ACCEPT AN ImitATION!
EPROM emulator to speed software development

PLUS
Communications
Satellites—the past, the present, and the future

JLLH power amplifier details

HOME AND CAR SECURITY SPECIAL
Alarm system to build
Person-sensing light project
Infra-red mini-alarm

DIO... COMPUTING... MUSIC... RADIO... ROBOTICS
High performance, low price kits for today's musicians

DIGITAL DELAY LINE

Digital delay circuitry is an absolute necessity for high quality studio work, but usually comes with a four-figure price tag.

Powertran can now offer you digital quality for the price of a high analog unit. The unit gives delay times from 1.6mSecs to 1.6 secs with many powerful effects including phasing, flanging, A.D.T., chorus, echo and vibrato. The basic kit is extended in 400mSec steps up to 1.6 seconds simply by adding more parts to the PCB.

Complete kit (400mS delay) ........................................ £179
Parts for extra 400mS delay (up to 3) .................................. £19.50

MPA 200
100 watt mixer/amplifier

Here's a rugged, professionally finished mixer amp designed for adaptability, stability and easy assembly. Using new super-strength power transistors and a minimum of wiring, it offers a wide range of inputs (extra components are supplied for additional inputs), 3 tone controls, each with 15dB boost and 15dB cut, and a master volume control.

Complete kit .................................................. £79.50

CHROMATHEQUE 5000
ETI 5-channel lighting effects system

Many lighting control units are now available. Some perform switching and others modulation of light output according to musical input. The Chromatheque combines both functions. It controls 5 banks of lamps up to 500W each in either analog or digital mode. And the 5 channels give more colours and more exciting linear and random sequencing than is possible with 3 or 4-channel systems. Versatile light level controls enable the lights to be partially on to suit the mood of the occasion. Wiring is minimal and construction straightforward.

Complete kit .................................................. £99.50

TRANSCENDENT 2000
ETI single board synthesizer

This professional quality 3-octave instrument is transposable 2 octaves up or down, giving an effective 7-octave range.

There is portamento pitch bending, VCO with shape and pitch modulation, VCF with high and low pass outputs and separate dynamic sweep control, noise generator and an ADSR envelope shaper. Other features include special circuitry with precision components to ensure tuning stability.

Complete kit .................................................. £150

SP2-200
2-channel, 100-watt amplifier

The SP2-200 uses two of the power amplifier sections of the MPA 200 (above), each with its own power supply. A custom designed toroidal transformer enables both channels to simultaneously deliver over 100W rms into 8 ohms. Each channel has its own volume control, and a sensitivity of 0.775mV (0dBm) makes this amplifier suitable for virtually all pre-amps or mixers.

Complete kit .................................................. £99.50

Goods subject to availability. All prices exclusive of VAT and correct at time of going to press.

Powertran Cybernetics Ltd.

Powertran Cybernetics Ltd, Portway Industrial Estate, Andover, Hants SP10 3ET. Tel: (0264) 64455

All prices are exclusive of VAT and apply to the U.K. only. Allow 21 days for delivery. Overseas customers - please contact our export department for the name and address of your local dealer.
FEATURES

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WATFORD ELECTRONICS
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POLYESTER CAPACITORS: 33nF. 50V; 8V: 100nF. 15p.

BÁ100

RANGE

$19

SILVER MICA (Values 10pF)

WATFORD

00200

N5406

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AUGUST IS TEST EQUIPMENT TIME

Since we last looked at test equipment in June and July 1983, certain of our competitors have duplicated — but not matched — our surveys of DMMs and 'scopes. So we're going to be looking at the other side of the coin, as it were, with a group of articles that examine the types of gear that are available, the types of gear you'll find you need, how you might go about building your own (and when it's not worth trying to build it yourself) and finally, we'll be attempting the ETI tour of debugging common circuits.

ALL THIS AND MORE IN THE AUGUST ISSUE OF ETI, ON SALE JULY 6th.

DON'T FORGET TO GET YOUR COPY TO READ ON HOLIDAY!

ETI is carefully designed to provide sufficient shade when placed over the readers eyes so as to permit sleeping in the strongest of sunlight.

CMOS Tester

Carrying on in the test equipment theme is a nifty little project for a CMOS tester. Not only can it be used to test to see if a known device is working, it should be possible to deduce what unfamiliar items with odd-looking numbers are.

Sharp Joystick Interface

For all those of you out there who think that computing should be fun (Humbug) — Editor, Computing Toady), this project should shed a little joy on one machine which is presently stick-less.

'Audio Design' Power Amp PSU

Following on from the power amp described in this issue is the PSU you need to get it going, as ever from the workshop of John Linsley Hood.

B SR P256 TURNTABLE


Complete manual arm. This kit has a complete manual arm and is designed primarily for disco and studio use where all the advantages of a manual arm are required.

Price £33.60 each + £2.50 P&P.

OVP POWER AMPLIFIER MODULE

NEW OVP100 Mk.II POWER AMPLIFIER MODULE. Power Amplifier Module complete with integral heat sink, toroidal transformer, power supply and glass fibre p.b. assembly. Incorporates drive circuit to power a compatible LED volt meter. New improved specification makes this amplifier ideal for P.A. Instrumental and Hi-Fi applications.

APPLICATIONS

Output Power: 110 watts R.M.S.

Load: Open and short circuit proof. 16 ohms.

Frequency Response: 15Hz - 30KHz 3dB.

H.F. - 0.01%.

S.N.R. (Unweighted) - 118dB + 3.5dB.

Sensitivity for Max Output - 500mV at 300 – 110 – 75mm Price - £31.99

(+ £2.50 P&P v. Volt Meter Price - £8.50 + £2.50 P&P.)

Large S.A.E. for details of oscilloscope, speakers, kits, amp. modules, equalisers, turntables, etc.

PEIZO ELECTRIC TWEETERS - MOTOROLA

Join the piezo revolution. The low dynamic mass (no voice coil) of a Piezo tweeter produces an extremely transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts either in parallel. FREE EXPLANATORY LEAFLETS SUPPLIED WITH EACH TWEETER.

LOUDSPEAKERS POWER RANGE

THREE QUALITY POWER LOUD-SPEAKERS 15" 12" and 8" See Photo

Ideal for both Hi-Fi and Disco applications. All which have attractive cabinets, quality (ground lined) facing materials. Specifications and Prices.

Type A 15" 8 ohms.

Impedance 8 ohms.

Dimensions 92dB.

Sens. 95dB.

H.F. - 0.01%.

Freq. Resp. to 10KHz.

Price £57.99 each + £3.50 P&P.

Type B 12" 4 ohms.

Impedance 4 ohms.

Dimensions 92dB.

Sens. 95dB.

H.F. - 0.01%.

Freq. Resp. to 10KHz.

Price £39.99 each + £3.50 P&P.

Type C 8" 2 ohms.

Impedance 2 ohms.

Dimensions 92dB.

Sens. 95dB.

H.F. - 0.01%.

Freq. Resp. to 10KHz.

Price £21.99 each + £3.50 P&P.

PANTHER HOBBY KITS. Proven designs including glass fibre printed circuit board and high quality components complete with instructions.

FM MICROTRANSMITTER (BUG) 90-105MHz with very simple modification. Range 100-200 metres with 45, 55, 144 (9 volt) Price £8.62 + £1.50 P&P.

S.WATT FM TRANSITTER 3 WATT 85 - 115MHz varicap controlled professional performance. Range up to 3 miles 35 x 84 x 122mm Price £213.75 + £1.50 P&P.


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- High speed 24K byte extended basic interpreter
- Powerful TMS9995 16 bit microprocessor
- 48 bit floating point gives 11 digit accuracy
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- 16 colours available on the screen together in graphic mode
- Fast line drawing and point plotting basic commands
- High speed colour shape manipulation from basic
- Full textual error messages
- String and Array size limited only by memory size
- Real time clock included in basic
- Interval timing with 10mS resolution via TIC function
- Named load and save of basic or machine code programs
- Auto-run available for any program
- Powerful machine code monitor
- Assembler and Disassembler included as standard
- Auto line numbering facility
- Full renumber command
- Simple but powerful line editor
- Flexible CALL statement allows linkage to machine code routines with up to 12 parameters
- Basic programs may contain spaces between key words to make programs readable without using more memory
- Over 34K bytes available for basic programs
- Extended basic includes IF-THEN-ELSE
- Interfaces for screen and cassette included.
- Supports bit manipulation of variables from basic
- Error trapping to a basic routine included
- Basic supports Hexadecimal numbers
- Separate 16K video RAM for graphics

With this powerful machine (featured in Electronics Today International as a constructional project) you have access to highly advanced systems and software developed specially by MPE Ltd for the CORTEX. For business, education, R & D – or simply increasing your knowledge and understanding of computers – it beats comparably priced off-the-shelf machines hands down!

**Statements**

- IF
- ELSE
- ON
- GOTO
- GOSUB
- POP
- REM
- FOR
- NEXT
- ERROR
- INPUT
- PRINT
- TIME
- WAIT
- TON
- TEXT
- GRAPH
- PLOT
- UNPLOT
- RETURN
- FTA
- RESTOR
- LIST
- SHAPE
- SPRITE
- SPUT
- SOFT
- MAG
- MAGTOF
- TON
- MWD
- BASE
- CRB
- CM
- ERROR
- CASE
- RENUM
- ERROR
- SUPPORTS bit manipulation of variables
- Interfaces
- OVER using key machine code
- Extended basic includes basic
- Flexible
- Simple but powerful line editor
- Error trapping to a basic routine included
- Basic supports Hexadecimal numbers
- Separate 16K video RAM for graphics

**Self assembly kit**

**£295**

All prices exclusive of VAT. Carriage paid.

**Optional Extras**

- Floppy disc interface electronics £96.50
- Hardwire kit & connectors for disc drives £40.00
- RS232C interface kit £9.20
- Pair of 5¼" disc drives (SS) £300.00
- Pair of 5¼" disc drives (DS) £590.00

*Full assembly instructions and 216 page users manual.*

**POWERTRAN cybernetics ltd.**

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<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
<th>Price</th>
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<tr>
<td>NE557N Dual version of the 555</td>
<td>61</td>
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<td>uA741CN DIL low cost op amp</td>
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<td>uA741CN Dual 741 op amp</td>
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<td>0.70</td>
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<tr>
<td>uA741CN 741 with external frequency comp</td>
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<td>HA3088 18W PA from 14V</td>
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<tr>
<td>TDA2002 8W into 2 ohms power amp</td>
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<tr>
<td>LUN2833 1W max. 3-12V power amp</td>
<td>61</td>
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<tr>
<td>M53357 Low power NFBM IF and detector</td>
<td>61</td>
<td>2.85</td>
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<tr>
<td>LUN3859 Low current dual conversion NFBM IF and detector</td>
<td>61</td>
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<tr>
<td>LM3900 Quad norton amp</td>
<td>61</td>
<td>0.60</td>
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<tr>
<td>LM3909N Spin Dil LED Flasher</td>
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<tr>
<td>KB4444N Radio control 4 channel encoder and RF</td>
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<tr>
<td>KB4445 Radio control 4 channel encoder and RF</td>
<td>61</td>
<td>2.75</td>
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<td>ICM7555 Low power CMOS version of timer</td>
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<td>IC1038CC Versatile AF signal generator with sine/square/triangle</td>
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<td>TK10170 5 channel version of KB4445</td>
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<td>HAI12002 Protection monitor system for amps, PSC, TK1 etc</td>
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<td>HAI12017 83dB S/N photo preamp</td>
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<td>MC14112 300 baud MODEM controller</td>
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Microprocessor & Memories

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<tr>
<td>Z80A Popular and powerful 8bit CPU</td>
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<tr>
<td>Z80AF10 2 port parallel input/output</td>
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<tr>
<td>Z80ACT 4 channel counter/timer</td>
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<td>Z8281 28 Micro comp. and Basic</td>
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<td>61163 LS16K (2kx8) CMOS</td>
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<td>62132 32K (4kx8) quad RAM</td>
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<td>41162 16K (16kx1) 150ns</td>
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<td>2764 64K (8kx8) 40ns</td>
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Voltage Regulators

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<td>7805 5V 1A positive</td>
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<td>7812 12V 1A positive</td>
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<tr>
<td>7815 15V 1A positive</td>
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<td>7905 5V 1A negative</td>
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<tr>
<td>7912 12V 1A negative</td>
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<tr>
<td>7915 15V 1A negative</td>
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Transistors

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<td>BC182 General purpose</td>
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<tr>
<td>BC237 General purpose</td>
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<tr>
<td>BC237 Plastic BC107</td>
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<tr>
<td>BC238 Plastic BC105</td>
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<tr>
<td>BC232 Plastic BC109</td>
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<tr>
<td>BC230 Complement to BC237</td>
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<tr>
<td>BC238 Complement to BC238</td>
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Monolithic Capacitors

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<td>BC267 Driver/power stage</td>
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<td>BC337 Driver/power stage</td>
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<td>MPS13 NPN Darlington</td>
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<tr>
<td>MPS1A3 PNP Complement to MPS13</td>
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<tr>
<td>J130 JFET for HF-VHF</td>
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<tr>
<td>J176 JFET analogue switch</td>
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<td>0.65</td>
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<tr>
<td>3SK51 Dual gate MOSFET-VHF amp</td>
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<td>3SK88 Dual gate MOSFET-Ultra in tobe</td>
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<td>TIP11A Output stage</td>
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<td>TIP32A Complement to TIP11A</td>
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<td>VN66AF VMOS Power FET</td>
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<td>ZTX8866 Edline version 2N3866</td>
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<td>IN4001 Rectifier diode</td>
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<td>IN4002 Rectifier diode</td>
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<td>IN4148 General purpose silicon</td>
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Silicon Controlled Rectifiers

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<td>BRYS5-100 100V 8A</td>
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<td>CD12DI 400V 4A</td>
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<td>CD12DI 80V 8A</td>
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3mm Diameter LEDs

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<td>V178P Red</td>
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<td>V179P Green</td>
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<tr>
<td>V189P Yellow</td>
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5mm Diameter LEDs

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<td>CYQ72L Green</td>
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Polyester

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Crystal Filters 2 Pole Types

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Defend your home and property with the 'Minder' radar-Doppler alarm system!

As one would expect, this product comes very soundly and safely packaged — so we expect no problems with equipment being damaged in the post.

The equipment supplied is as follows: a main unit, with a radar sensor and key-operated switch, a small siren unit for interior mounting, which is powered from the main unit, an external siren which is normally powered from the main unit, but which has its own internal battery capable of keeping the alarm sounding for quite some time when power is removed, connecting wire and two instruction booklets, one covering normal operation and one covering installation.

The main unit uses the Doppler effect to detect the presence of an intruder (in much the same way that the Ecolight featured elsewhere in this issue uses ultrasound). This has the great advantage that you don't have to go to the trouble of installing door switches, pressure mats, etc (although these can be added to the system if you feel it is necessary). However, you do have to obtain a licence for the unit; this is normally a formality, and the form to apply for the licence comes with the kit.

We recommend testing out the sirens with a great deal of caution — the internal siren is itself quite a lot louder than other brands of external siren, and can be positively painful to be near when it is sounding!

Ever conscious of the fact that although ETI is a technical magazine, we do have some not-so-knowledgeable readers (you wouldn't believe some of the enquiries we get — or perhaps you would!), we found a grandfather in his 60s, a proud possessor of four thumbs, incipient arthritis and plenty of spare time. His comments follow:

"Why two sets of instructions? Not being very technically-minded, I found it a little off-putting to be immediately presented with three pages of technical specification. (This is, however, obviously something many ETI readers would wish to see, and a selection of the specs is reproduced opposite — Ed.) Let it suffice to say that whilst I found the instructions confusing, and think that they could have been better written, I did, in the end, manage to install the system correctly.

"I have had frequent and close contact with the police during my lifetime (no, not for the reasons you immediately suspect...), and for this reason, decided to contact the local crime prevention officer before installing the alarm. This proved to be extremely useful, and besides giving me much fascinating information about the local villains, he advised me on the positioning of the control unit and the usefulness or otherwise of adding pressure sensors, door switches, etc. One definite oversight in the instructions — which we can correct here — is that you should contact your CPO before you install any alarm. Bad planning can nullify the effectiveness of any system — and anyway, we all pay the CPOs' wages through our local rates!

"A power cord of 3 metres seems a bit on the short side, especially as the best place to site the unit is 2 metres up the wall. However, if you're doing a thoroughly professional job, you may want to arrange for a special supply point right next to the unit, which besides being more elegant than having a power cord trailing about the place, might actually discourage a villain who had actually got in from thinking he can disable the alarm by removing the power.

"The other cables supplies are certainly ample, at least for my needs. However, they are grey — and all the world seems to have white coloured halls nowadays. Still, I suppose one should really be thinking about concealed wiring anyway.

"Installation of the outside siren caused me to reach for the gin bottle and then still baffled — probably more so, if the truth were told — to seek advice from the local ironmonger. The unit is not light, and the 1" screws that came with the kit were not up to my pebble-dashed walls, especially in view of the bad weather we are prone to in my area.

"Another point on this topic — trying to hold a fairly heavy unit in one hand and mark out the drilling holes on the wall with the other, whilst teetering at the top of a ladder in a very chilly eaves — is not fun, even for youngsters without arthritis. It makes life a lot easier if you make a template, in cardboard, from the alarm back-panel, and use this to site the attachment holes.

"To conclude, let me say that the above are comparatively minor quibbles, as I have the alarm successfully installed and running. Perhaps it would be tempting late to say that I am still waiting for its first, real-life test..."
THANDAR 'MINDER' ALARM

To: ETI Burglar Alarm Offer
ASP Ltd
1 Golden Square
London W1R 3AB

Please send me .... 'Minder' burglar alarms at the fully inclusive price of £94.88. I enclose a cheque/postal order* made payable to Argus Specialist Publications for £ .............. p

OR

I wish to pay by Barclaycard/Access* Please charge my account number: ________________________________

Signature ..........................................................................................................................................

Name ...............................................................................................................................................

Address ...........................................................................................................................................

Please allow 28 days for delivery. Offer applies to UK only.
* Please delete as appropriate

ETI JULY 1984
DIGEST

**Teletonic Instruments**

Claim that the new Nikusio oscilloscope is the lowest-priced instrument of its type on sale in the UK. The COS 5100, which was shown for the first time in this country at the All Electronics Show, is a dual beam model with a bandwidth of 100 MHz and will sell for £975 plus VAT.

Features of the instrument include a third auxiliary vertical input and a sensitivity of 5 mV/div at 100 MHz or 1 mV/div at 20 MHz. Also included are sweep delay and alternate sweep capability, trigger with 'autolock', automatic trigger or manual trigger level control, and variable trigger hold-off to handle difficult variable mark space ratio pulse signals.

The COS 5100 has a 6 inch rectangular (8x10cm) flat-face CRT with internal graticule and an accelerating potential of 18 KV. Display modes are CH1, CH2, dual, CH3 or trigger view, and X-Y add and used in dual mode with CH3 and add displayed the COS 5100 will, if put into dual sweep, show 8 traces simultaneously.

The COS 51000 weighs 7.3 kilograms and measures 340x190x450mm. For further details contact Teletonic Instruments Ltd, 2 trigger or manual Castle Hill Terrace, Maidenhead, Berkshire SL6 4JP, tel 0628-73933.

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**TV Protection**

Special 'Burglar Alarm' TV sets will be available in all Radio Rentals showrooms throughout Merseyside for a limited trial period from May to July 1984. Operating on an ultrasonic basis, the alarm device transmits an extremely high pitched and piercing sound when triggered and is capable of alerting anyone and frightening off intruders.

All the householder has to do is switch off the TV and set the alarm which becomes 'armed' as soon as the room is vacated. When movement is detected the alarm is triggered. Even should the mains electricity be disconnected, either deliberately or by power cut, the alarm will continue to sound. The TV incorporates a system for overcoming false alarms which also allows the user to re-enter the room to switch off the device, but they don't seem to want to tell us how it works!

On the basis of the market trial in Merseyside, Radio Rentals will decide whether to launch the sets nationally. The 22" screen size burglar alarm remote control Teletext television can be rented for £16.00 per month or there is a 26" screen size version at £17.00 per month. The rental costs are only a little more than the normal monthly rental for equivalent sets without this facility.

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**Component Minifile**

The Ship Company's Component Minifile is a plastic storage drawer which contains a continuous length of thick polythene folded to provide sixty slim pockets. Each pocket is supported by a plastic strip which spans two runners on either side of the drawer top, and a strip of paper can be inserted into each plastic support to identify the contents of the pocket. The Minifile is designed to store resistors, capacitors and other small components in conditions which allow a particular value to be located quickly and easily.

We have had a minifile on trial for a few months and have used it to store a variety of different items. It is not well suited to any but very small components, but otherwise provides an ideal storage medium. It looks as though it ought to be possible for small items to slip out of the sides of the pockets but in practice this was not a problem. Phil Walker took the Minifile home for a while and let his son use it for his stamp collection, for which it proved ideal except that static sometimes made it difficult to remove the stamps. This would, of course, make it unsuitable for many semiconductors, although it is unlikely to be used for this purpose anyway on grounds of size.

The Minifile costs £11.00 plus VAT and is also available as a multi-drawer unit in a locking, portable cabinet suitable for field use. Suppliers include Watford, TK Electronics and Bradley Marshall.

The Ship Company Ltd, Macroom County Cork, Ireland.

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**Teletonic Instruments**

- ElectroMusic Research have produced a MIDI (Musical Instrument Digital Interface) unit which allows any MIDI compatible instrument to be used with a BBC microcomputer. When used with their MIDItrack program it allows composition on up to six tracks with a memory assignment of 750 notes storing details of pitch, dynamics, note length and style. Full on-screen editing features are provided and completed compositions can be saved on cassette or disk. The interface box, connection cable and MIDITrack on cassette or disk costs £109.95 from Electronic Music Research, 14 Mount Close, Wickford, Essex SS11 8HG, tel 03744 67221.

- Densitron Corporation have produced a short form catalogue which covers their range of LED, LCD, DC. Plasma and electromechanical indicators and display modules. The catalogue also describes their range of light pens and bar code readers and is available from Mr M. J. Monday, Densitron Europe Ltd, 50 London Road, Sevenoaks, Kent TN13 1AS, tel 0732-435 522.

- Lloyds Bowmaker Finance Group have launched an Industrial Achievement Award which offers a first prize of £15,000 to the UK small business judged to be most profitably exploiting new ideas and best placed to continue making a profit. The competition is open to all UK owned companies and unincorporated businesses with an annual turnover between £100,000 and £1,000,000, and entrepreneurial readers should contact The Secretary, Industrial Achievement Award, Lloyds Bowmaker Finance Group, Finance House, Christchurch Road, Bournemouth BH1 3LQ, tel 0202-22077.

- An error appeared in the short item in last month's News Digest concerning South Warwickshire College's electronics summer school. The residential course, entitled Hobby Electronics, will run from 23rd to 27th July, not April as stated. The details are otherwise correct as given, and further information can be obtained from Graham Winton, South Warwickshire College of Further Education, The Willows North, Alcester Road, Stratford-upon-Avon CV37 9QR, tel 0789-66245.

- Serious Software have introduced an interpreter which allows the artificial intelligence language LIStP to be run on a 48K Spectrum. It features colour 'turtle' graphics, LOAD, SAVE and VERIFY functions, user definable functions with a variable number of parameters and the ability to support machine code subroutines. The cassette containing the interpreter and a demonstration program comes with a programmer's manual and costs £5.50 including postage and packing or £2.00 if ordered from overseas. Serious Software, 7 Woodside Road, Bickley Bromley, Kent BR1 2ES.

**Heat Sensing Light**

Semiconductor Supplies International Ltd have introduced a 40 watt security-courtesy light which switches on automatically when it detects infra-red radiation from a heat source such as the human body. The sensing range is 12 metres, the spread 90 degrees, and the unit has an output which can be used to switch other lights or electrical equipment. The unit is adjustable to stay on for between 2½ to 5½ minutes after it ceases to detect infra-red radiation. The output can be used to control other electrical equipment consuming up to 400 watts, for example, other lights round a building, a burglar alarm or halogen security floodlights. These may be selectively switchable.

**Exhibitions, Conferences, Etc**

It's all of three months since we last presented a round-up of forthcoming conferences, exhibitions and other meetings of interest to the electronic fraternity, and the pile of press releases once more looms large before me. Here, then, in something chronologically ordered, are the pick of the bunch.

Electronics for Peace are holding a series of regional conferences this summer in order to allow electronic and computer engineers to meet and discuss the wider social and military implications of their work. The first conference is in Sheffield on Saturday June 2nd (the day after this issue is scheduled to appear, but we know some people manage to get hold of their copy early), the second conference is in Bristol on Saturday June 9th and the final one is in London on Saturday June 16th. Details are available from ELF, 151 Courthouse Road, Maid-enhead, Berkshire SL6 6HY, tel 0892-46354 or 0628-20225 (both numbers evenings only).

The Computer Fair is described as Europe's biggest personal and small business computer exhibition and takes place at Earl's Court in London from the 14th to the 17th June. The exhibition is arranged in two distinct areas, one devoted to home computers and the other to business systems, and the first day has been designated a business/trade only day. Opening hours are from 10.00 am to 6.00 pm on the 14th, 15th and 16th June and 10.00 am to 5.00 pm on the 17th, and further details can be obtained from the Exhibition Manager, The Computer Fair, Reed Exhibitions, Surrey House, 1 Throwley Way, Sutton, Surrey SM1 4QJ, tel 01-643 8040.

The Electronic Organ Constructors Society are holding a TMS 3617 workshop (what that is in London on the 23rd June. Other meetings in London this year include a discussion on amplifiers and speakers on September the 8th and one on PCB manufacture and UV box construction on the 17th November. The EOCs is a non-profit making organisation which exists to promote the design and construction of organs and other electronic music instruments by their enthusiasts. It holds five meetings a year in the London area and others in the provinces and also publishes a magazine five times a year. Details of both the meetings and the society generally are available from Percy Vickery, the Publicity Secretary, 5 Cringle Avenue, Southbourne, Bournemouth, Dorset BH6 4XH, tel 0202-423863.

The Leeds Electronics Show is in its 21st year and takes place at Leeds University from the 3rd to the 5th July. The show includes a full programme of seminars and the organisers claim that the exhibitors will range from large established, market leaders in the industry to small up-and-coming companies. For details contact the Leeds Electronics Show, Evan Steadman Services Ltd, The Hub, Emson Close, Saffron Walden, Essex CB8 1HL, tel 0799-266699.

The What Peripherals? exhibition will be held at the Barbican in London from the 13th to the 16th September and promises to offer visitors the opportunity to compare a wide range of peripherals for their systems. The full-colour magazine and guide which will be issued free to all those attending contains comprehensive details of all peripherals whether the manufacturer is exhibiting or not. Tickets cost £2.00 each including adults and £1.00 for under sixteens and can be purchased in advance from Computer Marketplace (Exhibitions Ltd, 66 Wymering Road, London W5).

Maximum switching voltage is 200V DC, and maximum switching current is 0.5A. The contact rating is 10W. Operating time is typically 6ms after the threshold sensitivity is exceeded, and the duration of contact closure is typically 15-22ms. The sensor measures 38mm x 13mm x 10mm, and its operating temperature range is -35 C to +85 C.

Hamlin Electronics Europe Ltd, Didsbury, Manchester, tel 03779-4411.

**Preset Threshold Shock Sensor**

A new shock sensor based on high-reliability reed-switch technology has been developed by Hamlin. The Model 3818 sensor produces a signal when a preset threshold force of given magnitude and direction is exceeded, and its potential applications include shock sensing and safety-device actuation in the automotive, farm-machinery, machinery and construction industries.

The sensor consists of a magnetic reed switch surrounded by a compression-type coil spring linked to a toroidal ferrite magnet. The mass of the magnet and the spring constant are selected so that the reed switch is actuated at a given acceleration force is applied. The switch assembly is enclosed in a rugged housing which protects the components and is also used for mounting the electrical connections. The standard Model 3818 has a threshold sensitivity of 5g, but other sensitivities are available to customer requirements.

The International Symposium on Electrostatics takes place in Southampton from the 26th to the 28th September, and aims to provide an understanding of the fundamentals of this subject and to discuss the applications and hazards. The symposium is organised jointly by Southampton University and Oyez Scientific and Technical Services Ltd and is aimed at a wide range of specialists including those in the microelectronics, avionic and other industries. For details contact Miss Helen Raquel, Oyez Scientific and Technical Services Ltd, Third Floor, Bath House, 56 Holborn Viaduct, London EC1, tel 01-236 4800.

The World Computer Ergonomics Conference will be held at the Whitbread Conference Centre in London on the 4th and 5th of October and aims to bring managers, users, designers and programmers together to discuss input languages, interactive procedures, VDU health hazards, input devices and work-station ergonomics. The conference is sponsored by Ericsson Information Systems and will be toured to three of the American States and to Stockholm and Helsinki as well as London. For details contact Karen Lee, Exhibition, 72 Fielding Road, Chiswick, London W4, tel 01-995 8536.

ETI July 1984
Piezo Resonators

RBS have introduced into the UK the UN-Quartz range of piezoelectric ceramic resonators which, they claim, offer excellent stability for a wide variety of tuning applications at a fraction of the cost of quartz devices. Using a circular piezoelectric element supported at its central nodal points and operating in the radial resonant node, the resonant frequency is inversely proportional to the diameter. To accommodate a range of resonant frequencies from 185kHz to 500kHz five package sizes are available from 0.430 inches to 0.740 inches. Frequency tolerances of ± 0.2% are standard and the resonator will not drift more than ± 0.2% from the 25°C frequency over the range 0 to +65°C. The resistance at resonant frequency is less than 10 Ohms. These UN-Quartz resonators are said to be ideally suited for tuning high frequency, square wave oscillators in clock and baud rate generators for computers, calculators and digital instruments. In telecommunication dial tone synthesiser and digital pulse dialling they provide an inexpensive sine and square wave control and are cost-effective for frequency control in TV receivers, CRT display terminals and carrier-current systems for remote controls and alarms.

A comprehensive manual describing standard types, specifications and circuit applications is available from RBS Ltd, Unit 4, Airport Trading Estate, Biggin Hill, Westerham, Kent TN16 3BW, Tel Biggin Hill 71011.

Alarms Yourself

The Blade DIY electronic alarm kit comes as a basic kit which can be extended almost indefinitely by means of a wide range of add-on modules. The system can be extended to provide fire as well as theft alarm facilities and the manufacturers claim that it can be installed in your house in a single weekend.

The basic kit includes the control unit, an outside bell, an inside siren, a rechargeable battery, a personal attack button, a standard pressure mat, a stair-type pressure mat, a door window switch, five magnetic door switches, 30m of four-core cable and 100 cable clips. Accessories which can be purchased to extend the system include window foil and connector cards, a breaking glass sound detector, an infrared intruder detector and an external strobe light. Further door switches, pressure mats, etc can also be added to the system and all the accessory packs come complete with instructions. The system uses a key rather than a combination lock for setting and uses the usual entry and exit delay arrangements. The protected area can be divided into two zones so that you can move freely around in one part of the house while unoccupied areas are protected. The circuit is so arranged that cutting any of the wires will sound the alarm, and the bell is timed to sound for 20-30 minutes once triggered before resetting, thus complying with the noise pollution laws. The four-core cable is colour-coded and the main wiring diagram in the instruction is similarly coloured so as to make installation as simple as possible.

The Blade alarm system basic kit costs £143.75 inclusive of VAT and the various accessories range in price from a matter of pence for anti-tamper switches to £54.90 for the infrared intruder detector. Blade Electronic Security, 217 Warbreck Moor, Aintree, Liverpool L9 0HU, Tel 051-523 8440.

Courses

A lot of literature has landed on our news desk in the last month concerning technical courses, mostly computing, aimed at everyone from the well-heeled holiday-maker to the unemployed youngster seeking a career.

The London Computer and Electronics School opened recently in Hammersmith, West London, and offers six and twelve month courses to anyone aged 19 or over who is unemployed and has not been in full-time education in the past two years. The school is funded by the Manpower Services Commission, the Department of Trade and Industry, the London Borough of Hammersmith and Fulham and the BOC group of companies, and will pay its students a wage of around £40 per week according to personal circumstances. The courses on offer are computer programming and computer operation, both of which last six months, and an electronics technician course which lasts twelve months. For details contact Tony Fielden, Director, London Computer and Electronics School, Glenthorne House, Hammersmith Grove, London W6, tel 01-741 9345.

M.A.P.S. Ltd are running three consecutive one week computing holidays for the handicapped, beginning on July 23rd. Four hundred applications were received for the twenty-five places on a one-week course run last year, so the number of places on each of the courses this year has been increased to sixty. The Holidays will be held at Valence School in Westerham, Kent, a boarding school which caters for 110 handicapped pupils during term time and is thus well equipped for the purpose, and the total cost will be £145, although there is a possi-
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<td>AF181</td>
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TI-66 Programmable Calculator

Texas Instruments have announced a new, full specification programmable calculator, the TI-66, which comes in a horizontal computer-like case and provides the college student, engineer and science professional with more than 170 scientific functions, large memory area and user friendly programming features.

The calculator has arithmetic, logarithmic, trigonometric, statistical, and polar to rectangular conversion features. It can accommodate a maximum of 512 program steps or 64 data memories with each memory convertible to 8 program steps. With 9 levels of parenthesis and 6 levels of subroutines it can handle almost any problem. When entering or reviewing a program the TI-66 displays readable alphanumeric abbreviations of the instructions. It uses the same set of instructions as the TI-3/59 family of calculators, and the constant memory feature retains data and program information even when the calculator is turned off. It also connects to TI's PC-200 thermal printer, giving it printing and listing capabilities.

The TI-66 should already be available in the shops and its recommended retail price is £44.99 including VAT.

Low-Voltage Audio Amplifier ICs

Sprague Electric has launched a dual, low-voltage, audio amplifier IC for use as a stereo headphone driver in portable radios, tape players and other battery-operated equipment. The ULN-3783M comes in an 8-pin plastic mini-DIP case and requires few external components, significantly reducing system size, weight and production cost.

Rated for operation up to 12V, it has a voltage gain of 42dB, low noise and excellent channel separation. Operating in class AB, it features a very low quiescent current and will operate with a supply voltage as low as 2.4V at reduced volume without any significant increase in distortion. Other features include an ability to operate over the temperature range +20°C to +85°C, and built-in protection against AC short circuits. The package has a copper alloy leadframe which maximises heat dissipation without the need for an external heat sink.

Also new from Sprague is the ULN-3784B 4-watt audio power amplifier, a 14-pin dual-in-line device designed for consumer, automotive and communications applications. It operates from a single supply voltage between 9 and 32VDC, and when operating from a 24V supply will deliver 4 watts of low-distortion audio into an 8 ohm load. Output power with a 28V supply is typically 4.8 watts into a 16 ohm load. The plastic package has tabs for attaching an inexpensive heat sink to increase power dissipation, and can be used with a standard integrated circuit socket or printed circuit layout.

The ULN-3784B is a direct replacement for the LM380N and the NM384A and, in addition to providing a significantly improved performance, offers a wider margin of protection against supply transients. Performance characteristics include a high input impedance, a fixed internal gain of 34dB, and an ability to operate over the temperature range -20°C to +85°C. Other features include built-in protection against thermal overloads and AC short-circuits, and internal bandwidth limiting which provides a significant degree of immunity to radio frequency interference.

Sprague Electronic (UK) Ltd, Salbrook Road, Salfords, Surrey RH1 5DZ, tel 02934-5666.

PCB Grid Film

Universal Grids are a range of PCB layout films which have a pale, blue grid printed on them. PCB designers can thus tape directly onto the film without using graph paper or a grid sheet as backing, and because the grid is blue it will not show up when the artwork is photographed.

The grid sheets are made from a highly stable, polyester matt film and are available with either metric or imperial rulings and in sizes from A1 to A4. The manufacturers claim that a significant improvement in accuracy can be achieved by working directly onto a grid printed film, and suggest that the sheets will also find wide application in other areas of draughting and design.

A pack of eight A4 Universal Grid sheets costs £5.17, a pack of five A3 sheets costs £6.21, A2 sheets cost £2.84 each and A1 sheets cost £4.00 each. Further details and a list of stockists are available from Universal (Electronics) Grids Ltd, P.O. Box 3, Liskeard, Cornwall, tel 0579-28878.

ETI JULY 1984
ACORN COMPUTER SYSTEMS

ACORN COMPUTER INTERFACE

A full implementation of the IEEE-488 standard, providing computer control of compatible scientific and technical equipment, at a lower price than other systems. Typical applications are in experimental work in research and educational laboratories. The interface can support a network of up to 16 other compatible devices, and would be an invaluable addition to the capabilities of test equipment allowing them to run with the optimum of efficiency. The IEEE 488 System ROM is supplied £92.

ACORN SOFTWARE

BASIC BBC OFFICE

FULL RANGE

MONITORS

MICROCOMPUTERS

EPROM PROGRAMMERS

ACORN SOFTWARE (BBC FULL RANGE)

ALL 16 Bit microcomputers use the Acorn BASIC Compiler Software. This allows the full benefits of the Acorn operating system to be used, so that programs can be written, tested and compiled without leaving the speed of the computer, and transferred to cassette or paper tape.

ACCESSORIES

ACORN HARD DISK SYSTEM

The Acorn Micro System is designed as an Series II compatible hard disk system and a CP/M compatible operating system. It opens up the vast range of CP/M software, with full graphics ability and business applications. The system is supplied complete with the "perfect" kit in a range including: "Perfect Writer", "Perfect Speller", "Perfect Calc" and "Perfect File". Full TORCH gardening is also supplied allowing sophisticated networking between other units. This will allow access to information and communication within 10 or 15 upgraded BBCs.

ACORN EPROM ERASERS

The flashing LED illuminates the erasable EPROM and allows the erasing to be monitored. As the EPROM is reprogrammed, the LED will go on and off. It is a 100% duty cycle eraser and erases all specified EPROMs.

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VERSATILE EPROM EMULATOR

If imitation is the sincerest form of flattery, your EPROMs are going to have a lot to blush about. Design by Mike Bedford.

Microprocessor systems may be divided into two main categories. The first group, which will be familiar to all home computer enthusiasts, is usually referred to as a personal computer and is comparatively highly priced. Such systems contain a large amount of memory, mostly RAM and a wide variety of I/O connected to devices such as keyboards, VDUs, etc., making them very versatile pieces of equipment which may be programmed to carry out an almost infinite variety of different tasks. The second group may be described as minimal microprocessor systems and are used for control applications. Even domestic appliances now include such systems as their cost compares favourably with that of dedicated digital electronics. Such a system is designed to do one specific task and for this reason has less memory than systems in the first group, most of this memory being ROM or EPROM, and the I/O is not designed to interface with normal computer peripherals.

This brings us to the question of how software is developed for such dedicated control systems. To put it simply, this may be carried out on the system itself or on a separate development system. If the control computer itself is to be used it will have to be given some facilities additional to those required to carry out its final task. This is obviously out of the question in the commercial world where the extra cost would be prohibitive. In the amateur world, however, this approach has generally been used, the board having a monitor EPROM and interface to a keypad and LED display.

If software could be developed on a separate computer the availability of editors, assemblers, compilers and hardware such as displays and mass storage devices would simplify the process very much. However, unless special hardware is available, the development cycle will then consist of:—modify software—program EPROM—test on target system—modify software etc. etc. The fact that this process involves programming EPROMs slows it down very much.

This article describes the construction of a piece of hardware which allows software to be developed on a separate computer without having to program EPROMs until the program is perfected. An EPROM emulator is basically a dual port memory card, i.e., a RAM board which may be accessed from either computer. The method of operation is to produce software on the development system and download the object code to the emulator, after which the control computer may access the card as if it were its own memory. To ease interfacing to the target system the emulator is fitted with a length of ribbon cable and a DIL header which may be plugged directly into an EPROM socket.

System Philosophy

The most convenient way to add an EPROM emulator to a home computer is to interface it directly onto the bus so that it may be accessed as memory. However, this is also the most system dependent way of adding the hardware, which means that it will only be usable with one type of computer or, at best, only with computers using one family of processors. This emulator has been designed so that it may be interfaced in quite a number of different ways and the user may pick the method which is most suited to his particular computer.

a) The board has been artworked to the Microtan standard so that users of this computer may plug it directly into the motherboard and access it directly as system memory.

b) Since the TANBUS signals are fairly standard among 6502, 6800 and 6809 systems, owners of other computers using these processors may interface the emulator card onto the bus so long as they sort out the physical aspects of this (i.e., making sure the edge connectors match).

c) For those users with computers utilising different processors (including the large number of Z80 systems) or those with a memory map, which is already full, the emulator may be interfaced via a parallel port. Although this is a very versatile method there are certain disadvantages: a small amount of downloading/uploading software is required on the computer, and 23 bits of parallel I/O are needed for the interface.

d) The most versatile method of all is also the most complicated, and for this reason will be dealt with in a separate article. This is to add some local intelligence in the form of a simple processor board or an RS232 interface to the emulator. The system would then be able to communicate with any computer having a standard RS232 serial interface using standard system routines on that computer. In fact, the universal EPROM programmer card described in the August and September '83 and January '84 issues of ETI may also be added to the system, giving a three card intelligent EPROM programmer/emulator which may be interfaced to virtually any computer and which would provide very comprehensive firmware development facilities.

The card described in this article is even more versatile than the foregoing paragraph would suggest. So far we have only considered the card as an EPROM emulator. The board is, of course, essentially an 8K RAM card and thus may be used as a memory extension without any reference
to emulation. In these days of 16k and 48k computers an extra 8k may not seem a very big leap forward, but the basic Microtan has only 1k of RAM and even if the TANEX card is being used this board would double the amount of available RAM. In addition the emulator contains low power CMOS memory and battery back-up facilities, enabling data to be retained on power down. Even in a system with a full memory map it may be used as external non-volatile memory, accessing it via a PIA.

**Design Process**

This article not only describes the construction of a piece of equipment which readers may assemble for their home computers, it also describes the various options which have been used in the design and how the circuit as it now appears was arrived at.

**Choice Of Ram** We have already noted that an EPROM emulator is essentially a random access memory (RAM) card. The most fundamental design consideration therefore is what type of RAM ICs to use. Since it was felt that the memory on the card should be non-volatile, being backed up by a battery when the computer is switched off, the choice is limited to CMOS static RAMS, all other devices having too high a current consumption to be powered from a battery for very long.

The next question is the total size of the memory to be used, and how this total should be made up in terms of individual chips. The choice is essentially between 2K byte devices and 8K byte devices. The 8K devices have only recently been introduced and as a result are still very expensive. For this reason alone, rather than any technical consideration, these memories were rejected in favour of 2K RAMs. So how many devices should be used on the emulator? Four can easily fit onto an 8" x 4½" card without making it double sided. At least 8 chips could be put on a double sided card, but it was thought that on grounds of economy the board should be made single sided if at all possible. Four ICs will in fact give 8K bytes of memory in total which means that all EPROMs up to and including the 2764 (or 3564) may be emulated. At the moment most amateur computer equipment uses 2716s, 2732s or occasionally 2764s, so this seems quite an adequate solution if, at a later date, a need arises to emulate larger EPROMs, two such boards could be used together with a small amount of additional logic.

The final question, then, is exactly what 2K byte CMOS static RAMs to use. Not all CMOS static RAMs have a low enough standby current for battery backed-up applications, and the choice eventually narrowed to the 6116L or the 5516. The 5516 has a number of advantages over the 6116L, having a standby current of 1.0µA (depending on temperature) compared to 4.0µA typically for the 6116L, and two CE inputs, one specifically intended for a power-down signal, hence simplifying battery backed-up operation. Further, standby mode is only guaranteed on the 6116L if all the inputs are held to within 0.2V of 0V or VCC (except for CE which must be high) which means that 21 pull-up or pull-down resistors are required.

In spite of these considerations, the 6116L was eventually chosen on the grounds of its lower cost. Assuming a 100 mAh capacity battery is used, a data retention time of quite a few thousand hours will still be achieved. The circuit will be slightly more complicated but it was thought that it would be a cost reduction in the region of £10 which was of prime importance. It was also realised that, since 6116Ls have a standard JEDEC pin out, designing the circuit around these devices would mean that users not wanting battery back-up can choose a number of other, less expensive, 2K x 8 RAMs.

**Interfacing The Ram** In order to address 8K bytes of memory, 13 address bits (A0-A12) are required (8192 (8K) = 2^13). Of these 13 bits it is evident that 11 will connect directly to the 6116L devices whilst the remaining two will be required to select which of the four RAM chips to address. This implies an arrangement like that shown in Fig. 1, where the 1½ 74LS139 is a 2 to 4-line decoder, a device which inputs a 2 bit binary value and gives a logic zero at one of the outputs depending on the input value. The eight data bits obviously connect directly to all the RAM chips.

If there was a standard 8K memory card for an 8 bit microprocessor system, the board select signal would take a logic low value for one combination of the remaining address bits (A13-A15) hence locating the board in one of the 8, 8K blocks available within the 64K addressing space. This would ideally require a 3 to 8 line decoder, but since there is already a 74LS139 in the circuit only half of which is used, it seems more appropriate to use the other half and then use A15 or an inverter to select it.

Since this is not a simple 8K RAM card but an EPROM emulator, there is an alternative board select condition, namely, when the EPROM socket is being read. To generate the final board select signal therefore, the two active low signals are ORed. This is shown in Fig. 2. It should be noted that, in the final version, the link arrangement associated with A15 has been slightly changed to avoid the possibility of 2 TTL loads being connected together.
applied to this signal. Note also that an external board enable signal from the edge connector is link selectable. This was added to reduce by 2 the number of PIA lines required when interfacing the card in his way.

So far we have discussed how the 8 data bits and 11 of the address bits connect to the 6116Ls without considering whether these are the EPROM address and data busses or the corresponding host computer signals. Both sets of signals must be connected to the RAMs, but if this is done directly it would short the bus of the host computer to the bus of the target system, a condition which would prevent either system functioning.

The answer is to use buffers, only one of which may be enabled at any one time. It was decided that the buffers to the target system should normally be enabled but whenever the development computer required access to the memory it would take priority, enabling its buffers and disabling those to the target system. Address busses are always uni-directional; as such a 74LS244 buffer may be used. Data busses can be either uni-directional or bi-directional depending on whether there is write access to the memory. The data bus to the host must be bi-directional so a 74LS245 is used, whereas the data bus to the EPROM socket only requires read access and a 74LS244 is sufficient.

During initial testing it was discovered that the target system port occasionally suffered from read errors. This was caused by false CE signals generated in the host during the first half of the processor cycle in which addresses are not valid. Since the duration of such signals is very short, the addition of a capacitor effectively overcomes this problem. Figure 3 illustrates this aspect of the circuit.

One final point on the interfacing of the RAMs to the address and data busses. You might expect A0 on the host and target systems to be connected to A0 on the RAMs, A1 to A1, etc. This is not the case in this circuit. From an electronic point of view there is no reason why it should not have been interfaced this way, and if it were not for the fact that the author also produced the PCB artwork, this is the way the circuit would have been designed.

It was designed in the manner presented so as to simplify the artwork and keep the number of wire links down to a minimum. This might seem a strange decision to make but as far as the outside world is concerned, the address pin labelling on the RAM chips is quite arbitrary. It makes no difference what order they are connected in — each address bit combination still addresses a unique location within the IC. A similar argument may be applied to the data pins on the ICs. It should be noted that this method should not be used when interfacing EPROMs as these will have been programmed assuming the correct signal order and hence compatibility must be maintained.

Fig. 3 The use of buffers to prevent the host and target systems being simultaneously connected to the RAM chips.

Fig. 4 a & b Generation of the OE and R/W signals.

**RAM Control Signals:** We have already dealt with A0-A10, D0-D7 and CE on the 6116Ls; this leaves the OE and R/W still to be connected. These signals are equivalent to the Intel NRDS and NWDS respectively and Fig. 4a shows the standard method of generating them from 6502 signals. Since the EPROM port of this card has no write access to the RAM, the generated NWDS does not require ORing with a similar signal associated with the EPROM port. However, when the RAM is enabled by a read from the EPROM port but a R/W is generated by a write to some other memory on the host system, the signal must be gated with HOST SELECT in order to prevent a false write. The OE, on the other hand, does require ORing with a corresponding signal on the target system.

The additional two gates required are shown in Fig. 4b which extends Fig. 4a. It should be noted that OE and R/W can both be active when a write to the card is being carried out from the host system and the target system is attempting a read. This is not a problem since the data sheet for the 6116L makes it clear that, under these circumstances, the write takes priority over the read. This is perfectly acceptable since the host is to have priority over the target port.

**Supply And Power-Down Circuitry:** To ensure that there is data retention when the main computer supply is switched off a battery supply is required. Since the 6116L only requires 2.0V in its standby mode,
the readily available PCB mounting 3.6V 100mAh battery is a perfect choice. Figure 5a shows a circuit in which the battery is trickle charged via the current limiting resistor when the main supply is present, supplies current to the RAMs via the diode when the main supply is not present, and is prevented from discharging through the power supply under these conditions by the transistor which will be turned off. The resistor value is selected to give a charging current of 1.0mA (the current stated for this battery in the data sheet). From Ohm’s Law, this will be V/I where I is this charging current and V is the potential difference between the battery and the main supply (5V-3.6V) or in other words 1.5k ohms. Although there will be a potential drop of typically 0.7V across the diode, there will still be 3.6V-0.7V=2.9V available to the RAMs, which is within the specification for these devices.

It now remains to decide how to generate the power available signal. For the purposes of supply isolation the requirements are not too stringent — all that is required is for it to go sufficiently high to turn on the transistor when the supply voltage is higher than the battery voltage. There is another use for this signal however, to write protect the memory on power down. Since the major part of any computer system is made up of TTL devices and these are only guaranteed to function correctly at supply voltages of 4.5V and above, it is quite feasible that random signals on the bus will cause un-intentional writes to take place on power-down, hence corrupting the data in the RAM.

Considerable time was spent to find some way of accurately detecting a voltage level of about 4.75V to generate the supply available signal, but any such method would involve the constructor in some quite precise setting up which would obviously be undesirable. The method eventually used does not require any setting up, and although it does not succeed in accurately detecting 4.75V experiment shows that it works. The level detector is simply a potential divider and transistor so arranged that, when the supply voltage is greater than about 4.2V, a potential of greater than 0.7V is present at the transistor base which turns it on and hence gives a logic low signal. This arrangement is shown in Fig. 5b. If an attempt is made to detect something much closer to 4.75V, the transistor tolerances might cause the transistor not to turn fully on at 5.0V.

The need for write protection of the RAMs has already been mentioned. This is done by gating the four chip enable (CE) signals in Fig. 1 with the supply available signal in such a way that they can’t go low when the power isn’t present. Obviously, the gates used need to be active even when the main supply is not present, so they must consume little power and work on a low supply voltage. This demands a CMOS device. Figure 6 shows this gating arrangement which is used to modify the circuit given in Fig. 2.

If the circuit portions illustrated in Figs 1-6 are connected together the result will be the complete circuit diagram shown in Fig. 7. There will be a few changes from the circuits already given due to the following—

1) A few extra gates have been added as buffers to ensure that no more than 1 TTL load is presented to any bussed signal.
2) To minimise the number of IC packages required, two gates have sometimes been used to replace a single gate of a different type. For example, an AND gate followed by an inverter has been used as a NAND gate in two places.
3) Gates have sometimes been drawn in negative logic notation to clarify their function. In the final circuit diagram, however, these have been translated to their more conventional forms.
4) The 6116L RAMs are only in their low power standby mode when all their inputs are within 0.2V of either 0V or VCC. The resistors in the 8L packages, ie R1, R2 and R3, have been added to ensure this.
5) In accordance with normal digital practice, a number of decoupling and reservoir capacitors have been connected across the supplies.

6) Since a number of less expensive but higher powered RAMs are pin compatible with the 6116L devices, and since not all users would require all four RAMs to be non-volatile, links have been added to allow the user to select either the main supply or the battery supply to each of the RAMs.

Next month: Construction and use

HOW IT WORKS

Since a lengthy description of the design process has already been given, this section simply presents a simplified picture of the circuit, outlining which components are associated with each particular task.

The memory is made up of four 2K x 8 RAMs, these being IC8, IC9, IC10 and IC11. The RAMs are connected to internal data and address buses which are isolated from the host and target system busses by various tri-state buffers. IC5 buffers the host data bus, IC12 and IC14 the host address bus, IC6 the target data bus and IC13 and IC15 the target address bus. The circuitry comprising IC1 and IC2d controls the buffer enabling and ensures that both sets cannot be enabled at the same time and that the host takes priority. IC1 and most of the remainder of IC1 and IC2 are associated with generating the RAM CE, OE and V/ W signals by a combination of control signals from both ports. The RAM CE is split into four separate signals for the four RAMs by IC3b, and IC14 ensures that these signals can’t be active under power-down conditions. This circuitry requires a signal indicating that the appropriate portion of the host memory map has been addressed, and this signal is generated by IC5a, IC1d, IC1k and IC2k. The remainder of the circuit is associated with the battery supply and power-down circuitry.

**Fig. 6** A modification to the circuit shown in Fig. 2 which provides write protection for the RAMs on power-down.
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COMMUNICATIONS
SATELLITES(PART 1)

Just by picking up the 'phone and dialling a number, you could put yourself in the space age. In this short series of articles, Roger Bond will be looking at the real world of satellite communications.

Any space enthusiast will tell you about Telstar and any school boy will tell you of the killer breed of satellites pranging each other on the big screen. In between these two extremes is the reality of modern satellite communications.

In 1962, Telstar was the first, in circular orbit around the earth and at a height of about 250 miles. So it was visible for only about half an hour from any given earth station, and Goonhilly's first aerial weighing 1100 tons had to be quite a smooth operator in order to track this fast-moving busyboby.

In June 1965 Early Bird (INTELSAT I) went into geostationary orbit over the Atlantic. INTELSAT stands for International TELEcommunications Satellite and a geostationary orbit is an orbit stationary with respect to a point on the earth, i.e. the satellite is moving with the earth's rotation and so staying in the same position with respect to the earth's surface.

Two other satellites took up station over the Pacific and Indian Oceans in 1967 and 1969 respectively and earthlings were fully covered by eyes in the sky. These three satellites formed the INTELSAT I network working to Andover (USA), Kaisting (Germany), Goonhilly (UK) and Pleumeur Bodou (France). These satellites provided 240 circuits but could work to only one ground station at a time. INTELSAT II removed this limitation. The signal strength from these satellites was so low that receiving equipment had to be cooled in liquid helium (-268.8 °C) to suppress background noise. Receiving signals from these satellites was like trying to pick up heat from a one kilowatt electric heater stationed as far away as the moon.

In 1968 Aerial 1 at Goonhilly was joined by a second and in 1972 by a third aerial. Aerials are located in the south of England because the further south the antenna is, the less ground-generated interference it will 'see'; the further north the aerial, the closer to the horizon the satellite gets, until it vanishes from sight.

INTELSAT III was launched in 1968 and could provide 1500 circuits or 4 television channels or a combination of the two. Compare this with INTELSAT II which had to suppress its 240 circuits in order to transmit television. The design life was also increased from three years to five years. Today's satellites are designed for a life of seven years and an estimate of seven out of eight successful launches. A commercial satellite cost about £10 million to build and about £13 million to launch in 1977 so the insurance premiums are quite high. By comparison, aerial three at Goonhilly cost £2 million. Today a satellite costs about £50 million to build and launch.

In 1977 INTELSAT IV was launched with a life of seven years but in this short space of time the demand had increased so much and technology had advanced so rapidly that the IVA was launched in 1978 followed by today's INTELSAT V in 1980. The main difference between the IV and IVA apart from an increase of circuit capacity (4000 to 6000), was assignment by demand, SPADE, on the IVA — but more about that later.

Modern Satellites

To understand the trend and thinking towards modern satellite communications we need to start with INTELSAT I to IV. Intelsat I like all modern satellites is positioned 36,000 km above the earth and produces a 0.5 sec delay in a two way conversation. That is the time it takes for radio waves travelling at the speed of light to 'bounce' off the satellite. These signals are transmitted upwards at a frequency of 6 GHz and down at 4 GHz, so inside the satellite is a transponder which is a receiver, a frequency changer and a transmitter.

In fact there are twelve transponders each with a

Figs 1-4 The changing face of satellites: (from left to right) INTELSAT I, II, III, IV. Shown at the top of the page is Telstar (photo by courtesy British Telecom).
bandwidth of 36 MHz and a guard band of 4 MHz between transponders. Therefore the total satellite bandwidth is about 500 MHz. There are two types of aerials:
a) The global beam, which is a horn type and radiates a beam of 17° width;
b) The spot beam, which is a paraboloid dish radiates a much narrower beam, only 4.5° in width, which covers a smaller area on the earth. The effective power is 35 dBW (that is, to the receiver on earth, the signal is 35 dB up on what would be radiated by a dipole aerial radiating 1 watt of RF power); by comparison, the effective power of the global beam is 23 dBW.

The spot beams, with their focussing, are used for high-density traffic, from one point and another, eg USA to UK. The global beams, being unfocussed, carry signals of interest to many countries; so one small user-country can communicate with another by extracting at the earth station the carrier that is of particular interest to it and rejecting all the other carriers; this facility is used mainly for television.

Compared to INTELSAT III, INTELSAT IV has a smaller bandwidth for the same channel capacity and this is achieved by reducing the frequency deviation of the FM (Frequency Modulated) carriers. The guard band is 10% to 20% of the occupied bandwidth for IV compared to 60% to 90% for III. The FM carriers can cope with 24 channels up to 960 channels depending on the carrier chosen. These channels are 4 kHz audio channels which may be used to carry data or speech.

**INTELSAT IV Earth Segment**

Engineers use the jargon ‘space segment’ for the earth station. Usually restrictions on the launch rocket payload limit the size of aerials that the satellite can carry and the power available to feed those aerials. Hence the burden of picking up weak signals from satellites and radiating strong signals back becomes the responsibility of the earth segment.

To keep the earth station costs down, the number of different sizes of carrier frequency is restricted to nine. The carrier to noise ratio is about 10 dB so expensive threshold demodulators, also used in INTELSAT III, are still needed.

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![Fig. 5 The insides of INTELSAT IV.](image)

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Fig. 6 A travelling wave tube.

One kind of threshold demodulator is the frequency modulated feedback type, in which a fraction of the output signal from the demodulator is fed back to a voltage controlled oscillator which is controlled by a phase comparator. This helps to reduce the deviation of the centre frequency to zero, and the accurate centring of the signal gives an improvement of the carrier-to-noise ratio.

We shall look at the transmit and receive directions of the earth segment separately but they do have certain aspects in common. For instance, they both use travelling wave amplifiers.

One kind of travelling wave tube (TWT) is the helix type (Fig. 6), in which a spiral coil of wire is used to propagate the signal. The pitch of the spiral turns determines the speed of signal propagation. A magnetic field parallel to the axis of the tube prevents spreading of the electron beam. Reflection at the output could cause oscillations and an absorber is used to prevent this.

The other thing that they have in common is that they both use an IF of 70 MHz, although transmit and receive frequencies are different, these being 6 GHz and 4 GHz respectively.

**Transmit Direction**

The intermediate frequency is 70 MHz which is converted to 6 GHz. There are two stages of power amplification using travelling wave tubes. The first TWT gives 39 dB gain over its 500 MHz bandwidth and the second TWT gives about 30 dB gain. For a single carrier the power of the transponder can be concentrated; for several carriers the power must be distributed. If multiple carriers are used with, say, an output of 1 kW each, the minimum gain will be 30 dB and, because of the manner in which TWTs operate, this will be at the top of the spectrum. The maximum permissible variation is 10 dB over the 500 MHz satellite band.

Supergroups, which are blocks of twelve channels each 4 kHz wide, are reassembled at the earth station depending on their destinations. The supergroups occupy the bandwidth 60 kHz to 108 kHz. Groups on landlines occupy the bandwidth 60-108 kHz = 48 kHz and it is possible to fit another group in the spectrum space below 60 kHz, starting at 12 kHz ie 60-12 = 48 kHz.

A 60 kHz pilot is inserted at the earth station and failure of this pilot will cause changeover to standby equipment at the earth station. The sub-baseband 4 to 12 kHz is used in 4 kHz lots for engineering services. Each 4 kHz has a speech channel in the range 300-2600 Hz and the rest of the 4 kHz slot is used by five telegraph channels.

The portion below 4 kHz is used for energy disposal. A symmetrical triangular waveform is applied to the modulator during light traffic periods to spread the energy across the spectrum and prevent peaks of high energy.

Low capacity equipment will have less standby than...
high capacity equipment. For instance, for 24-channel telephony, there is one standby of equipment for every five in use. For high capacity carriers, say 900 channels between the UK and USA, the RF equipment that is usually duplicated is demodulators, baseband equipment ie equipment which assembles groups of channels, and double down converters which are explained in the next section.

**Receive Path**

Figure 8 shows the receive path of earth station equipment illustrating double down conversion. The first IF is at 770 MHz and the second at 70 MHz. But before it gets to this stage it passes through three stages of parametric amplifiers, cooled to a temperature of 16 K. These amplify a weak signal of typically 120 dBW by 30 dB. The signal then passes through a travelling wave amplifier which supplies another 40 dB amplification over the whole 500 MHz bandwidth. We can now develop the picture in Fig. 8 to that in Fig. 9.

There is a choice of power amplifiers. Travelling wave tubes are more flexible but the multi-cavity klystron is more efficient. The TWT needs to work about 10 dB below full power to avoid intermodulation distortion. On the other hand the klystron needs time for tuning up and there can be long breaks if a frequency change is required.

Threshold extension demodulators lower the threshold of the impulsive noise. This threshold is the point at which the signal-to-noise ratio becomes unacceptable and too much information is lost. The semiconductors used have specially doped junctions with reach-through effects which enables low power signals to be regenerated.

With the present state of art of transistor technology, a total noise figure of 10,000pW has been chosen as a design limit for a satellite link. Any signal greater than this can be detected, any signal below this figure is lost. All the time designers are developing new methods of reducing noise in equipment enabling the detection of weaker signals.

Most of the noise comes from the aerial itself and its feeding network. If we take G as the gain of the aerial and T as the temperature in degrees absolute then G/T gives a rough rule of thumb relating aerial gain to temperature in order to detect a signal in the presence of noise. We can see that increasing the value of G gives an improved figure hence the large diameter aerials at earth stations. We can also improve this figure of merit by reducing T which is why the equipment is cooled reducing thermal agitation and hence reducing the noise contribution from thermal noise.

Earlier we mentioned the need to limit the number of different carriers to nine. However by 1975 these had increased to twenty and the early frequency splitters used circulators but now stripline couplers giving two outlets each are available. A circulator is a waveguide with a ferrite rod at the axis of the waveguide and if an external magnetic field is applied to rotate the wave then a wave perpendicular to port one will exit at port three, a wave perpendicular to port 2 will exit at port 4 and so on.

A stripline is a metallic conductor embedded in dielectric. It's all part of the move away from the bulkiness of waveguide 'plumbing' and towards the compactness of semiconductor-like devices and integrated circuits if possible. Because of the large power outputs already available, the manufacturers of microwave devices have been slow to take advantage of developments in integrated circuits.

**SPADE**

Time is big money on a satellite link so what better way to use it than to assign speech slots only when demanded? This of course makes it expensive for the earth station which needs to have computer controlled equipment. SPADE stands for Single channel per carrier, Pulse code modulation, multiple Access, Demand assignment Equipment.

The 12 transponders of Intelsat IV each had a bandwidth of 36 MHz and carriers (when modulated) with bandwidths of 2.5 MHz, 5 MHz, 7.5 MHz, 10 MHz, 15 MHz, 20 MHz, 25 MHz and 35 MHz. These could carry speech channels from 24 up to 960. For instance, if a carrier with a 35 MHz bandwidth is chosen, the transponder's 36 MHz is taken up. Alternately for fewer channels a combination of the smaller bandwidths can be chosen. This can be wasteful if a country wants 35 channels. The carrier giving 2.5 MHz bandwidth and carrying 24 channels is not sufficient so a carrier with a 5 MHz bandwidth with a 60 channel capacity is allocated. But with only 35 channels used, the rest is wasted. In any case these channels are active for only a few hours each day because of for instance time differences between the two countries involved.

In addition, only one half of a circuit is working at any given time since usually one party speaks while the other listens. Taking all this into account there is only 40% activity during a conversation and a channel unit on the SPADE system transmits a carrier only when speech is present (i.e. the power is turned off when not needed). This must not be confused with TASI (time assigned speed interpolation) which is used mainly on submarine cables (in TASI, the channel is re-assigned to another talker when the user ceases speaking). A transponder can support the power requirement of 400 channels but with 40% activity this can be doubled to 800 channels since the channel unit conserves satellite power. SPADE was used to a more limited extent on Intelsat IV, but fully implemented on Intelsat IV A, whose profile is shown in Fig. 10 and in 1974 twenty earth stations started SPADE operations.

One 36 MHz transponder is divided into 800 channels each 45 KHz wide, ie. a 4 KHz audio channel when frequency modulated, occupies 45 KHz. Eight hundred channels equals 400 circuits since two channels are required for two-way conversation.

The king-pin of SPADE is the demand assignment
signalling and switching unit (DASS) which controls the setting up of calls with up to 49 terminals at other earth stations. Communication between earth stations is over common signalling channels (CSC). These are shared by all stations on a time basis as follows.

As signalling information is extracted at the terrestrial interface unit (TIU) Fig. 11, converted to digital form and transmitted over the 128kbit/s CSC link. One earth station must act as control and transmit a reference burst with its own data burst and the burst of all other stations synchronised to this on a TDMA (time division multiplex assignment) basis i.e., in a given time frame, every station transmits a little information in its given time window. In the receive path, the TIU converts digital signalling back to analogue since the terrestrial networks use analogue signalling mainly.

When a request is made for a call, the DASS unit selects a pair of frequencies from its bank and informs the distant station via the CSC of the chosen frequencies. Then all DASS units immediately update their channel records.

When the call is finished the DASS unit releases the circuit and returns the carriers to its bank. DASS units can be programmed to record the duration of calls for charging purposes and any failures for engineering purposes. It is quite remarkable, the amount of work that computers could handle as long ago as ten years!

The 4kHz analogue channels are converted to digital and transmitted at 64kbit/s. This can easily handle data at 1200 bit/s, 2400 bit/s and 4800 bit/s which are the normal data rates over a 4kHz audio channel when used for data transmission.

**Calling All Shipping**

Around 1974, when SPADE stated operations, the need was felt for a satellite service to ships, mainly because the MF and HF radio service was starting to get congested. Moreover, radio is subject to fading for hours, even days.

Transmission started in the L band at 1.5 GHz from satellite to ship and at 1.6 GHz from ship to satellite. A bandwidth of 7.5 MHz was allocated and in the Atlantic region 80 channels would be required by 1990. At 50 kHz bandwidth per channel, a MHz out of the allocated 7.5 MHz would be used and 7000 ships were expected to use this service.

In 1978 the USA launched MARISAT (MARitime SATellite) and Europe MAROTS (MARitime Orbital Test Satellite). MARISAT operated at 6/4GHz (C band) between satellite and coast station and MAROTS at 14/11 GHz. These were experimental satellites. MARISAT changed to INMARSAT in 1982 and this stands for International MARitime SATellites. MARISAT is now MARECS, MARitime European Communications Satellite. All very confusing!

Initially satellites will be power limited rather than bandwidth limited but future satellites will have high speed data at 9.6 Kbit/s for facsimile (transmission of still pictures like weather maps, newspapers etc.), ship operating information, navigation, rescue and fleet messages.

Operation is by means of SCPC (Single Channel Per Carrier) similar to SPADE. Two methods of modulation are available, narrowband FM or phase-shift keying. The former gives a better carrier-to-noise ratio.

So messages are passed in two stages, from coast station to satellite then from satellite to ship at a different frequency. Because of the call-charging limitations of countries, shore to ship calls are semi-automatic but fully automatic for ship to shore.

We've seen earlier how it was the responsibility of the earth segment to provide signals of sufficient strength for transmission as well as detect weak signals in the receive path. However a ship's aerial is limited by space so is up to the satellite to provide sufficient power. A gain/noise temperature (G/T) of 4dB/K at the ship's aerial is typical.

The other thing that is typical of a ship is a roll of up to 30° and pitching up to 10° so the aerial must be stabilised with a gyro scope to provide an aerial pointing of ±1°.

To find the satellite, step tracking is used. The aerial is moved slightly, then the voltage fed back from the demodulator is used to decide whether the received signal from the satellite has increased or decreased. If the signal has decreased, the aerial is turned in the opposite direction but if the signal has increased, the aerial is turned another small step in the same direction.

The aerial locates the satellite accurately by acting in azimuth and elevation in turn.

The UK is the third largest shareholder in INMARSAT and there is a pair of satellites over each of the Atlantic, Pacific and Indian Oceans. One satellite of each pair is in service and the other in spare. Actually, "Satellite" is not quite accurate. INMARSAT does not have its own satellites but leases transponders off Intelsat.

Because of power limitations, only 40 of the 286 carriers can be transmitted simultaneously. In future INMARSAT may launch its own satellites capable of transmitting 125 carriers simultaneously and the possibility of aeronautical communication is being explored.

Aerials at Goonhilly serve the maritime community with a 14m diameter aerial and 3KW transmitter. It transmits in the C band, (6/4 GHz) to a satellite in the Atlantic Ocean Region.

Since there is more than one coast earth station (CES) in each ocean region there is a need for a network co-ordination centre in each region. There are at Charleston (USA) for the Atlantic Region, Iberaki (Japan) for the Pacific Ocean and Yamaguchi (Japan) for the Indian Ocean. INMARSAT headquarters are in London.

**Fig. 10 INTELSAT IVA.**

**Fig. 11 A SPADE terminal.**

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Size of Heat Sink Range:

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<tr>
<td>HS210</td>
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34
THE WARLOCK BURGLAR ALARM

"Save a joule — Lose a jewel — What a fool; Spend a joule — Save a jewel — That's cool!" Phil Walker, of whose poetry, John Betjeman is reputed to have said "It's enough to make a banana blush", can at least design a good burglar alarm.

This project has been designed to give considerable flexibility while keeping the cost down. It can be used with either two-wire or four-wire systems and will give anti-tamper protection to the wiring if required. The unit also provides suitable connections for use with a self-protecting audible alarm which we hope to publish soon.

The unit as described caters for up to four pairs of alarm loop circuits containing normally closed switches or can simultaneously deal with normally open switches if necessary. Each pair of alarm loops consists of one loop at ground potential and one loop at about +12V. Breaking either loop or shorting one to the other will trigger the alarm. One pair of loops is designed to be used as the anti-tamper circuit and can be left operative while the rest of the system is disabled. Another loop pair is fitted with a circuit which allows restricted exit and entry and a time delay (from 8 to 90 secs) so that an authorised person can leave and re-enter the premises without setting off the main alarm.

It should be possible to use this project with most types of active and passive alarm sensors although some of the active ones will need external power.

The Circuit
This project is designed to monitor up to eight alarm loop circuits. These loops are connected in pairs with one circuit at ground potential and the other at supply potential. Two pairs are simple loop sensors which respond immediately if either loop is disconnected or one is shorted to the other. The third pair is connected to the exit/entry delay system and allows a timed exit period and timed entry period before setting off the alarm. The last pair are very similar to the simple loop sensors with the exception that they can remain active when the rest of the circuit is inhibited.

The loop sensing circuitry for all the loop pairs is identical and very simple in operation. The same current flows through both loops of a pair and is determined by a single resistor. If either loop is broken then the current will divert into one of the input transistors which will then cause an alarm condition to be flagged. Shorting the two loops together causes a similar condition at the output as it robs the sensor circuit of its power supply.

The alarm latch and condition indicating circuitry is also virtually identical for each loop pair. It has been designed so that while the pair is inhibited by its own switch the LED is off. When a loop pair is enabled but the alarm module is disabled by the key the LED will be on and steady while the loops are in a safe condition and will flash if the loops are in an unsafe condition. At this stage no alarm will be scored and the cause should be rectified before enabling the alarm. Once the unit has been enabled an alarm signal arrives at one of the three non-delay loop pairs the latch will be set and an alarm condition will be sent to the output circuit to activate the audible warning device(s). Also the LED for that pair will flash. Note that the state of the loops will have no further effect on the alarm latch.

The operation of the delay loop pair is a little different. The alarm condition from the loop sensor circuit sets a latch which in turn starts a counter which counts 8192 pul-
HOW IT WORKS

This project can be considered in five parts. These are:

a) the input loop sensors
b) entry and exit delay circuit
c) alarm latch and condition indicators
da) alarm trigger, local sounder and remote relay switch
e) power supply

The first section consists of four identical circuits each of which provides two loops. One loop operates on 0V potential while the other operates at close to the supply rail. The current flowing through each loop is determined by R1 in the first circuit and similarly in the others. If both loops are complete, this current will flow through the external via D1 and D2 and both Q1 and Q2 will be in the off state. Thus the collector of Q2 will be in the high state.

If the upper loop is broken, the current through R1 will now flow through D9 and the base of Q1. Q1 will now conduct and allow current to flow down R2 into the base of Q2. This transistor will now conduct and pull its collector low to signal an alarm condition.

If, on the other hand, the lower loop is broken, the current through R1 will now flow via D10 into the base of Q2 and thus turn it on giving the same alarm condition.

Finally, if the two loops are shorted together by some agency the supply voltage will be dropped across R13 while the collector of Q2 will again go low to signal an alarm.

This should provide a good measure of protection against most tampering with the wiring.

The second section of the project is the entry and exit delay. This is a fairly complex as it performs several functions. The input from the line sensor circuit first enters IC1a where it is gated with the reset signal from IC2a and a time-out signal from IC3.

If the reset signal is active (output of IC2a high) there is no further action required. Also the outputs of IC1a and the speaker enabled lower causing IC3a output to remain high. This causes IC3 to be reset. The high output from IC2a resets and holds IC4a and b.

If, however, the reset signal is inactive, the alarm input going low causes the output of IC2a to go high. This forces the latch formed by IC1b and IC2c to change state with IC1b output going low. This removes the high on the output to IC3 which will start to count the pulses coming from the oscillator IC2b. IC3 is a 14-stage divider which increments each input pulse. The output from the 6th stage controls the audio frequency oscillator IC2c which generates a blep sound from the piezo-electric speaker. X1. The output from the 14th stage clocks IC4a and b when it goes high and simultaneously resets IC3 via the sections of IC1. If IC4a is clocked its Q output goes high and its Q output goes low. If the counting period of IC3 the alarm input has gone high then the output of IC5a at the time of clocking IC4b will be low otherwise it will be high. The current state of IC5a is clocked into IC4b at the end of the counting period and if is low no alarm is given. If it is high then the alarm is sounded.

After the first such sequence in which the alarm is not activated, if the alarm input signal goes active again, a similar sequence is followed with the exception that the output of IC5a is held high by the Q output of IC4a being low. At the end of the count period the alarm will be sounded whatever the state of the sensor signal.

The circuit around IC5b, c and d are present to cause either LED5 or LED6 to flash at the alarm end time to indicate that exit or entry time delay is active.

ALARM LATCH, ETC

The circuit around IC6 forms a status indicator for the alarm sensor signal. In the first timing period, the latch formed by IC6a and IC6b is disabled by the low on IC4a Q output. If an alarm condition is detected by the loop sensor circuit then the output of IC4a will go high but will not latch. This will allow a low frequency flash signal from IC2b to drive IC6a and hence LED1. In the second timing period the latch will be enabled and an alarm condition occurs, it will stay with the flash signal enabled.

The alarm signal from this part of the circuit is taken from the Q output of IC4b and goes low to signal an alarm condition.

The circuit around SW1 and D17 allows the whole channel to be disabled/detected. This causes the LED1 to be turned off whereas a normal low on the reset line via R25 will cause the rest of the circuit to reset and LED1 will be on if the alarm sensor is not active and flashing if it is.

The circuits for the other latch and condition indicators are virtually identical with the exception that the input to the NAND latch goes directly to the reset line via its resistor in these channels the alarm signal is taken from the NAND latch as an immediate result is required. The reset circuit for channel 4 is slightly modified such that it can remain active when the other channels are turned off.

ALARM TRIGGER ETC

The outputs from all the latches are collected into a NAND gate IC10a so that any one which goes low will cause the output to go high. This is then gated with the reset signal such that both must be high before the alarm is sounded. The output of this gate, IC10b, is normally high and iseps Q9 conducting. If it goes low, RLA1 is deenergised and the main alarm sounds. This mode of operation ensures that cutting off the power supply will sound the alarm.

Also if either IC10b output goes low or channel 4 latched output goes low, Q10 is switched on and the buzzer X2 sounds. This is to allow tamper-
ing to be detected without setting off the main alarm.

POWER SUPPLY
This part of the circuit uses a standard bridge rectifier and capacitor arrangement but the regulator system is a little unusual. The circuit uses an LM317 regulator with its reference terminal connected to a 12V battery. This means that the output voltage will be about 1.2 volts above the battery voltage. While AC power is applied the battery is charged via R46 and the main circuit is supplied via D27 at about 12.5V. If the power fails the circuitry will be powered from the battery via D28 ensuring that the alarm circuit is always powered.

Fig. 1 Circuit diagram

ses from an oscillator, whose frequency (and hence the delay time) is controlled by the variable resistor RV1.

When the count is complete, the state of the loop sensor is tested. If it is still in the alarm condition the output from the circuit activates the output stage immediately. If, however, the loop sensor circuit is non-active — ie the door is shut — the alarm is not given and the circuit goes into its second stage.

During the first stage (normally while you are leaving the property) the green LED will flash while the timer is operating and the red LED will flash while the door is open. If, once the first stage of operation is complete, the loop sensor circuit becomes active again, the counter circuit will start again but this time the alarm will sound at the end of the time period whatever the state of the loop sensor unless the alarm is disabled with the proper key.

During this stage the orange LED and the red LED will flash. During both timing stages a bleep will
Fig. 2 Overlay diagram

### PARTS LIST

- **RESISTORS** (1/4W 5% carbon film)
  - R1-20, 25, 45-48: 47K
  - R21-24, 35-6, 3: 10K
  - R26, 49-52: 10K
  - R27, 28: 1MΩ
  - R29, 30: 47K
  - R31-34: 100K
  - R5: 680K
  - R9: 100K

- **CAPACITORS** (100 volt PCB mounting polyester unless stated)
  - C2, 2, 12, 13, 15, 30, 47K
  - C4: 100K
  - C5, 6, 7, 8, 10: 1µF 25V electrolytic
  - C7, 8, 9: 10µF Tantal. bead or min. at 25V

- **SEMICONDUCTORS**
  - IC1: 4025
  - IC2: 4093
  - IC3: 4020
  - IC4: 4013
  - IC5, 6, 7, 8: 4011
  - IC10: 4012
  - IC11: LM317K
  - Q1, 3, 5-7, 10: BC122L
  - Q2, 4, 6: BC182L
  - Q3: NE418 or similar
  - D2, 23, 24, 25, 26, 27, 28, 29: U4002
  - BR9: 2N4402
  - BR1: 2N5402

- **MICROCHIPS**
  - IC11: 4012

- **MISCELLANEOUS**
  - LED1, 2, 3, 4: 0.2 inch red LED
  - LED5: 0.2 inch yellow LED
  - LED6: 0.2 inch green LED
  - X2: PB272F piezo sounder
  - X1: 12V PCB mounting buzzer
  - RL1: 12V relay 2 pole changeover 5A (Maplin XV98B or similar)
  - SK1, 2, 3, 4, 5, 6, 7, 8: 4 way PCB mount screw terminals
  - F5: 2A 20mA fuse + PCB holder
  - F6: 1A 20mA fuse + PCB holder
  - BI: 12V 280mA-HR Ni-Cd battery (or 2x6V)
  - T1: 12V 20VA transformer in box with suitable fuse
  - PCB: large die-cast box: small microswitch with NO contact (ie contact closes when switch operated); heatsink for IC11 (see Fig. 3); TO3 mounting kit and thermal grease; spring clips for batteries; solder tag: wire: solder, etc.

The reset circuitry is arranged around a three-way keyswitch. In one position all the unit is switched off. This is to allow you to do maintenance or add extra sensors. In the second position most of the unit is disabled with the exception of the loop pair used for the anti-tamper circuits. This is the normal "off" position which allows full access to the premises but sounds an internal alarm if the wiring or alarm unit is molested; for this facility we have assumed that there will be someone nearby who can investigate. In the last position the unit is fully active and ready to go. Any alarm conditions will be dealt with as appropriate.

All the alarm outputs from the sensor and latch circuits are gathered into a gate circuit which also uses the state of the reset line as an inhibit. The output from this drives a power relay via a transistor such that the relay is de-energised when an alarm occurs. This prevents someone just cutting the sound so that you are aware that something will happen soon if you take no action.
wires to stop the alarm. The output from the gate circuit also drives an internal buzzer which also serves as the alarm for the anti-tamper loops.

Power for the whole unit is normally supplied from a 12V AC external supply which is rectified and smoothed. This is then roughly regulated by a monolithic regulator IC which also charges the internal battery. If the external AC supply is cut off then the internal battery will supply the circuit for at least a couple of hours. This should be long enough to cover a mains failure but a larger battery may be needed in some cases.

If a three-position keyswitch is not available or extra security is required then two two-position switches could be used. One of these would control the main unit while the other would control the anti-tamper circuit. By connecting the latter to the main reset line instead of directly to ground both keys would be needed to totally disable the unit.

**Construction**

The majority of the components for this project are fitted on to the PCB. This should reduce the scope for errors but, as usual, care must be taken to insert all the diodes, transistors, ICs and polarised capacitors correctly. There are quite a few links on the board and all of these must be inserted correctly. It would probably be best to insert IC holders into the PCB first followed by resistors, diodes, capacitors and terminal blocks. The links could be inserted immediately after the IC sockets. The last things to fit are the large component such as fuseholders, relay, buzzer, the LM317 and heatsink and C5. When fitting the regulator IC note that it should be insulated from the heatsink.

The LEDs should not be fitted yet as they could be positioned on the foil side of the PCB to poke through the box when assembled. At this stage it would be prudent to test the circuit. Use a 12V supply into the battery terminals and check that each part of the circuit from the loop sensors onward is operational. It will help to wire the keyswitch at least temporarily.

When the board is working correctly the LEDs can be fitted in place and permanent wiring installed to the keyswitch and piezo sounder. All other wiring is done via the screw connectors for the eight loop-sensor circuits, the relay contacts and power supply. The PCB is designed to fit into a large die-cast box with its Ni-Cd battery but not the transformer. This should be housed in its own box or could possibly be a suitably rated bell transformer. The box used for the unit should have a micro-switch fitted into it such that the removal of the lid will activate it. This switch and a pair of wires in the power cable should form one of the anti-tamper loops. The other is available for general use.

We shall be dealing with the use of the alarm unit, including the wiring up to the siren unit, in the near future, when we describe the siren unit itself.

**BUYLINES**

We suggest you make do with whatever buzzer you can find for X2, all the better if it actually fits the PCB. With the keyswitch, if you can’t find a single three-way device, two two-way ones can be used as already described. Nothing else should cause any problems.
ELECTRONIZE
CAR ALARM

The repertoire of alarming noises generated by Ian Pitt's car has just been increased by one — courtesy of Electronize Design.

The Electronize car alarm consists of a simple control panel which mounts below the dashboard and a bulkhead-mounting box containing the main circuitry which can be hidden away in the engine compartment. The existing courtesy light door switches are used to detect anyone entering the vehicle and the horn and the headlights are used to attract attention. The only other additions are a switch to detect when the bonnet is opened and a similar arrangement for the boot if one is not already fitted.

The circuit is armed by pressing a button on the dashboard control panel, after which a delay circuit allows thirty seconds for leaving the vehicle and closing all the doors. Opening any of the doors after that triggers the circuit into entry delay mode, allowing ten seconds to get inside the car and switch off the alarm. Opening the bonnet or the boot will trigger the alarm immediately, as will attempting to remove a radio or any other accessories attached to the sensing loop. Turning the ignition on will also trigger the alarm immediately and, provided the car has a conventional or standard CD electronic ignition system, will prevent the engine firing. If a contactless CD system is fitted the engine will start, but the alarm will still be triggered. A safety interlock prevents the circuit being armed when the engine is running, thus removing the possibility of a driver accidentally knocking the alarm switch while the vehicle is in motion and thus causing the engine to cut out.

A key is used to turn the alarm off, making it impossible for an intruder to disarm the system during the ten second delay after a door has been opened. The key consists of a miniature stereo jack plug containing two 1% tolerance resistors. Two further resistors are contained in the alarm circuitry, and only if the two pairs match will the alarm switch off. The 1% resistors are supplied with the kit and Electronize claim that they are chosen from a range of 45 values, giving a total of 2025 possible combinations for a pair.

The alarm circuit employs a low power quad op-amp and four CMOS ICs to give a very low drain current. A thyristor is used to inhibit the ignition circuit and a multiple relay switch the horn and headlights. This allows the switching to be entirely independent of the supply rails, enabling the horn switching circuit to be connected directly across the horn push regardless of whether the horn is switched on the positive or earth side. The relay is driven by an oscillator so that the horn and the headlights pulse on and off when the alarm is triggered. A further feature of the circuit is that, once armed, the main unit will continue to operate even if the leads between it and the control panel are cut.

Construction

The kit arrives packed in a number of small, polythene bags each with a packing slip carrying the packer's initials, and includes just about everything you could need including the solder. No errors or shortages were found in the kit as supplied and everything was easy to find and identify.

The first stage in the construction is the assembly of the PCB. The instructions include an overlay diagram and a full component listing and each item is identified by its colour code or physical appearance as appropriate. The PCB has all the component positions marked on it in white in a very helpful fashion — the thyristor, for example, which could easily be mounted either way around, is accompanied by a note on the PCB which shows on which side the type number should appear. The instructions are also very clear and include a section on general soldering principles, although I am not sure that a circuit of this complexity would be attractive to a beginner. The only error I could find anywhere in the notes was a reference to the earth lead which should be attached to the PCB but which is not shown on the overlay diagram. However, since there is only one hole it could possibly go into and since it is shown on the installation wiring diagram further on in the instructions, this didn't pose much of a problem.

The complete kit as it arrived, except that the PCB is shown here already assembled.
A couple of perspective drawings show how the little control panel should be wired and the accompanying instructions are again fairly comprehensive. The jack plug is quite simple to assemble because it only contains two resistors, but a drawing is used to make it clear which resistance goes where since it is important that they exactly match the pair in the main alarm box. Two jack plugs and two sets of resistances are provided so that a spare key can be assembled.

At this stage, with the control panel, the jack key and the main unit all complete, I decided to set the system up on the bench and try it out before installing it in my car. With a couple of 12 V lamps to simulate the presence of the horn and headlights, it was a simple task to check the unit through almost all aspects of its operation and establish that it was working quite correctly. I also took the opportunity to try it out at various supply voltages and found that it would work satisfactorily over a far wider voltage range than it is likely to encounter in normal use.

Electronize give reasonably detailed instructions for installing the alarm but obviously cannot take account of all the many makes and models of car the system might be fitted to. A little bit of care and thought is thus required here, and the installation is likely to take rather longer than the initial assembly. It took me a full morning to get everything installed and connected up, and a few odd hours later on to test the system, tidy up the wiring and put everything back as it should be. The amount of time the process takes could vary enormously according to the make of car and your familiarity with its wiring.

The main box was readily attached to a blank section of the bulkhead using the self-tapping screws provided. The small control panel proved just as easy to fit underneath the dashboard and again is attached using self-tapping screws. The bonnet switch, however, was not so easy to fit. Electronize intend that it be installed from above into a cross-member or other horizontal surface onto which the bonnet closes, but I found that the switch would not then compress sufficiently to allow the bonnet to be closed. Accordingly, I attached the switch to the underside of a panel, spaced it away with washers and secured it with pop-rivets, allowing just sufficient of the plunger to protrude to ensure efficient switching. The difficulty encountered in fitting this item is going to vary enormously from car to car, but I see that plunger-type door switches with various stem lengths are available quite cheaply from car accessory shops, so if the example provided really does prove impossible to fit it should not be difficult to find a more suitable replacement. You may also need to purchase such a switch if you wish to extend protection to the boot but do not have an automatically switched boot light already fitted.

When the main box, the control panel and the bonnet switch are in place, the final task is to connect them all up. I had no trouble finding an existing cable access hole through the bulkhead into the engine compartment, and soon had the main box and the control panel connected together using the four-core cable supplied. The remaining cables from the main box I bundled together and secured with cable ties (not provided), branching each one out as necessary so as to keep the wiring fairly neat. Sleeved 1/4" connectors are provided with the kit so I started with the leads using them and connected up the bonnet switch and the ignition lead via the negative side of the ignition coil. A tag and self-tapping screw are provided for the earth lead which I attached to the bulkhead fairly close to the main alarm box. The positive lead is simply taken back to the fuse box and attached using another of the 1/4" connectors. An accessory lead input is provided on the alarm, allowing a wire to be threaded through a number of devices such as radio/cassette, fog lamps, etc. before finally being attached to earth and so arranged that breaking the lead will immediately trigger the alarm. How this is attached will depend upon the accessories to be protected, but a 1/4" connector is included in the kit for this purpose.

The remaining wires all have to be tapped into existing cables to make connection with the horn, headlights and the courtesy light door switches. I found it necessary to remove the dashboard and the parcel shelf from my car in order to locate all of the wiring I needed access to, and a circuit diagram of the car's electrical system with wiring colours marked on it proved very useful here.

The actual connections are made using 'tap-in' connectors. For the benefit of those unfamiliar with these handy devices, they consist of a plastic case which is grooved to carry one cable straight through and one cable end, and have a small, serrated metal blade which is pushed through the case when the wires are in place and which cuts the insulation on the two wires so as to make the connection. I have used them before on several occasions, but I found the type supplied by Electronize very fiddly to use. In the most extreme case, I found it difficult to line up the heavy-gauge horn feed wire present in my car alongside the much thinner horn leads provided with the alarm, hold the plastic case closed over the two, fold the blade flap into place and then squeeze the whole together with a pair of pliers, all...
One of the ‘tap-in’ connectors supplied by Electronize. Similar connectors of much simpler construction are widely available.

whilst working in a cramped and uncomfortable position under the dashboard. After some minutes of repeatedly failing to line everything up I gave in and purchased a small pack of ‘tap-in’ connectors of much simpler construction from a high-street car accessory shop. These, as I had expected, were much easier to use and I had no further difficulty in making the connection to the horn circuit.

With the installation complete I tentatively applied power to the system, having first removed one connection from each of the car’s horns. A full test procedure is given in the instructions and I followed this through without encountering a single problem. The alarm worked perfectly in all respects, the headlights flashing vigorously to indicate the alarm state and the LED on the control panel correctly indicating the dormant, armed and active states by being on, or flashing as appropriate. When I had thoroughly checked the system, I reconnected the horns and once more armed and triggered the alarm. A few strident blasts synchronised with the flashing headlights confirmed that here, too, all was working correctly, and I’m sure the neighbours are grateful for my testing the system in this way rather than leaving the horns connected throughout the test sequence.

I must confess to having been slightly intimidated by the alarm at first, almost afraid to leave the car with the alarm switched on in case it suddenly went berserk and started flashing its headlights and sounding its horn for no apparent reason. Happily that has not happened, and I am steadily gaining confidence in the system’s ability to protect the car without generating false alarms. Window stickers warning that an alarm system is fitted are provided with the kit and this visible deterrent inspires a further degree of confidence. I am not quite sure why anyone should want to steal my rust-striped, twelve-year-old saloon, but I received a timely warning a few weeks before the alarm was installed when a vehicle of a similar age and condition belonging to a friend was borrowed for a joy ride and severely damaged. It’s nice to think that they would now have considerable difficulty trying to do the same thing with my car. They might even choose to attack another car instead, one without an alarm system. Your’s, perhaps?

The Electronize Electronic Car Alarm costs £19.95 in kit form or £29.95 built and ready for installation. Both prices include VAT but exclude postage and packing for which £1.00 extra should be added. Electronize Design, Tam Valley Industrial Estate, Magnus Road, Wilnecote, Tamworth B77 5BY, tel 0027-281 000.
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Most NEW CARS already have electronic ignition. Update YOUR CAR.

---

**ELECTRONIZE**

**ELECTRONIC CAR ALARM**

**HOW SAFE IS YOUR CAR?**

More and more cars are stolen each week and even a steering lock seems little help. But a car thief will avoid a car that will cause him trouble and attract attention. If your car has a good alarm system well there are plenty of other cars to choose from.

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In this second part of the practical realisation of audio theory, John Linsley Hood describes the design of a very high quality audio amplifier, using MOSFETs.

In the previous article, describing the accompanying preamplifier, the basic design requirements of this power amplifier were outlined. These were: that it should offer an audio quality which was as good as the best commercial unit on the market, if only because there isn't any point in aiming lower than this; that is should have an input sensitivity and impedance which were both sufficiently high that signals from auxiliary sources could be routed directly to it, without manipulation by the preamplifier; and that it should be direct-coupled to the LS units.

Several other things followed on from this basic general specification: for example, if it is intended to be possible to route signals from auxiliary inputs directly to the power amplifier, to avoid any possible degradation in quality by preceding stages, then the power amplifier needs to have gain and balance controls on its input, rather than situated in the preamp. Another feature which is implied in this design spec is that the output stage should be based on the use of power MOSFETs, because they can offer a sound quality which is at least as good as that of bipolar transistors operated in class-A without the enormous penalty of the thermal dissipation of such designs.

I have a great liking for valves, myself, because they can be pretty to look at, they don't mind getting hot (in class-A use), and, with a good design, they are pretty well burst-proof. However, they need output transformers, and these are invariably so destructive of the potential performance of the circuit, especially in transient response, that I feel, sadly, that valve amplifiers are about in the same league as an oil tanker with sails and masts, a romantic idea taken over by events.

Some other things which I hadn't dwelt upon, but which are necessary to consider if one is after the ultimate quality league, are stabilised power supplies, direct coupling, and the maximum practicable symmetry of the drive circuitry.

Stabilised PSU?

Looking at these in turn, the advantage of a stabilised PSU is that it will give a somewhat more solid bass response (mid range and treble response are more influenced by the circuit design of the amp and its feedback loop characteristics), and that the power output is identical under steady-state and transient conditions. In some ways this is an advantage, in that it will make power output specs less dependent on measuring conditions, and can help deliver more power into lower impedance loads. In some ways, though, it is less beneficial, because the simple power supply with output capacitor can, for a brief time, which is all that is needed on some transients, provide a higher peak power. (I looked at these pros and cons in an earlier article in ETI Jan. 1983). Many of these advantages can be gained, at lesser expense, by feeding the relatively low current, class-A gain stage of the audio amp from its own PSU, separate from the power supply which feeds the output devices. However, there is yet another possibility in a stabilised PSU system which has finally swung my preference that way, and that is that it can be made to perform a LS protection system.

With any direct coupled amp, in which the output stage midpoint is taken directly to the LS units, there is a danger that an output device failure will damage the LS drivers, so a fuse, or a relay to disconnect the LS line, is a necessary precaution. Unfortunately, fuses and relay contacts tend to impair the electrical integrity of the circuit, which is made more apparent by the relatively high currents which are flowing in these paths. Gold-plated relay contacts do not impair the performance too much, provided that the thickness of the plate layer is adequate to survive the duty, but it would be better still to do without them.

Therefore, in this circuit I have chosen to provide the LS protection function by monitoring the DC offset at the LS terminals, and using any excess voltage detected at this point to electronically disconnect both of the output stage power supply lines, with a suitable warning that this has happened.

Drive Symmetry

A further design aspect in the power amp which I have not yet discussed is that of drive symmetry. Ideally, any power amp should be capable of operating with equal facility in either polarity direction. This becomes of importance where large voltage swings are likely, which is in the final

Fig. 1 Simplified structure of audio amp circuit.
class-A driver stage of the power amp, and in the output transistor pairs, Q3 and Q4 and 5, respectively, in my schematic circuit of Fig. 1, which is itself a simplified version of my Fig. 5, in the fifth part of my Audio Design series (ETI, Jan 1984).

It isn't too difficult to make the output stages themselves quite symmetrical — within the limitations imposed by the transistors, which, in the case of the devices chosen, don't take effect until we get up to very high frequencies — but this is not true of the driver stage, Q3, and its constant-current source load. This is the point at which a conflict of requirements becomes apparent. If the biasing of the output stage is to remain constant, the load for Q3 must have constant current source characteristics, but it also must behave as an effective dynamic load for the amplifier stage Q3.

If the load on Q3 were purely resistive, there would be no great difficulty in satisfying this requirement, but there is, inevitably, some capacitance at this point, due to the output stage loading, and it then becomes essential that the current flow through the constant current source shall be able to charge this capacitance, as the voltage at Q3 collector falls, at a rate which is greater than the fastest negative-going rate of change called for by the incoming audio signal.

An apparently neat answer to this problem is given by the kind of circuit shown in Fig. 2, in which the input long-tailed pair drives a further symmetrical push-pull stage of amplification. Q3 and Q4, and the current mirror driven by Q3 provides a dynamic load for Q4. This was first introduced by National Semiconductors in the mid-1970’s, in their LH0001 op-amp design, and adopted by Hitachi as the recommended driver stage for MOSFET power amplifiers using their devices.

However, there are snags. The first of these is that the current mirror load isn't any kind of constant current source, which leads to further consequential problems in maintaining output stage bias stability. The second is, surprisingly, that on close examination and comparison of the two systems, that of Fig. 1 is both more linear and also has a superior reactive load transient response — other things being equal — to that of Fig. 2. This is possibly the reason why such an obviously elegant solution to this problem has not found much favour in the minds of the IC designers, whose products overwhelmingly favour the Fig. 1 scheme, which is the layout I have ultimately returned to, with the implicit requirement that Q3 current must be adequate.

**MOSFETisation**

There are, however, some further improvements which can be made to this circuit, and of these, the major one is the replacement of the small signal transistors by low power versions of the power MOSFETs, which are now available. These are both faster and more linear than the equivalent bipolar junction transistors, and, in principle, all of the bipolar transistors shown in the original circuit (Fig. 5, ETI, Jan 1984, p45) could be so replaced, with suitable adjustments to the circuitry, as shown in Fig. 3.

The current mirrors and constant current sources perform functions that do not benefit from 'MOSFETisation', and the higher mutual conductance of the input bipolar devices is definitely useful in maintaining a high circuit gain. However, N-channel MOSFETs are faster than P-channel equivalents, because electrons travel faster than holes, so to make it possible to use an N-channel device for Q3, the input stage must be recast to use PNP transistors for Q1 and Q2, rather than NPN types.

Another possible improvement would be to use small-power MOSFETs to make Q4 and Q5 into compound output pairs.

In this form, the circuit gives an excellent performance. However, I am all in favour of simplicity, and with the small-power MOSFET final class-A stage, a sufficiently high stage gain is available for the output MOSFETs to be used as simple source-followers. Moreover, careful tailoring of the output and driver circuitry allows the removal of the output inductors normally essential in this style of circuitry. The final circuit layout is shown in Fig. 4.
Conflicting Requirements

In every audio power amplifier circuit design there is a conflict between the requirements of low harmonic distortion, smooth transient response, and reactive load stability. This arises because low harmonic distortion demands both that the basic structure of the circuit, and its component elements, shall be such that it has high intrinsic linearity, and that the negative feedback loop will provide an effective measure of linearity enhancement. However, a smooth transient response, and good reactive load stability both require that there is a good phase margin in the feedback loop at the point at which the amplifier gain has reached unity. This comparison is shown in Fig. 5.

The loop gain characteristics shown in curve (a), in which the gain is maintained at a high level to as high a frequency as possible, and then rolled off rapidly so that it is less than unity at the 180 phase shift point (if it is unity at this frequency the amplifier will oscillate uncontrollably), will give better THD (because the amount of feedback applied at higher frequencies is greater) than the type of characteristic shown in curve (b). On the other hand, the kind of amplifier response shown in (b) will have much better reactive load stability on ‘awkward’ loudspeaker loads, and will generally be more predictable, and ‘smooth’ sounding, in spite of rather worse THD.

Obviously this is one of the occasions where one wants to have the cake and eat it, and if one is a commercial manufacturer, one is more or less forced to adopt the ‘low THD’ choice, because this will be measured and quoted in the test reports, with the — to my mind — very important reactive load transient response taking pot luck; after all, this isn’t a quotable parameter.

Since I am in the happy(?) position that I design amplifiers for my own use and pleasure, and not for sale, I am more concerned with how they will sound then how they will measure. Nevertheless, I am an engineer, and I have a normal engineers pride in doing things competently — which means, in practice, that I cannot call the job done until I have at least equalied, if not improved upon, the best performance I have so far come upon, in my own or in commercial designs. (Yes, I do look at, and test, whatever commercial units come my way, and I study their circuits to see if I can learn anything from these, in the way of clever engineering or crafty pieces of circuitry. Sadly, my feeling is that elaborate and expensive paths have been adopted to achieve a result which could have been done as well or better with more simple and economical means.) For the record, the performance of this circuit, in respect of the THD levels obtained, without sacrifice to transient response, is the best I have achieved so far. I do not, at this moment, want to try to better it.

The THD figures are quoted in Table 1, and the way in which the THD varies with power and frequency, at max. output, is shown in Fig. 6a and 6b. I show the THD vs. power output at 10kHz, because, on the prototypes, the THD at 1kHz is, at all power levels below clipping, below the residual circuit and measurement apparatus background noise level. Such distortion products which can be extracted from this noise floor can be shown to originate in the signal source, and are around the 0.0002% level (−94dB).

Circuit Analysis

As mentioned earlier, the design decision in the concept of this amplifier was that its input impedance and sensitivity should be such that it could be driven directly from the sort of input signal, in magnitude and impedance, which could be expected from typical auxiliary units — tuners, cassette recorders and the like. In practical terms this implies an input sensitivity of about 150mV and an input impedance greater than 100k.
This determines the input impedance requirements of the input transistor stage, which can be met, adequately, by an input long-tailed pair of reasonably high gain transistors operating at a collector current of 250μA. At this collector current, the typical current gain of the devices chosen is 250, giving a base current of 1μA, and a Zin of about 330k.

To ensure that the input stage has a good DC balance, so that the output offset voltage of the amplifier is close to zero, the base-circuit DC resistances for the input long-tailed pair (Q1 and Q6) are made similar, at 150k, and a 1kΩ DC-offset adjust pot, RV2, (1kΩ cermet) is connected in between the two emitters. This is adjusted so that the output voltage of the power amp is within about 50mV of 0V.

The input signal to the power amp is derived from the 100k gain control, RV1, via C1 and R2 — which acts with the 330pF input capacitor to lessen the sensitivity of the circuit to impulse noise or radio breakthrough. The current feed for the input stage is derived from the +50V line by the constant-current source, Q2 and Q4, through which the current flow is set to 500μA by the resistor R5 (1kΩ), and the collector load for the input stage is provided by the current load for the input stage is provided by the current mirror configuration of Q3 and Q5. By using high current gain transistors in this position (their operating collector voltages are very low) the current flow through Q3 is forced (by the action of the overall DC negative feedback loop in the amplifier) into a very close equivalence to that through Q5.

The action of the bypass capacitor across the emitter resistor of Q3 is to increase the output impedance and effective dynamic gain of this current mirror — an option which is available to us because we are driving a very high impedance following stage: the small-power MOSFET, Q10, whose gate circuit is effectively an open-circuit, apart from some 75pF of feedback amplifier gain and phase characteristics.

Table 1 Harmonic distortion at 10 kHz (80W/8 ohms).

<table>
<thead>
<tr>
<th>HARMONIC</th>
<th>DISTORTION (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>0.0007</td>
</tr>
<tr>
<td>3rd</td>
<td>0.0003</td>
</tr>
<tr>
<td>5th</td>
<td>0.0015</td>
</tr>
<tr>
<td>7th</td>
<td>0.0021</td>
</tr>
</tbody>
</table>

The second, class-A amplifier stage, using the MOSFET Q10, is quite straightforward in operation. The operating current is held at 10mA by the constant current source Q9 and Q11. If the current exceeds this value, the voltage drop across the 56kΩ resistor R12 exceeds the 0.56V turn-on voltage for Q11, and it steals more of the base current fed to Q9 through R15. If the output current from Q9 falls, the converse occurs, and Q9 is turned on more fully. This constant source current protects the operation of this stage from an inadvertent output short-circuit, during a positive-going voltage excursion. A similar protective function is performed, in respect of an output short-circuit during a negative-going voltage excursion, by Q7 and R13. If the current through Q10 and R13 exceeds 14mA, Q7 will turn on and clamp the gate voltage of Q10. The actual class-A standing current through Q9 and Q10 is set at 10mA, as the largest practicable current flow compatible with the 625mW dissipation of Q9 (Q10 can dissipate 1W). Note that the collector/drain tracks on the PCB are broadened to assist in heat removal from these devices.

The choice of the class-A stage DC operating voltage (±50V) is determined only by the need to provide an adequate voltage swing to the output stage MOSFET gates.
For an output power of 80 watts into an 8 ohm load, an RMS voltage swing of 25.3V RMS is needed. This is equivalent to peak-to-peak voltage swing of 71.55V. However, it must be remembered that, at the peak output currents demanded (4.47A), the MOSFETs will require a 6V source-to-gate voltage. Also the circuit of Q9 and Q10 will only swing to within 2V of the positive or negative supply rails. Finally, at 4.47A, the voltage drops through R23, R24 and R27 will amount to 1.78V on each half cycle. Adding these together, we get 71.55 + 2 + 1.78 + 2x(6V) = 89.33, so ±50V will be quite adequate.

The necessary forward bias for the output MOSFETs is generated by the 'amplified diode' circuit of Q8, which is bypassed by a small, non-polar, capacitor in the interests of HF symmetry, as is the zero DC offset adjust pot RV2.

Although the circuit will operate satisfactorily with a single pair of output MOSFETs, more power from the same HT supply voltage, an improved THD performance, and better low signal level, pure class-A, performance can be obtained, at a relatively modest extra cost, by doubling-up the output MOSFETs. These can be paralleled quite easily, provide that they have separate source and gate resistors. Since it is preferable for the gate resistors to be mounted close to the MOSFET gate pin connections, these are not included on the PCB.

**Earthing**

In order to avoid unwanted earth-loop effects, between the low-current input signal earth lines, and the high-current output earth lines, the '0V' lines at the inputs and outputs of the amplifier boards are separated, but joined on the PCB by a low-power 10 ohm resistor, R28. Each supply rail is decoupled, on the board, to its appropriate '0V' line by a 220uf/470nF electrolytic/non-polar combination.

Without transistor input overvoltage protection is given by the ZD1/D1 and ZD2/D2 networks connected between the outputs of the driver stage and the output of the amplifier, which limits the maximum forward gate drive voltage to 8.5V. The output 'buffer' resistors, R27 and R28, serve two functions. These are to assist in rejecting externally generated signal voltages on the LS line, due for example to dynamic delayed echo effects within the LS units, from the amplifier internal NFB line, and also in allowing the amplifier, unusually in the case of a power MOSFET unit, to operate without an output LS line inductor.

The reactive load transient performance of this circuit is extremely good, in spite of the low level of HF THD. This is in part due to the 'tuning' of the amplifier phase characteristics in the 100KHz – 300KHz region by the R10/C8 network. By altering R10 one can tune the output to give a virtually impeccable square wave response (i.e., identical with or without added load capacitance) over the range 8R/100u to 8R/2.2uF — for R10 values from 220k to 600k. The mid-range value I have chosen is about optimum for 1uf/8R, though the actual differences in performance on either side of this value are very small.

**Channel Balance Adjustment**

I have chosen in this design to adjust the relative gain of the two channels by alteration of part of the low-signal level NFB resistor arm using R9 and RV3. With a two gang 1k0 pot., one half of which is connected in each channel in a reciprocal fashion, a ±6dB gain adjustment of each channel with reference to the other, is provided. A two gang pot. is essential to prevent inter-channel breakthrough.

However, I am aware that this is a point of some controversy among users, some of whom very much prefer that each channel should be capable of reduction to zero output. For those who prefer this style of operation, I would recommend that a twin-spindle, concentric, input volume control is employed, RV3 be deleted, and R9 replaced by a 390R resistor.

**Construction**

A suitable PCB layout is shown in Fig.7. As mentioned above, the layout employed will affect the performance at HF, and the consequent phase shifts within the feedback loop. Therefore, I strongly urge that the suggested layout is retained.

**General Considerations**

It has been demonstrated to me, in relation to an earlier design of mine, that the component types employed can have a significant effect on audible quality. In particular, the capacitor employed in the NFB loop (C7) is a very sensitive component, where a consider-
able improvement in sound quality — not readily measurable instrumentally — can be gained by the use of non-polar rather than, for example, a polar (tantalum bead or aluminium electrolytic) type. Polypropylene capacitors are probably the best choice, but these are bulky and difficult to obtain in large volumes, so I have designed this unit around the second best choice in this position, polycarbonate, and C7 is built up from two 4u7 polycarbonate capacitors connected in parallel. (10u polycarbone capacitors are fairly rare, but if you can obtain them, one of these can be used instead.)

With the values chosen for R8 and R9, this gives a low frequency -3dB gain point of 14Hz, which is adequately low. The resistor types should be metal film 0.3 watt, or wirewound, as appropriate, and C8 is two 10pf polystyrene foil capacitors connected in series.

The other larger value capacitors, apart from the supply line decoupling electrolytics, are radial lead, stacked film, polyester types.

I will describe the setting up of the amplifier, the general component layout of the prototype, and the power supply and DC offset protection circuitry in the next article.

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Fig. 7 The recommended PCB layout.

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ETI JULY 1984
Coloroll Ltd, a company more usually associated with wallpaper, has decided to enter the DIY burglar alarm market. So what’s it got to do with ETI? Jack Shaw finds himself crawling beneath the floorboards to find out.

If a burglar alarm to my flat in the name of investigative journalism? Could this be a way of exchanging worrying about someone breaking into my flat for worrying about whether or not the alarm is going to trigger spuriously?

However, perhaps worse than this was the thought that I might be expected to give the system a practical test. How could I do that — break into my own flat? Ask the local, friendly burglar to give the system the once-over? Or wait until someone tries it out in earnest?

Luckily the people at ETI are very reasonable — they didn’t expect me to do any of this, just install the device in question and say what I thought about it.

High-Tech
Some readers might be asking themselves, “Why is ETI interested in this sort of alarm anyway?”. The answer to this question is that it is the first (at least, so far as we are aware) DIY alarm to use a combination of LSI technology and modern computer-like styling. It could be the shape of alarms to come — at least, the manufacturers think it will be.

The LSI technology is in the shape of a ULA (uncommitted logic array) developed specially for professionally installed security systems by Munford and White PLC, one of the UK’s leading designers and manufacturers of electronic security equipment. (Although the alarm bears the name ‘Coloroll’, and is being marketed by this company, it is in fact manufactured by Munford and White.)

The use of LSI makes it possible for the main control unit to be quite small — 9” by 5½” by 1¼” deep, which, coincidentally, is almost exactly the same size as a Sinclair Spectrum. Like the Spectrum, the Housewatch 2000 has a separate mains supply (which is, in fact, a plug-mounted transformer, the rectifier, etc, being mounted inside the control unit). However, the unit does contain all the connectors for the alarm circuits, (housed under a removable panel protected by an anti-tamper switch), a numeric touch-panel, used to enter the code number to enable and disable the system (rather than fumbling around with a key), and a sounder.

Siren Song
The other main unit supplied in the kit is the siren unit, which is also positively dinky, being little larger than the control unit (although manufactured from metal as opposed to what looks like high-impact polystyrene for the control unit). The siren contains a smallish PCB with a bit of its own circuitry and the back-up NiCad battery, which supplies the whole system in the event of mains failure.
power being removed for whatever reason. The circuitry sets off the alarm unit in the event of the wires to it being cut.

The siren transducer is a small (about 5") speaker with a clear plastic cone — and, despite a small size, believe me, the noise it is capable of making is ear-splitting.

The remaining components supplied are the PSU (as already mentioned), the flush-mounting door switches (with operating magnets etc.), one surface-mounting door switch with magnet, a pressure mat, a personal attack button, a large amount of interconnecting wire (15 metres of four-core cable for the control unit to siren link and 50 metres of twin-core for the wiring of the sensors to the control unit), screws, rawplugs and cable clips, and an instruction manual. Coloroll claim that they supply all your need to install a complete alarm system, and, with a couple of reservations, I found this to be the case.

**Getting Hooked**

The first thing that the manual recommends you to do is to hook up the PSU, control unit and siren on a table-top, to familiarise yourself with the system. Although the manual doesn’t say so, this also gives you the opportunity to discover if any of these units are faulty before you’ve got them well-installed. In my case, all was OK.

At this stage, you can set the code; this is a four-digit number (but with no repeated digits and no zero) which you use for setting and disabling the alarm (by my reckoning, this gives a total of 3024 possible codes). You set the code by plugging wires with bare ends into sockets — see photo if this explanation sounds a bit garbled! In my mind, this method must raise the question of long-term reliability. If a contact becomes ‘dicky’, you can’t disable (or for that matter, enable) the alarm, and you will probably end up setting off the alarm via the control-unit anti-tamper switch before you can identify and remake the contact. I think that screw connectors would have been preferable for this job, and there certainly seems to be room for this to be done on future generations of the alarm.

**Planning Ahead**

The next stage is to plan the system carefully, so as to achieve maximum security with minimum effort. The alarm allows for a number of circuits to be used. There are two designated areas, zone 1 and zone 2, and these are where most of the door switches would normally be wired. The difference between the two circuits is that when the alarm is set in the ‘part’ mode, only contacts in zone 1 (plus other circuits described later) are monitored — so zone 2 can be the sleeping area, enabling you to set the alarm in ‘part’ mode and still go to the loo at night without waking the neighbourhood! The other zone available is that for the exit/entry area; contacts here don’t set off the alarm immediately, but give you time to disable the alarm. There are also two other circuits — the anti-tamper circuit, which you can use to implement a four-wire system (ie running four wires rather than just two to all the contacts, making it far harder to bridge the circuits), and the personal attack circuit, which will set off the siren whether or not the alarm is disabled.

I found that the planning of the zones given in the manual was not necessarily the logical way for me to lay out my own system. This is probably because I live in a flat rather than a house. I used the circuits as follows: zone 1 is for the back door and to defend the door to the cellar where the PSU and much of the wiring are; zone 2 is used for all the interior door contacts; and the exit/entry circuit was used for the flat front door (although I...
intend to add the pressure mat to this circuit once I have
decided on the most suitable position near the front win-
dows). So I would suggest using the lay-out in the manual
as a good guide, but not necessarily the only way it is
possible to design the system.

However, the main problem I had was in deciding
where to put the external siren, and how to get the cable
to it. As I live in a ground-floor flat, and I didn't think my
upstairs neighbours would relish my drilling holes in
t heir floorboards and wall, the height at which I could
mount the siren was a bit limited, although you do need a
fair-sized ladder to get to it nonethe-less. However, I
found when attempting to drill the wall to take the cable,
that the wall was somewhat thicker than I had antici-
pated; the drill bit, bought specially for the job, and some
15" long just wasn't long enough to go through the
1900s-built solid wall, and I (almost literally) had to dig
around to find a thinner section of wall, eventually find-
ing a spot above the front bay windows. Actually, the
otherwise very thorough manual is rather lacking in
advice on locating and wiring to the external siren.

Because access to the under-floor area is fairly easy, I
decided to run most of the wiring here. For this reason, I
decided that it was unnecessary to adopt a four-wire sys-
tem. However, it was contemplated to the extent that I
checked to see if there was any means of identifying one
of the leads in the two-core wire supplied for the door
switches. Unfortunately, there isn't — which would
mean quite a lot of fiddling if you did try to implement
the four-wire system. Wouldn't it be better to have sup-
plied wire with a ridge down one side, as with some
loudspeaker cables? I can't see that such identification
would be of any use to an unwelcome tamperer, becuase
it doesn't reveal how the wires have been used.

The recommended method of taking the wire from
door switches, mounted in the bottom of the door, was,
at least for my ham-fisted self, impractical. What I resor-
ted to was taking the cable down the front of the frame
below the switch (see drawings) and thence under the
carpet or straight down under the floorboards. The cable
was set in a chiselled channel, which I then covered over
with a suitable filler.

Another practical point is that unless the switch and
its magnet are parallel to one another, the contact will
not close no matter how close the magnet gets to it! This
is rather obvious really, but I still made the mistake at
least once of trying to twist one with respect to the other.
The manual suggests a maximum gap of 6mm between
the contact and the magnet, and I found this had a
goodly safety allowance built into it.

Finally on the door contacts, I found it quite feasible
to mount them on the hinge-side of the door, thus put-
ting them more out of the way. Whilst this made it pos-
able to open the door slightly without setting off the
alarm, it was impossible to go through the door.

Some Complaints
All the complaints I have about this kit are relatively
minor, and didn't prevent me from getting the system
installed and working in one day (although there are
some bits I will be adding when I have time). However,
there are some aspects that could be better thought
out.

Firstly, I very quickly ran out of the cable clips sup-
plied; but I will readily admit that it was pretty good to be
supplied with these in the first place. The rawplugs sup-
plied were for solid walls, not cavity walls, and whilst this
is OK for the external alarm, if possible you want to be
able to take the wiring to the back of the control unit, and
this means, almost certainly, mounting this unit on a
hollow (plasterboard) wall — so how about providing
some cavity fixings?

There are two methods of wiring more than one
switch on the same circuit, as suggested in the manual,
one is to run the lead from the first switch to the next (the
switches are all closed in the un-alarmed state, but there
are three spare screw terminals on the switches them-
selves, so wiring them like this causes no problem).
However, if you have door switches at opposite ends of
your dwelling and the control unit in the middle, it's
easier to take the wires to the control unit and join them
there. The other method the manual suggests is twisting
together the leads to be joined at the central unit, then
wrapping with insulating tape — this is far from the most
reliable method of joining the leads, and for the
electronics-minded installer, the best method would
seem to be soldering the leads then covering the joint
with heat-shrink (keeping the iron well away from the
main unit when you do this). However, I cut a section of
terminal block and used this to make the join — but
it would have been better if there had been two or three
spare terminals in the control unit for this task.

Finally, and I think most seriously, the lead from the
PSU is a bit on the short side, being only two metres long.
Unless you're very lucky, you're unlikely to have a spare
mains socket close enough to the control unit. You can
extend the lead from the PSU to the control unit, but this
seems to spoil the neat idea of having a plug-mounting
PSU. I think that it would have been better to have sup-
plied a wall-fixing transformer unit, with good long input
and output leads. I doubt whether anyone who couldn't
correctly wire a mains plug should be allowed to attempt
to install this unit. In my own case, I solved the problem
by installing an extra socket on the ring-main, which just
happened to pass close enough to the control unit to
reach.

In Operation
At the time of writing I have had the unit in use for less
than a week (such are contributors's deadlines — Ed) so
it is difficult to comment on the long-term reliability.
However, the system is extremely straightforward to
use. As you come through the front door, a bleeping sound reminds you to disable the alarm fairly smartly, or the neighbours will get a nasty shock. So, all you have to do is remember to set the alarm as you leave — and the system does tell you if any of the door switches are not closed when you try to set it, so you shouldn't be able to go wrong, should you?

Fortunately, I have yet to have a real test of the system. But, at the same time, the little box with 'Housewatch 2000' written on it that sits above my bay window is probably the most effective deterrent one could ask for — although I must say that I am not convinced that it is a good thing for it to be quite a bit smaller than all the other sirens in my street (although it doesn't ruin the appearance of the house, either)!

The control unit is neat and practical

Conclusion
I can recommend the Housewatch 2000 to ETI readers; there are a few minor niggles but it and a few things that could have been better thought out, but the important aspects are all spot on. Let it suffice to say that I have now stopped worrying about anyone breaking into my flat, and I am contemplating installing one of these systems at my mother's house.

The Coloroll Housewatch 2000 should be widely available through DIY outlets for around £170. If you have any difficulty, please contact Coloroll Ltd, Riverside Mills, Crawford Street, Nelson, Lancashire BB9 7QT, telephone 0282-67777.

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**ICS**

ETI JULY 1984
Make a burglar go "Eek — a light" with the Ecolight! No, that's not how it got its name (it stands for ECONomy LIGHT), but we hope it could have that effect. Design and development credits go to Geoff Philips; the author of the pun wishes to remain anonymous for obvious reasons.

The ETI Ecolight (economy light) looks more or less like a conventional weatherproof bulkhead light fitting. Inside the fitting, however, is an electronic circuit which turns the light on only when it is required. A light sensor makes sure the Ecolight is off during the day and at night the light is turned on only when movement is detected by an ultrasonic beam. The light will remain on as long as there is movement in the vicinity of the light, some of the reflected ultrasound will be frequency-shifted, by the Doppler effect. The Doppler effect is what causes the sound of a train or car horn to apparently change in frequency as the train or car pass you. The difference here is that the sound which is having its frequency changed is being 'bounced' off a moving object rather than emitted by it.

At the Ecolight receiver, both the unshifted and shifted ultrasound components arrive. However, in terms of amplitude of signal, the receiver doesn't 'see' two separate signals but one combined signal. This combined signal is not a steady high-frequency signal, but one which is modulated, as the original unshifted and the shifted frequencies move in and out of phase, alternately reinforcing and cancelling (at least partially) each other.

The modulation is at a fre-
Fig. 1 Circuit diagram of the Ecolight.

Construction And Testing

Fig. 2 shows the component layout for the control PCB for the Ecolight. Take the usual precautions when handling and soldering the CMOS IC (IC4) otherwise construction of the PCB should pose no problems.

It is a good idea to test the PCB by itself before wiring it into the light fitting. If you don't, you can guarantee that the unit won't work, especially if you've made a neat job of the soldered connections, and you'll end up proving sod's law once again.

Temporarily connect the ultrasonic transducers to the PCB taking care to observe polarity (case is 0V) and also to distinguish between transmitter and receiver (receiver is marked 40R and transmitter 40T). Set RV1 to mid position. Set the on time to minimum (RV2 fully anticlockwise) and the dusk level to max (RV3 fully clockwise). Mask off the daylight sensor (LDR1) with plasticene to fool the Ecolight into thinking it's nighttime. Finally connect 240V mains to X1. Take extra care here. Work on a well-insulated bench and remember that some of the PCB tracks will be live. If an oscilloscope is available, look at the collector of Q2 with respect to 0V. The received ultrasonic frequency of approx 40kHz should be seen which should be steady amplitude if there is no moving object in the path of the ultrasonic sensors. RV1 adjusts the frequency of the transmitter oscillator IC1 and gives a degree of sensitivity adjustment to the unit. At the extreme ends of RV1 there are unstable regions of the oscillator which will be seen as last amplitude variations in the received signal. These regions should be avoided.

How It Works

IC1 is connected as medium high frequency oscillator which drives the ultrasonic transmitter transducer, TX. The frequency can be adjusted by RV1.

The received ultrasonic signal from the receiver transducer, RX, is amplified by Q1 and Q2, which are connected as a high-gain doublet. Bias for Q1 is provided via R3 and R5, and because of the presence of C3, the AC gain of this pair is quite high. The received signal is peak rectified by D1.

If part of the signal is Doppler shifted due to reflection from a moving object, then a beat will occur between the unshifted and shifted components of the received signal, resulting in the ultrasonic signal being modulated by the much lower frequency beat signal. D1, C4 and R6 form a detector with a relatively long time constant (about 3ms), and these detect the modulation signal. This is buffered by Q3 and passed to IC2 via C5.

IC2 forms a threshold detector whose level is set by the values of R8, 9 and 10 at about 60mV; when the peak value of the detected signal exceeds this value, IC2 will trigger negatively. This starts to discharge capacitor C6 via D2 and R13 (the capacitor is initially charged via R12 and R13, the output of IC2 being high in the presence of no modulation). If the signal exceeds the threshold by a sufficiently large amount for a sufficiently long period, C6 will be discharged enough to trigger the monostable IC3. After this, any disturbance which exceeds the basic threshold level will re-set the monostable capacitor, C9, via D3 and Q4. The period of the monostable is decided by C9, R14 and RV2. The monostable supplies current to relay RL1 which switches the mains supply to the lamp.

At the onset of daylight, the resistance of LDR1 reduces to the point at which pin 12 of IC4b is reduced below this gate's threshold. IC4b output goes high, and, provided IC4a output is also high, which will be the case when the monostable is not triggered. IC4c output will go low, holding the reset pin of IC3 low and preventing the monostable from triggering. Hence the light will come on only when there is no daylight, but the light will not attempt to inhibit itself from operating. Additionally, R15 and C10 cause pin 13 of IC4b to be held low for a short period after the lamp has extinguished, similarly preventing the monostable from triggering; this is to prevent false re-triggering of the unit due to relay armature movement, supply rail disturbances, etc.

NOTE: IC1, 2 ARE 555 IC2 IS 741 IC3 IS 7413 IC4 IS 4011 OR SIMILAR Q1 IS 2N3904 OR SIMILAR Q2 IS 2N3906 OR SIMILAR ZD1 IS 6.2V ZENER LDR1 IS ORP52 RL1 IS 12V RELAY
If you do not have access to an oscilloscope do not despair, with RV1 set to mid position switch on and listen for the relay armature to click in. Chase the kids out of the workroom put the cat out and then keep perfectly still. After a few seconds IC3 should time out and the relay will click back to its de-energised state. Move your hand in front of the sensors whereupon the relay should energise. If it doesn't check that no light is leaking onto LDR1 (this device is very sensitive). If the relay is permanently energised and will not drop out, try moving the position of RV1 slightly, as you may be in an unstable region of the oscillator. The output of IC2 is high for no movement and goes low to trigger IC3 and hence energise the relay. Thus, if there is no negative-going disturbance at the output of IC2 the fault is in the receiver section, Q3, IC2. If the output of IC2 is seen to switch negatively when there is movement then check the voltage at pin 4 of IC3. If this is at 0V then the timer is being inhibited. Suspect the daylight sensor circuitry. Pin 11 of IC4 should be at logic 0 for the unit to function.

Assuming that you have been successful so far, remove the mask from the daylight sensor and confirm that the unit ceases to function. The PCB is now ready to be fitted into the light fitting.

Assembly Of Unit

The PCB has been designed to fit a Coughtree SP10 light fitting although it should be suitable for any fitting with enough internal space away from the direct heat of the lamp. If the SP10 fitting is to be used then cut two of the corners off the PCB as indicated by the copper strips. Lay the PCB inside the SP10 at the opposite end to the lamp. Drill two M4 clear holes in the SP10 casing using the holes in the PCB next to the relay as a guide for the drill. Fit two M4 screws from the rear of the SP10.
case and secure the screws so that the PCB can be secured to the SP10 some 10mm away.

The ultrasonic transducers have to be mounted in a suitable manner to allow them to be pointed in the desired direction. For the original prototype, they were mounted in two plumber's copper elbow joints brazed together, as can be seen from the photographs. However, the original transducers do not seem to be available any more, having been replaced by larger transducers that won't quite fit in a common size of pipe fitting. Fig. 3 shows the new mounting method, and the transducers supplied in the kit (see 'Buylines') will need to be mounted like this. However, if you choose different transducers, you may be able to use the original method. Whatever you do, note that the transducers must be reasonably well protected, since most types are not waterproof.

**Buylines**

We do not anticipate many problems in locating components for this project, with the possible exception of the transducers. However, we see no reason why the design should not work with the many alternative types of 40 kHz transducers there are on the market.

For the lazy, a full kit of the electronics (including the PCB and the 'Acorn' inserts for the transducers but excluding the light fitting, copper elbow joints and heat shield) is available from G.P. Electronic Services for £21.05 including VAT and p&p. For the slightly more adventurous, G.P. can supply the PCB on its own for the inclusive price of £4.50.

Fig. 3 Alternative method of mounting the transducers.

Use screened cable to wire up the transducers to the PCB. Pass the cable through the copper elbows or the back of the 'Acorn' inserts, then through the side of the case of the SP10 via a rubber grommet. Wire up the sensors and the SP10 lamp to the PCB. Fit the PCB in the SP10 via the two M4 screws. Note that the PCB is earthed via these screws making contact with the 0V track; if you use some other fixing method, these two points on the circuit must be connected, and, if the case is used metal, this must be earthed either from this point or directly.

The final job is to wire up 240V mains to the connector X1; note that the live must be fused, so if you are wiring directly to the mains, either use a fused connection unit or find space to fit a panel-mounting fuse. Alternatively, you could always use a fused plug (a 3A fuse should be used).

**Fitting and Final Testing**

The Ecolight should be securely fixed to a wall away from bushes and plants, which would cause false triggering, and sheltered from high winds. In order to test the unit in daylight it is necessary to mask off the ORP12 device again with plasticene. Angle the ultrasonic sensors in the desired direction and determine the best setting of RV1 for the sensitivity required. Do not set the sensitivity too high, however, as you may be troubled by false triggering in high wind conditions. Once you are happy with the setting of RV1, then you can set RV2. RV2 should be advanced clockwise to give the required time delay for the light to switch itself off after movement in the ultrasonic beam has ceased.

The dusk level pot may now be set up. Remove the plasticene from the ORP12 and, at dusk, turn RV3 fully anti-clockwise. The Ecolight should now be inhibited. Turn RV3 clockwise whilst moving your hand in front of the beam until the Ecolight just starts to function.

It is recommended that an aluminium heat shield be fitted over the PCB to prevent overheating of the electronic components. A hole will be required in the shield however to allow the ORP12 device to function. Bear this in mind when adjusting the dusk level. Turn RV3 further clockwise if you want the Ecolight to come on earlier in the evening.
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This interruptible-beam intruder alarm offers all the advantages of infrared operation and yet is simple enough for almost anyone to build. Design by Frederick Howard.

Infrared Intruder Alarm is shown in Fig. 1. A multivibrator produces a one millisecond pulse ten times a second and this switches a 50 kHz oscillator which in turn drives the IR (infrared) diodes. The diodes are fitted with an integral lens which focuses their output into a narrow beam. Provision has been made on the PCB for up to four diodes in series to be used, giving a high energy output and a reasonably wide beam, but if the alarm is to be used only over short distances it is possible to use fewer diodes just by inserting links in the vacant positions.

In the receiver, a lens focuses the incoming beam onto an infrared detector diode placed in series with a tuned circuit. The signal from the diode is fed to an amplifier which is also tuned to 50 kHz and the output is then fed to the detector. If the beam is interrupted so that no signal arrives at the detector, an audible warning device is energised to sound the alarm. A timing circuit holds the alarm on for one-to-two minutes and then resets it ready to be re-triggered if the beam is disturbed again. Since the circuit requires a little time to stabilise, a further timing circuit holds the alarm off for a short period after switch on.

In normal operation the transmitter and receiver will be placed opposite one another and in direct line, but for short distances the two can be stood side by side and the beam reflected from an opposite wall or other surface. This might be convenient in a narrow hallway or other location where one wall is relatively featureless and where it would otherwise be difficult to conceal one of the units.

Construction

The transmitter and the receiver are both assembled on PCBs and then installed in identical plastic boxes. It does not matter in which order you assemble them since both will have to be substantially complete before you can move on to the setting-up. Begin by soldering the IC sockets and the passive components into place on each PCB, then add the diodes and finally the transistors. The ICs can be installed in their sockets when all the soldering is complete. The IR diodes should be left off of the transmitter PCB until it has been installed in its box. It will save time later on if you solder into place the end of R5 on the transmitter nearest to D3 and Q1, but temporarily connect the other end to the positive supply rather than soldering it into the hole adjacent to R4 as shown.
The drilling details for the transmitter are shown in Fig. 6. Note that only three bolts are used to hold the PCB to the front panel, the fourth corner being occupied by the IR diodes. You may find that you don't need all four IR diodes for your particular application, so it is a good idea to install only one to begin with and to link across the remaining holes on the PCB. If you do this, you will only need to drill a single hole for the diode rather than the slot shown.

**PARTS LIST — TRANSMITTER**

<table>
<thead>
<tr>
<th>RESISTORS (all 1/4 W 5%)</th>
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<tbody>
<tr>
<td>R1, R4, R7</td>
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<tr>
<td>R2, R5</td>
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<td>R3</td>
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<td>R6</td>
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<td>RV1</td>
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<th>CAPACITORS</th>
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<td>C1</td>
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<td>C3</td>
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<td>C4</td>
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<th>SEMICONDUCTORS</th>
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<td>IC2</td>
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<tr>
<td>Q1, Q2</td>
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<tr>
<td>D1-4</td>
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<tr>
<td>D5</td>
</tr>
<tr>
<td>ZD1</td>
</tr>
<tr>
<td>LED1-4</td>
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</tbody>
</table>

**HOW IT WORKS — TRANSMITTER**

Integrated Circuit IC1 consists of four electronic switches, two of which are connected as an asymmetric multivibrator. The ratio of charge to discharge time for C1 is controlled by R2 and R3. This ratio results in a narrow positive going pulse of about 1 millisecond, which is fed to the base of Q1 through R5 at a rate of 10 times per second. The base voltage is limited to 5.6 volts by the zener diode ZD1.

IC2 is coupled as a multivibrator producing symmetrical square waves at the output. The frequency of 50 kHz is set by C3 in conjunction with resistors R6, R7, and RV1. IC2 is only switched on when transistor Q1 conducts. The 50 kHz oscillator is thus pulsed for one millisecond every ten times per second. The pulse voltage is limited to 5 volts to ensure frequency stability independent of battery voltage.

The oscillator output is applied to transistor Q2 which controls the current through the infrared emitter diodes, LED1-LED4. The pulse current through the diodes is controlled by D3 and D4 in conjunction with R9. The peak pulse current is about 120 mA, but because they are pulsed at 50 kHz for only 1 millisecond in 100, the total battery drain is about 600 µA.

and of course, you can easily drill further holes and file out the slot should you later decide that you want to use more diodes. You should install the diode or diodes onto the PCB without soldering and then assemble the board onto the drilled front panel and the bolts. Each diode can then be dropped accurately into its hole, the leads bent over on the component side of the board to mark the correct length, and the board then removed from the front panel so the diode can be soldered finally into place.

The drilling details for the receiver case are shown in Fig. 7. Two large holes are required, one for the audible warning device and one for the lens. If you do not have any other means of making holes of suitable size in plastic, you can always drill a series of small holes and then link them up with a small, round file. If the appearance of the finished unit is important to you, the circle of holes could be made a little smaller than the desired diameter and then enlarged smoothly with a fine drill or piece of rolled-up sandpaper. Some audible warning devices have a fixing ring which covers the mounting hole. However, it is perfectly possible to use any audible warning device which will operate from 9 V and does not draw too much current, so you may wish to bear this point in mind when choosing.
The lens used in the prototype was obtained from RS and is sold as an inspection lens. This means that the plastic collar in which it is supported is equal in height to its focal length. Almost any other lens could be used provided its focal length can be accommodated within the receiver case — about 30 to 40 mm would be best. If you have a lens lying around but don't know its focal length, simply use it to focus the sun's rays onto a flat surface and then measure the distance of the lens from that surface. (Note that this will only work with the sun and not with artificial lighting; this is because the sun is so far away that its rays are very nearly parallel when they reach us.) If your chosen lens does not have a collar which extends for its full focal length, you will have to add a length of tube of suitable diameter and paint it black inside. Remember also that the top of the detector diode is a millimeter or two above the surface of the PCB and allow for this before gluing the lens assembly to the PCB. Make sure you centre the lens over the diode itself.

The final stage in the assembly of both units is to wire up the battery connectors via the jack sockets. The jack sockets serve as on-off switches, and are so arranged that inserting the plugs disconnects the supplies. This makes it difficult for an intruder to silence the alarm once it has been triggered. The audible warning unit in the receiver also has to be wired up and the units are then ready for testing.

Due to lack of space in this issue, we're afraid that you will have to wait until next month for the overlay for the PCB receiver PCB, the case drilling details, how to set up the alarm, and Buylines.

**HOW IT WORKS — RECEIVER**

The infrared transmission is directed or reflected onto the IR detector diode LD1, which is mounted at the focus of a simple lens. A 50 kHz resonant circuit, L1 and C1, forms the load for the detector. Only infra-red energy, from a 50 kHz source will give a voltage across the load, thus eliminating unwanted signals from lights or heaters. The detector is followed by a 3 stage amplifier, one stage of which has a 50 kHz tuned circuit as the collector load. This possess only the wanted 50 kHz signal and rejects other interfering signals. Transistors are used in preference to integrated circuit amplifiers as they can give a reasonable gain at 50 kHz for only a few microamps of collector current.

A constant signal level for any given input is maintained at the output of the amplifier by rectifying the signal through D1, in conjunction with D2. A negative DC voltage is generated across C10 which is proportional to the signal level. This negative potential is applied to the gate of the feedback transistor Q3 to control the effective resistance between the drain and source of this transistor. This determines the current negative feedback and hence gain of amplifier stage built around Q2. The time constant of the automatic gain control circuit is about 50 seconds.

The signal level at the emitter follower, Q7, is detected by D3 and Q8. For a constant signal level there will be a constant DC voltage on C16. This voltage will decrease when the beam is broken and increase when the beam is restored — the gain of the amplifier being slow to respond compared with the signal level detector time of response, which is of the order of one second for signal decay but almost immediate for signal increase. The sharp increase of DC level at C16 after the beam is restored will be transferred through to the base of Q9, switching on Q9 which in turn switches on Q10 and hence Q11 which energises the alarm. When Q10 goes positive it will hold Q9 on by supplying current through D9 and R26, latching on the whole circuit. C9, will now commence to discharge through R25. When the potential at pin 5 of IC1 reaches about 5 volts, pin 4 of IC1 will be connected to the zero supply and hence transistors Q9, Q10 and Q11 are all switched off. IC1 will now charge via D6, R29 and R31, releasing the switch on pin 4 of IC1 and leaving the circuit in readiness for any further disturbance of the beam.

The circuit needs time to settle to a stable gain and signal level. On initial switch-on, pin 5 of IC1 is held positive by the absence of charge on C19. This holds the base of Q9 to the zero supply line maintaining Q9, Q10 and Q11 in their cut-off state. When C10 has charged through D6, R29 and R31, the switch on IC1 will open and the circuit will be ready to detect a disturbance of the beam.

---

**Fig. 4 Circuit diagram of the receiver.**

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These two foil patterns are for the double-sided Oric/Atmos EPROM board, held over from last month.
The Infrared alarm transmitter board.

The Warlock alarm board.
The Audio Design power amplifier board.

The Ecolite board.
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– hydraulically powered
– microprocessor controlled

The UK-designed and manufactured range of Genesis general purpose robots provides a first-rate introduction to robotics for both education and industry.

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<tr>
<th>GENESIS P101</th>
<th>GENESIS P102</th>
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<td>Each robot in the Genesis range has a self-contained hydraulic power source operated from single phase 240 or 120v AC or from a 12v DC supply. Up to six independent axes are capable of simultaneous operation and all except the grip axis have sensing devices fitted to provide positional control by a closed loop system based on a dedicated microprocessor. Movement sequences can be programmed by means of a hand-held controller or the systems can be interfaced with an external computer via a standard RS232C link.</td>
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The top-of-the-range P102 has dual speed control, enhanced memory and double acting cylinders for increased torque on the wrist and arm joints. There is position interrogation via the RS232C interface, increasing the versatility of computer control and inputs are provided for machine tool interfacing. All Genesis robots are available either ready-built or in kit form. The latter provides not only extra economy but also valuable additional training as an assembly project. |

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<table>
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<tr>
<th>MICROGRASP</th>
<th>GENESIS P101</th>
<th>GENESIS P102</th>
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| A real programmable robot for under £300! Microgasp has an articulated arm jointed at shoulder, elbow and wrist positions. The entire arm rotates about its base and there is a motor driven gripper. All five axes are motor driven and four of these are servo controlled giving positive positioning. The robot can be controlled by any microcomputer with an expansion bus – the Sinclair ZX81 being particularly suitable. | Weight 34kg, max. lifting capacity 1.8kg
6-axis model (kit form) | Weight 36kg, max. lifting capacity 2kg
6-axis system (kit form) |

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Cortex 16 bit microcomputer | Goods subject to availability. All prices exclusive of VAT and correct at time of going to press. |
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<th>MONTH</th>
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<th>ORDER CODE</th>
<th>PRICE</th>
<th>KIT DETAILS</th>
<th>PROJECT BOOK</th>
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<tr>
<td>1. (1)</td>
<td>75W Mosfet Amp Module</td>
<td>LW51F</td>
<td>£12.95</td>
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<td>5 XA05F</td>
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<tr>
<td>2. (2)</td>
<td>Modern</td>
<td>LW99H</td>
<td>£44.95</td>
<td></td>
<td>5 XA05F</td>
</tr>
<tr>
<td>3. (3)</td>
<td>Car Burglar Alarm</td>
<td>LW78K</td>
<td>£6.95</td>
<td>4 XA04E</td>
<td></td>
</tr>
<tr>
<td>4. (4)</td>
<td>Ultrasonic Intruder Detector</td>
<td>LW93B</td>
<td>£9.45</td>
<td></td>
<td>Best of E&amp;MM</td>
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<tr>
<td>5. (5)</td>
<td>ZX81 I/O Port</td>
<td>LW76H</td>
<td>£29.25</td>
<td></td>
<td>4 XA04E</td>
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<tr>
<td>6. (7)</td>
<td>Syntom Drum Synthesiser</td>
<td>LW86T</td>
<td>£11.95</td>
<td></td>
<td>Best of E&amp;MM</td>
</tr>
<tr>
<td>7. (6)</td>
<td>Spectrum Keyboard</td>
<td>LW29G</td>
<td>£29.50</td>
<td>9 XA09K</td>
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- 9. (8) 8W Mosfet Amplifier
- 10. (11) Logic Probe
- 11. (13) Ultrasonic Intruder Detector
- 12. (6) VIC20/64 RS232 Interface
- 13. (10) Harmony Generator
- 14. (14) Spectrum RS232 Interface
- 15. (12) Keyboard for ZX81
- 16. (16) Noise Gate
- 17. (28) Burglar Alarm
- 18. (15) Hexadrum
- 19. (17) Guitar Tuner
- 20. (30) Synwave Sounds Synth

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