as TV programmes. Prestel allows independent organisations to put information in. You receive it by telephone and the information is available on your telly at the touch of a button or two.


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dight duly. 50
Medium power. \(100 \mathrm{~mm} .1 .4 \mathrm{C} / \mathrm{W} .70\)
Onsco/group. \(150 \mathrm{~mm} .1 .1 \mathrm{C} / \mathrm{W}^{\mathbf{E 2} .70}\)
Fan mounted on two drilled \(\begin{array}{r}\$ 3.50 \\ 100 \mathrm{~mm}\end{array}\)
heatsinks
\(\begin{array}{ll}\text { hearsinks } \\ 2 \times 4 \\ \text { CI } \\ 65 & \text { max. when used with }\end{array}\)
two 170 W
modules 536.00
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\section*{POWERAMPKIT}
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These are available in two versions - one uses standard components, And the other (the 5). use
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\(\square\)


Mk III FM Tuner series Carriage for Mk 111 tuner \(£ 3\) inc
The Mark III series FM tuner has been updated, and now includes a centre zero tuning meter as standard. The instruction manual has been meticulously revised, enabling easy assembly by constructors of various levels of experience - a preview copy may be purchased for \(£ 1.00\).
Mark III A series 'Reference series' tuner modules
Mark III B series 'Hyperfi' modules, with switched
IF BW , pilot cancel decoder
£ 198.95 inc.
A matching synthesiser unit will be made available later this year, and can be retrofitted to either version. All versions include digital frequency readout/clock, VU deviation meters, 6 preset stations, 10 turn pot manual tuning, toroidal PSU, output level adjustment, \(110 / 240 \mathrm{v}\) AC input. Full alignment service available.

\section*{Power Amplifiery \(\begin{aligned} & \text { Style and performance - with } \\ & \text { 'belt and braces' PSU design. }\end{aligned}\)}

After a couple of preview comments, it seems that many of you are waiting to hear about the matching HMOSFET power amplifier for the MK III tuner. Well, it's out at last complete with twin toroidal PSUs for comfortable 80W RMS per channel,
over 100 W peak, but limited by thermal shutdown of the HMOS. \(10 \mathrm{~W}-100 \mathrm{~W}\) log LED output peak indicator, DC offset protection and switch on pause relay. AC or DC input coupling, direct or relay protected output terminals. The works.
Only one version of this item: Complete kit ....... \(£ 178.25\) inc. Carr. \(£ 5\).
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More features and facilities, thanks
to DC switching and control design
Previewing the most comprehensive audia preamplifier vee switching and controi design
two tape in outching of 7 inputs. plus
toow pass, 2 high pass active filters, qenuine volume related loudness, 1dB two tape in/ours. 2 low pass, 2 high pass active filters, genuine volume related loudness. 1 dB
channel matching, with DC volume, balance, bass and treble controls. Suitable for bus fremote


\section*{LW-MW-SW-SW DC tuned and switched}

\section*{91072}

All switching of bands by a single pin to gnd. Varicap tuned, with LO or MW/LW plus 1 or 2 SW version MW/LW: \(£ 15.58+1\) SW \(£ 16.73\)

\section*{VHF Tunerheads}

Europes largest stock range for broadcast and communications. Probably also the world's details in the catalogues and PL. Specials are
also supplied in the region 30.220 MHz .

\section*{Pilat Cancel PLL Stereo decoders}

Again, Europe's widest range of stereo decoders the 944378 - pilot cancel including post decoder \(26 / 38 \mathrm{kHz}\) filtering and muting preamp output

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Broadcast FM IF strips for all occasions, including the new 911225 . with diode
switched narrow fitter option, ultra linear phase ceramic filters, \(84 \mathrm{~dB} \mathrm{~S} / \mathrm{N}\) and switched narrow fiter option, ultra linear phase ceramic filters, \(84 \mathrm{~dB} \mathrm{~S} / \mathrm{N}\), and
\(0.04 \%\) THD ( 40 kHz deviation). Plus usual things like AGC AFC, dey mute meter drive. \(£ 23.95\) (supplied in screen can with 0.1 edge connection system) Also the 7230 hyperfi series - as the 911225 , but with slope controlled AFC that operates in conjunction with signal level and an extra IF amp stage for DXing.

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The World's largest range of receiver DFMs is now
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possibility. 1 kHz SW resolution with 455 kHz or possibility. 1 kHz SW resolution with 455 k Hz or
10.7 MHz offsets, 100 Hz res up to 3.9999 MHz , and 10.7 MHz offsets, 100 Hz res up to 3.9999 MHz ,
VHF to 299.99 MHz in 10 kHz steps : \(£ 41.75\)

\section*{Semiconductors}
Radio/Communications ICs \(\begin{gathered}\text { FOR complete listings } \\ \text { SEE OUR NEW PRICELIST }\end{gathered}\)


\section*{POWER MOSFETS 100 W PA's made simple}

\section*{Components}

Since pioneering the 100 W compiementary MOSFET technique. Hitachl have developed a range of output devices and drivers that ought ro revolutionise opinions and attitudes towards the
design of all LF amplification systems. W: have a new 48 page application note If1.50 incl and complete sets of parts, modules and now the new complete PA system (see above). 2SK133 120v N-ch 100W MOSFET £6.33 , 2SJ48 Pch complement
\(\mathbf{£} .33\)
\(£ 7.39\) PA1018 Kit for 100W MOSFET PA less Heatsink £16.10. (£23 inc heatsink/bkt)

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The HA12017 is the last word in PU preamps, and general low noise audio design. It is an SIL IC, with 86 dB S/N in RIAA configuration, 10 v RMS output capability, \(0.002 \%\) typ THD at \(10 v\) RMS output (imagine the overload margin !!). It comfort ably supercedes discrete circuit designs in terms of price/performance, ánd takes the art beyond the TDA1042's capabilities. (Replaces HA1457) £1.80 each or an RIAA applications PCB with two ICs for £5.75. Complete with Rs\&Cs \(£ 9.95\).

Radio Control ICS Wen have various RC ICs, including NE544 KB4445 4 channel dig.prop. FM TX IC. 30 mW out (amplifyable) \(-£ 2.30 \mathrm{inc}\) KB4445/6 pair: \(£ 4.75\). Nrop 8 page data sheet \(35 p+\) or RCME syst. 22.65
CMOS, LPSNTTL, TTL, MPU:
Most CMOS is available in low Listings in the new pricelist. Volume also \(\operatorname{linea}\). and \(T T L O K\).

Things like ICM7216B, ICL8038, 8080A, 6800P, 2708, NE555, NE556, etc

\section*{Coming Soon}

\section*{SSB transceiver system \(\div 10 \mathrm{kHz}\) to 1000 MHz !!}

A modular VLF 10 UHF SSB TX/RX system at last. With the correct first mixer, the basic PCB covers 10 kHz to 1000 MHz . using LO fed from ext. source (Our 2 IC Mullard synth for instance) and RF PA for TX OP. O. 2uV basic sensitivity in HF. Typ cost for HF synth SSB RX will be
\(10.7 \mathrm{MHz} \quad 25 \mathrm{kHz}\) Channel spacing 8pole \(121 / 2 k H z\)
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first filter in synth. RX
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The data sheets shows varjous drive circuits, and give ifull
specifications with regard to broadband responses and power

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manufacturers - ALPS - come the biggest and
manufacturers - ALPS - come the biggest and best range of keyswitches, and data entry key board switches. The SCM81101 is shown here, with the KY5. 2 -part cap (with clear top, to enable easy fitting of your chosen legend. Other types ar available with built in LED, \(90^{\circ}\) mounting etc
SCM81101: 17p, KT5: 16p or 29p/pair
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LCD CLOCKS LCD DVM at 15 ua only. at \(15 U A\) only.
OVM \(9 v / 1 \mathrm{~mA}\)

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£ 19.30
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\(£ 2.88\)




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\section*{DRUM SYNTHESISER}

At last, ETI's own machine which peeoom-peeooms, bim-bams, whizeees or boo-ooms in all its onomatopoeic glory. Here is Roger Shore's original design for
 forming a stereo output with the added facility of a monitor amplifier circuit to power a pair of sterco headphones (allowing setting up of the synth without being overheard) comes to

All 42 ways of the control board (above) are used. Cut a slot at pin 37 for identification.
around \(£ 60\). This approximate price is inclusive of what we feel is a very nice housing (see Buylines) suiting the synthesiser down to a tee. A comparable price for a similar commercial unit is over \(£ 360\) - OUCH.

The modular construction means that any number of channels can be built as required and perhaps the most enterprising of you out there can envisage a complete electronic drum kit of bass, snare, tom-toms, high hat and cymbals for about half the price of a standard kit. Of course the extra drum sounds of the synthesiser are also there as required.

The ETI Staccato is a mains powered device, none of those nasty batteries running out on you half way through a gig. A simple microphone or miniature loudspeaker acts as the trigger sensor and can be positioned inside an existing drum, on the underside of a simple wooden block or, as in the prototype, inside or underneath a practise drum pad. The drum pad is probably the ultimate as it means a permanent and compact method of holding the sensor whilst maintaining a goodlooking and functional appearance

Also featured is a sensitivity control which adjusts for a very wide range of trigger sensors and levels which means that virtually any combination of microphone, or speaker and holder will trigger the synthesiser.

\section*{The ETI Staccato Drum Synthesiser}

Our aim was to incorporate a systematic approach to interwiring connections, therefore providing a unit that could easily be expanded. The most favoured compromise combined three PCBs; a power supply unit and monitor board, controlcircuit and a function board which holds all PC mounting potentiometers, switches and LEDs for a single channel synth.

Begin construction by building the power supply unit and monitor PCB, insert all pins and wire links followed by IC sockets, resistors, diodes, capacitors and semiconductors. Next in line is the control circuit; follow the same procedure as above. Take care when you come to wire the edge connector as all of the 42 ways have been used right down to the last pin! A slot will need to be made at pin 37 of the circuit board to polarise the edge connector.

The power supply board (above) also carries the monitor amplifier. The potentiometers for each channel are all mounted on one board (right).

\section*{Construction}

Before assembling the function board, it is wise to use it as a template for marking out the front panel. This will give a physical representation of the layout and will enable easy alignment of the potentiometers, etc after drilling. Mount all right angled, inter-PCB sockets ( 3 ways or 5 ways) around the edge of this board. Be sure to mount all potentiometers from the copper side of the PCB with their tags bent at right-angles. It is highly recommended that the specified switches are used (see Buylines) as they offer various switchable pinouts, especially in the case of SW3. To accommodate the switch bezel, a cutout of \(14 \times 14 \mathrm{mms}\) is required. Finally to save any embarrassment whatsoever, check the orientation of all polarised components before switch on!

Now you've built the staccato drum synth how about joining a band? At least one hour's practice should put you 'on the road' - not necessarily to stardom!


Fig.1. Block diagram of the ETI Staccato.
\(\qquad\)





\section*{Setting Up}

There are only three presets (RV5, 6 and 7) to adjust. Start by setting them all to mid-position then turn the noise control to minimum and switch the noise on. This effectively disconnects the sine filter from the circuit. Now switch the VCO to sine output. Switch the device on and adjust RV7 preset until a continuous signal is heard at the output. If an oscilloscope is available, adjust RV5 and 6 for minimum sinewave distortion. If no oscilloscope is available, simply adjust


Fig.2. Circuit diagram of PSU.


Fig.4. Circuit diagram of monitor amplifier.
the presets for minimum audible distortion. This may seem somewhat haphazard, but the human ear is very discerning where sine distortion is concerned! Once the minimum distortion position has been established, it only remains to adjust RV7 until the signal just disappears from the output .... and that's it!

Now, the golden rule is to experiment. Apart from the sounds for which the drum synth is well known, a whole range



Fig.5. Connecting details of monitor amplifiers.


Fig.6. Connecting details of switch LEDs.
Fig.3. Circuit diagram of the ETI Staccato Drum Synth.

of strange and wonderful sounds is possible, particularly if the LFO and noise generator are used. Vibratos, warbles, chimes and gongs are obtained using the LFO. Surf, wind, applause, snare drums and cymbals are obtained using noise.

\section*{HOW IT WORKS}

The block diagram (Fig.1) shows the main principle of operation of the synthesiser. It can be seen very simply as a voltage controlled oscillator followed by a voltage controlled amplifier. This means that the frequency of the final signal and its amplitude ie its pitch and envelope, are controlled by DC voltages derived from the original trigger. Two separate ramp generator circuits provide these DC voltages ano all necessary. parameters of these ramps are externally controllable. A low frequency oscillator can be applied to modulate the VCO if desired and a generator produces noise for cymbal or snare sound, etc.

The voltage controlled oscillator is based on the 8038 waveform generator chip, IC2. Its frequency is varied by adjustment of the pitch control RV4, allowing the initial frequency to be set to the required level. Alternatively, the frequency can be controlled by a varying DC voltage applied via D3, from the VCO ramp to be described later. The oscillator works over the frequency range between about 10 Hz and \(1 \mathrm{k5} \mathrm{~Hz}\). All three output waveforms available from the 8038 , sine, triangle and square waves, are used.

The trigger for the synthesiser is provided by a microphone (virtually any microphone will do) fitted inside a suitable drum or holder, even a tin can will do! The signal from the microphone is differentiated by C1, R1, so that surrounding sounds do not cause false triggering. The pulse generated when the drum is struck is then amplified by IC1a, the gain being varied by RV1. The output of this amplifier is then rectified by D1 to provide a positive going pulse which is fed to further amplifiers IC1d and IC4c. These op amps are connected as inverting amplifiers to provide negative going pulses to drive the VCO and VCA ramp generators.

The anode of ZD1 is normally at zero volts and the cathode at +15 volts. When the output of IC1b is driven negative by a trigger pulse the cathode of D2 approaches zero. This negativegoing pulse is rectified by D2 and charges C2 rapidly. C2 discharges through RV2 and R4, the val ue of RV2 varying the rate between a few milliseconds and several seconds. This DC ramp is buffered by IC1c connected as a voltage follower, to prevent RV3 affecting the C2, RV2 discharge time. As both ends of RV3 are normally at +15 volts, D3 is biased off. When the output of IC1c swings negative on receipt of the trigger, D3 is turned on and allows the ramp waveform to control the sweep input of the VCO. RV4 sets the lower frequency of the oscillator and as pin 8 goes more negative, the frequency rises. The range of this frequency sweep is determined by RV3 whose setting limits the negative swing of D3 cathode. However, C2 charges quickly and discharges more slowly. The characteristic falling sine sound of the drum synth is created at the output of the VCO. By use of RV4 pitch, RV3 pitch bend and RV2 slope a whole range of sweeps are possible.

The voltage controlled amplifier is based on the Motorola 3340 voltage controlled attenuator IC. The selected output from the VCO is fed to the IC and the output is fed to the volume control, RV8. The voltage controlling input is fed to pin 2 via RV7, which is preset so that with no trigger present there is no output. The VCA ramp generator functions in a similar manner to the VCO ramp generator. The baseemitter junction of Q1 is reverse biased to provide the noise source. This noise is ampli fied by Q2 and further amplified by IC5 whose gain is variable via RV11, determining the noise level to be fed to the VCA input.

Notice that when the noise is switched in, the sine filter, C4, is switched out. This is to ensure that when noise and sine are used together, this filter does not attenuate the useful part of the noise spectrum required. Although this marginally increases the sinewave distortion this is not noticeable above the deliberately introduced noise.

The low frequency oscillator uses IC4b as an integrator and IC4a as a Schmitt trigger, together making a triangle wave oscillator. The speed is varied by RV9 between about 0.5 Hz and 1 kHz , and the amplitude is varied by RV10. C9 can be switched in to integrate the triangle wave to provide a sinewave approximation for vibrato effects.


Fig.7. (above) Component overlay of the PSU and monitor amplifier board.

Fig.8. (below) Component overlay of the control circuit board. Take care when wiring the edge connector


\section*{BUYLINES}

A varied buylines, as certain components have been selected for easy construction. The exceptional case is part of a range (larger sizes available on request) supplied by Campbell Clarke Cabinets, 2 Arden Court, Church Road, Perry Barr, Birmingham, B42 2LF, Tel: 021-356-0890 - a very stylish wooden ended cabinet which is attractively priced at \(£ 11.50\).

The MEC switches are only available from Watford Electronics (order code SRL plus colour of switch cap) along with the knobs. Also state cap colour when ordering the knobs. The micro toggle switches can be purchased from Marshall's. Electrovalue stock the PC mounting potentiometers. For the inter PCB sockets, plugs and shells, Technomatic are suppliers. Our Remo practice drum pads were obtained from The Rhythm Box (Drum Store), 5 Denmark Street, WC2 8HLP, Tel: 01-240-3836. A crystal insert fits neatly inside these pads and acts as the trigger sensor.


Fig.9. Component overlay of the function board.

PARTS LIST
\begin{tabular}{ll} 
Components For One Channel \\
Resistors & \\
R1,2,4,5,12,13,14,18, & \\
\(20,24,26,27\) & 10 k \\
R3,22,28 & \(1 \mathrm{M0}\) \\
R6 & 270 k \\
R7,8,19,23,25,29 & 4 k 7 \\
R9,10,16 & 22 k \\
R11,21 & 220 k \\
R15. & 47 k \\
R17 & \(1 \mathrm{k0}\) \\
R38 & 2 k 21 W
\end{tabular}

\section*{Potentiometers}

RV1,2
RV3
RV4
RV5,6
RV7
RV8
RV9, 12
RV10
RV11
Capacitors
C1
C2,5
\begin{tabular}{l} 
C3 \\
C 4 \\
\hline
\end{tabular}
C4 \({ }_{\text {C6 11, }}\)
C7
C 7
C 8
C
C9
C13
C1
C14
Semiconductors
IC1,
IC2
IC3
IC3
IC5
D1-D4
ZD1
Q1,2
LED 1,2,3

1M0 lin PCB mounting
250 k lin PCB mounting
500k log PCB mounting
100k miniature horizontal cermet preset
10k miniature horizontal cermet preset
10k log PCB mounting
500k lin PCB mounting
100k lin PCB mounting
2MO log PCB mounting

4117 polycarbonate
1 u0 tantalum 35 V
100 n polyester
47n polyester
1 n0 polycarbonate
10 u tantalum 35V
470n polycarbonate
10 u 25 V electrolytic axial
100n polycarbonate
\(22 n\) polycarbonate
4u7 16V electrolytic

> TL084
> 8038
> 3340
> TL081
> 1N4148
> \(15 V 400 \mathrm{~mW}\)
> BC109
> \(0.125^{\prime \prime}\) dia red LEDs

Miscellaneous
SW1, DP 3 position slide switch (one pole used only) SW2,3,5, MEC 2 N/O, 2 N/C latching push button (see Buylines), SW4,6, SPST micro-miniature toggle, 43-way edge connector, \(8 \times 3\)-way right angle inter PCB connectors including plugs, sockets, shells, \(5 \times 5\)-way right angle inter PCB connectors including plugs, sockets, shells, case (see Buylines), 9 knobs, input and output sockets, 4 6BA tapped spacers (length), 4 6BA plastic spacers, trigger sensor, drum pads (if required), MEC switch cap colour green, blue and.yellow, knob cap colour 3 blue 2 red, 2 green, 1 white, 1 yellow for a single channel drum synth.
Additional Components For Two Channels
Resistors
\begin{tabular}{ll} 
R30,31 & 22 k \\
R32,33 & \(1 \mathrm{M0}\) \\
R34,35 & \(2 \mathrm{R7}\) \\
R36,37 & 150 R \\
& \\
Capacitors & \\
C14,16 & 1000 u 25 V PCB electrolytic \\
C15,17 & 1 u 016 V tantalum \\
C18,19 & 68 n ceramic \\
C20,21,24,25 & 100 n polyester \\
C22,23 & 220 u PCB electrolytic \\
Semiconductors & \\
IC6 & 7815 \\
IC7 & 7915 \\
IC8,9 & LM380 \\
BR1 & 1 A 50 V bridge rectifier
\end{tabular}

Miscellaneous
T1 15-0-15 6VA transformer, SW7,8 DPDT miniature toggle, FS1 500 mA fuse, stereo jack socket, length of 3 core mains cable.

\section*{Adastra public address equipment Adastra}



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\title{
MICROFILE \\ Henry Budgett leafs through the latest Vero catalogue to case his computer collection.
}

Welcome, once again, micro-fans to the world of small systems. I see that the ZX 80 topped the ratings for interest value last month, more on that in just a minute. Our busy network of spies has been burrowing deep into the fabric of both government and industry to bring you the following news items at great personal risk.

\section*{Micros For Schools}

A mole, deep within the echelons of the Department of Industry, has revealed the existence of an intrepid plot to give microcomputers to schools. Naturally there is a catch, or 22 , you have to enter a competition. Seriously though, a competition - in essay form - will be shortly announced for secondary schools with, currently, 100 British micros as prizes. Talks are being held with local industry and banking institutions in the hope that more finance - and hence more prizes will be forthcoming. Your Headmaster should have received details by now and a full Press release will shortly be given so watch this space for further details . . . . wild horses wouldn't make us reveal what system is being considered!

\section*{The Case For Nascom}

One of Microfile's more intrepid investigators recently emerged, smiling, from the latest Vero catalogue. It seems that the range of parts is so vast that you can box and house anything. The outcome of this is that if you order a \(3 \mathrm{D}-\mathrm{N}\) card frame you will be able to house your Nascom (1 or 2) for a mere £24.28. Added extras, such as modules, card fronts, Veroboards, edge connectors and a whole lot more can also be purchased along with a nice case to fit round it all.


Also discovered, and now in full-time use, is a card frame/ case to house a Tangerine system along with all the extras such as a module to fit the necessary power supply into. This is a half width, extended System KM4C with card guides for International boards (whew). The same frame can also take Acorns by fitting Eurocard guides and an indirect connector plate. Subtle stuff all this, and much more fun than just asking for "the box"!

\section*{Research Into Sinclair}

It appears that the author of this column may have been led a trifle astray during his research into the insides of the ZX 80. Shortly after the issue hit the streets a letter arrived from Clive Sinclair which refuted a number of points raised in the item. Here, in its entirety is the letter and readers who seek a fuller insight into the workings of the machine should either stifle their impatience or rush out and buy a copy of June Computing Today, which contains a full review.

> Dear Mr. Harris,
> The news item in the Microfile column of your April issue says some nice things about our ZX80 computer, for which many thanks, but unfortunately there are one or two errors of fact which I would like to correct.
> The first is that the operating language is not Tiny BASIC but quite a powerful true BASIC with, we believe, better editing facilities and greater speed than any of our competitors.
> Again, contrary to the news item the ZX80 has full machine code facilities. Although it is true that RAM extension is limited to \(16 K\) bytes, this is no small quantity when the tight packing the ZX80 achieves in its RAM is considered. Indeed, I suspect that more lines of BASIC can be accommodated on the ZX80 than on any of the competitors, all of which cost several times the price. At the other extreme the excellent Hewlett Packard machine costing around \(£ 3,000\) accommodates a maximum of \(32 K\) bytes of RAM.
> The final remark in the column doubts the practicality of adding new ROM's, extra languages and discs to the machine on the grounds that "the CPU is already rather overworked". The only thing the CPU does in our machine which it does not do in others is to drive the display, thereby saving integrated circuits, board area and costs, which is reflected in our selling price. It is not "overworking" the CPU in any sense as it would otherwise be idle during the display period.
> A new plug-in ROM will soon be available at an additional cost of around £20. extending the maths. capability of the computer to include log. and trig. functions, and also increasing the data handling capacity and incorporating a floppy disc facility.
> Yours sincerely,
> Clive Sinclair.

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\section*{TECH TIPS}

\section*{Light/Temperature Indicator}

M Miller, Reading

USing half a LM3900 quad Norton amplifier, either light or temperature can be monitored with this device. In the light monitoring mode a reverse biased LED was used (a clear type, not opaque) at output 1. The light value can be measured with a high impedance voltmeter, approximately \(0-30 \mathrm{~V}\) FSD RV1 sets a threshold voltage to 1C1a, so that either LED 1 or LED 2 will be on depending on whether output 1 exceeds the threshold voltage or not. In the temperature mode a 1 N4148 diode was used, also reverse biased. Any small glass diode can be used. The amplifier outputs are the same as in the light monitoring mode.


\section*{555 Voltage Control}

\section*{S Draper, Lincoln}

This circuit was developed to provide a cheap, reliable and accurate voltage controlled oscillator. It uses readily available components and the control over mark-space ratio common to other 555 circuits is retained. Frequencyvoltage response is linear over approximately one decade making the circuit useful in timing applications. Operation is as follows:

IC1 buffers the input voltage and produces the control current for IC2. IC2 is an operational transconductance amplifier and produces an output current proportional to the control current multiplied by the differential input voltage. This output current is used to charge and discharge the capacitor C 1 in the normal way. The equation for output high and output low times are given below:
\[
\text { Output high time }=\frac{\mathrm{R} 1 \mathrm{C} 1}{9024} \frac{(47.5+\mathrm{R} 4)}{\text { control }}
\]


Output low time \(=\frac{\mathrm{R} 1 \mathrm{C} 1}{192 \overline{\mathrm{~V}}_{\text {control }}}\)
where all resistances are in kilohms and all capacitances are in microfarads.

Current consumption is a miserly 10 mA from a 12 V supply making the unit suitable for battery power.
N.B. - R1 should not be less than 18 k .

Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items.
ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH-TIPS, Electronics Today International, 145 Charing Cross Road, London WC2H OEE.


The decimal point is now redundant as it doesn't help much and would require more switching on SW8. This can, therefore, be eliminated. This means that SW1,2,3,4 and 5 need only be two pole, so they can all be incorporated one 2 p 6 w rotary switch, further reducing cost. These two modifications do make the meter slightly less convenient in use, but this is outweighed by the reduced cost. To modify the existing PCB the tracks to pins 1,2,6 and 7 of IC7 are cut and it is then a simple matter to insert SW8 as shown.

\section*{DFM Mods}

\section*{R Lea, Amersham}

This is a simple, cost reducing modification to the DFM published in ETI June 1977. The need for three decoders and displays has been reduced to one.

The outputs from the counters (IC4-6) are switched via SW8 to a single 7447 decoder (IC7) driving a DL707 display. In use, the 'test' button on the original unit is pressed. When counting is complete, SW8 can be cycled through the digits to obtain a reading.


\section*{Sound Effects Unit}

P Layzell, Sandy
This circuit consists of four CMOS oscillators gated together in a configuration that will produce a multitude of effects from white noise to a multibanked Trimphone.

Each IC is connected as a warble tone generator and mixed together at the base of Q1. LS1 can be from 8 100 R , but the transistor tends to get a bit hot below 30 R , so a small heatsink may be needed.

None of the component values are critical and if desired, RV1,3 can be replaced by ordinary resistors without affecting the variety of sound effects too much.


\section*{16 Note-Sequencer}

\section*{P Gatehouse, Buckingham}

This circuit is designed to play a repeating sequence of 16 notes which are programmed by variable resistors. IC1 is a binary counter which runs off a PUT oscillator. The oscillator is built around Q1, which can be a 2 N 6027 or MEU21. The RC time constant connected to the anode charges up, causing the voltage at the anode to rise. At a certain voltage, controlled by R3 and R4, the PUT conducts. This allows the capacitor to discharge through Q3 as a good clean clock pulse. Q3 inverts the pulse to suit
the TTL requirements. The frequency of these events is easily changed by altering the time constant - a 100 k variable resistor was used.

IC1 generates a binary count on its four outputs - only if you ground both the reset terminals. IC2 selects a single output line for each of the sixteen possible input combinations. The result is that the presets are connected one-byone, in sequence. Q1 is the audio frequency oscillator, whose frequency can be changed by altering the resistors which determine the anode voltage of the PUT. Don't be tempted to leave out the diodes in series with the presets as
they block the normally 'high' outputs from interfering with the selected 'low' output. The type of diode used is not critical. 1N914s are probably the best (and cheapest).

Interesting results can be obtained by connecting a fairly large capacitor to various parts of the gate terminal of the second \((\mathrm{AF})\) oscillator. Connect the other terminal ground or positive line watch the polarity, if it's electrolytic. Another oscillator can be connected to the same outputs provided it is fitted with diodes isolating it from the first oscillator. If the outputs are mixed, polyphonic effects are possible.


\section*{CMOS/TTL Pulser}

\section*{C T Morris, Mid Glamorgan}

For a small extra outlay, a pulse trian facility can be added to the ETI Pulser that appeared in December 1975. The

NAND gates form an astable, which is gated by a flip-flop. When the pulse switch is pressed the flip-flop changes state and turns on the astable. Single shot or pulse trains are selected by a
change-over switch connected to the flip-flop and astable outputs.

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