MODULAR TEST GEAR TO BUILD

SUNRISE LIGHT BRIGHTENER

SOMETHING WE ATE

DIGITAL SOUND SAMPLERS

AUDIO... COMPUTING... MUSIC... RADIO...  BOTICS...
OMP POWER AMPLIFIER MODULES

Now you can:

1. World-wide reputation for quality, reliability and performance at a realistic price.
2. Four models available to suit the needs at the professional and hobby market.
   - Hi-Fi, Leisure, Instrumental and Hi-Fi etc.
3. When comparing prices, NOTE all models include Torode power supply, integral heat sink, Glass fab., P.O.D., and drive circuits to power compatible.

Supplied ready built and tested.

OMP 100 Mk II Amp, Module, 110v R.M.S., 4Watts. P.S.S. 5000mV+10x
Sens. 300 x 119 x 75mm Price: £39 99 + £7 50 f.p.

OMP/MF100 Mos-Fet. Very high spec. 110v R.M.S., 8 Watts & 6 Watts R.M.S.
Sens. 200 x 123 x 50mm Price: £79 99 + £5 50 f.p.


MF100

Full specifications available on request.

NOTE: Mos-Fets are supplied as standard. 100kHz bandwidth x Input Sensitivity 500mV). Required P.A. variant (55kHz bandwidth & Input Sensitivity 775o). Order - Standard or P.A. variant.

19" STEREO RACK AMPS

Professional 19" casied Mos-Fet stereo amp.

XLR connectors. 600w, 150w cooled. Three models. (Ratings R.M.S. into 4ohms).

Price £228 85 + £1 50 p.p.

STEREO DISCO MIXER

STEREO DISCO MIXER with 2 x 5 band L.
& R. graphic equalisers and twin 10 segment
LED Vu Meters. Many outstanding features
& Inputs including individual laders providing a
useful combination of the following -

3 Turntables (Mag), 3 Mics. 4 Line plus Mic.
with talk over switch. Headphone Monitor
Port. L & R Master Output controls. Out-
put (75ohm). Size 285 x 400 x 230. Price
£124 99 + £10 00 f.p.

STereo Mixer

HOBBY KITS

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


3 WATT FM TRANSMITTER 3 WATT 85/115MHz vascio controlled professional performance. Range up to 3 miles 26 x 84 x 12 mm
(120) Price: £11 49 + £7 50 f.p.

POSTAL CHARGES PER ORDER £1.00 minimum.


B. K. ELECTRONICS

UNIT 5, COMET WAY, SOUTHEND-ON-SEA.
ESSEX SS5 2TR TEL 0702 527 727

MICROBOX II THE 6809 SINGLE BOARD COMPUTER THAT YOU BUILD YOURSELF

VIDEO OUTPUTS KEYBOARD PORT PRINTER PORT SERIAL PORT SERIAL PORT

SYSTEM EXPANSION BUS
BATTERY BACKED REAL-TIME CLOCK/CALENDAR

128KBYTES SHARED MEMORY RAMDISC
HIGH SPEED SILICON DISC
ACTS LIKE A STANDARD "FLEX" DISC

ALPHANUMERIC DISPLAY
108 x 24 CHARACTER FORMAT.

USER DEFINABLE CHARACTERS.

STANDARD VDU
CONTROL FUNCTIONS

SYSTEM SUPPORT MONITOR
(8KB)containing:

- DISC AND INPUT/OUTPUT DRIVERS
- GRAPHIC PRIMITIVES
- TERMINAL TERMINAL
- TERMINAL TERMINAL
- UTILITIES
- AND DIAGNOSTICS
- "FLEX" BOOT AND CONFIGURE
- 60KBYTES USER MEMORY

FLOPPY DISC INTERFACE
- SUPPORTS SINGLE OR DUAL
- 40/80 TRACKS OR
- DOUBLE DENSITY DISC DRIVES

POWERFUL 6809 8/16 BIT MICROPROCESSOR

EPROM DISC (AND PROGRAMMER)
HIGH SPEED READ ONLY SILICON DISC
ACTS LIKE A STANDARD "FLEX" DISC
PROVIDES "INSTANT" SOFTWARE

BARE PCB's AND DOCUMENTATION
+ SYSTEM SUPPORT MONITOR
+ SYSTEM UTILITIES DISC - £95.00
FLEX + EDITOR + ASSEMBLER £75.00

8 SKILLICORNE MEWS · QUEENS ROAD · CHELTENHAM · GLOUCESTERSHIRE GL50 2NJ
Telephone: Cheltenham (0242) 510525
DIGEST An injunction to eat, or just to chew on the news? .......................... 7
READ/WRITE The first and last post. ......................................................... 16
REAL COMPONENTS It could be true or false, but when John Linsley looks at logic chips it's easy (or is that IC?). .......................... 20
THE SAMPLE LIFE Music by numbers means an increase in the rates. ...................... 27
AUTOMATIC TEST EQUIPMENT W.P. Bond investigates one of this year's buzz phrases. .................. 43
TECH TIPS Just the tip of the IC-berg. ......................................................... 53

PROJECTS

ETI 'SORCERER' STRING SYNTHESISER Graeme Durant ties up all the loose threads in the final part of this project. ......................................................... 32
MODULAR TEST GEAR These boards form the nucleus of a very versatile test set-up — and you can test that statement for yourselves. .................. 38

ETCETERA

REVIEWS PCB manufacture and a range of popular microprocessors are looked at in the books under review. ......................................................... 59
ALF'S PUZZLE A teaser for you from the brains in the basement. ......................................................... 59
TRAINS OF THOUGHT Roger Amos makes his points. ......................................................... 61
OPEN CHANNEL Keith Brindley's latest electric message. ......................................................... 61
PLAYBACK EXTRA Andy Armstrong reports from the first British Music Fair to be open to the public. ......................................................... 62
SCRATCHPAD Flea-byte's back and itching to go. ......................................................... 62
INFORMATION

PCB SERVICE see page 7
NEXT MONTH'S ETI .......................... 54
FOIL PATTERNS .......................... 55
READERS' SERVICES .......................... 58
ADVERTISERS' INDEX .......................... 63
CLASSIFIED ADS .......................... 64
### Transistors

<table>
<thead>
<tr>
<th>Value</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500</td>
<td>BC337</td>
</tr>
<tr>
<td>650</td>
<td>2N3904</td>
</tr>
<tr>
<td>510</td>
<td>2N3819</td>
</tr>
<tr>
<td>475</td>
<td>2N3821</td>
</tr>
<tr>
<td>300</td>
<td>2N3828</td>
</tr>
<tr>
<td>225</td>
<td>2N3829</td>
</tr>
<tr>
<td>150</td>
<td>2N3830</td>
</tr>
<tr>
<td>100</td>
<td>2N3831</td>
</tr>
<tr>
<td>75</td>
<td>2N3832</td>
</tr>
<tr>
<td>50</td>
<td>2N3833</td>
</tr>
<tr>
<td>25</td>
<td>2N3834</td>
</tr>
<tr>
<td>15</td>
<td>2N3835</td>
</tr>
<tr>
<td>10</td>
<td>2N3836</td>
</tr>
<tr>
<td>5</td>
<td>2N3837</td>
</tr>
<tr>
<td>3</td>
<td>2N3838</td>
</tr>
<tr>
<td>1</td>
<td>2N3839</td>
</tr>
</tbody>
</table>

### Capacitors

<table>
<thead>
<tr>
<th>Value</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>BC183</td>
</tr>
<tr>
<td>680</td>
<td>2N3840</td>
</tr>
<tr>
<td>470</td>
<td>2N3841</td>
</tr>
<tr>
<td>330</td>
<td>2N3842</td>
</tr>
<tr>
<td>220</td>
<td>2N3843</td>
</tr>
<tr>
<td>100</td>
<td>2N3844</td>
</tr>
<tr>
<td>47</td>
<td>2N3845</td>
</tr>
<tr>
<td>33</td>
<td>2N3846</td>
</tr>
<tr>
<td>22</td>
<td>2N3847</td>
</tr>
<tr>
<td>15</td>
<td>2N3848</td>
</tr>
<tr>
<td>10</td>
<td>2N3849</td>
</tr>
<tr>
<td>5</td>
<td>2N3850</td>
</tr>
<tr>
<td>3</td>
<td>2N3851</td>
</tr>
<tr>
<td>1</td>
<td>2N3852</td>
</tr>
</tbody>
</table>

### Resistors

<table>
<thead>
<tr>
<th>Value</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>100k</td>
<td>2N3853</td>
</tr>
<tr>
<td>50k</td>
<td>2N3854</td>
</tr>
<tr>
<td>25k</td>
<td>2N3855</td>
</tr>
<tr>
<td>10k</td>
<td>2N3856</td>
</tr>
<tr>
<td>5k</td>
<td>2N3857</td>
</tr>
<tr>
<td>2k</td>
<td>2N3858</td>
</tr>
<tr>
<td>1k</td>
<td>2N3859</td>
</tr>
<tr>
<td>500</td>
<td>2N3860</td>
</tr>
<tr>
<td>220</td>
<td>2N3861</td>
</tr>
<tr>
<td>100</td>
<td>2N3862</td>
</tr>
<tr>
<td>75</td>
<td>2N3863</td>
</tr>
<tr>
<td>50</td>
<td>2N3864</td>
</tr>
<tr>
<td>25</td>
<td>2N3865</td>
</tr>
<tr>
<td>15</td>
<td>2N3866</td>
</tr>
<tr>
<td>10</td>
<td>2N3867</td>
</tr>
<tr>
<td>5</td>
<td>2N3868</td>
</tr>
<tr>
<td>3</td>
<td>2N3869</td>
</tr>
<tr>
<td>1</td>
<td>2N3870</td>
</tr>
</tbody>
</table>

### Computer ICs

<table>
<thead>
<tr>
<th>Value</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>100k</td>
<td>2N3871</td>
</tr>
<tr>
<td>50k</td>
<td>2N3872</td>
</tr>
<tr>
<td>25k</td>
<td>2N3873</td>
</tr>
<tr>
<td>10k</td>
<td>2N3874</td>
</tr>
<tr>
<td>5k</td>
<td>2N3875</td>
</tr>
<tr>
<td>2k</td>
<td>2N3876</td>
</tr>
<tr>
<td>1k</td>
<td>2N3877</td>
</tr>
<tr>
<td>500</td>
<td>2N3878</td>
</tr>
<tr>
<td>220</td>
<td>2N3879</td>
</tr>
<tr>
<td>100</td>
<td>2N3880</td>
</tr>
<tr>
<td>75</td>
<td>2N3881</td>
</tr>
<tr>
<td>50</td>
<td>2N3882</td>
</tr>
<tr>
<td>25</td>
<td>2N3883</td>
</tr>
<tr>
<td>15</td>
<td>2N3884</td>
</tr>
<tr>
<td>10</td>
<td>2N3885</td>
</tr>
<tr>
<td>5</td>
<td>2N3886</td>
</tr>
<tr>
<td>3</td>
<td>2N3887</td>
</tr>
<tr>
<td>1</td>
<td>2N3888</td>
</tr>
</tbody>
</table>
British Computer Uses The 68020

Durham-Based Integrated Micro Products Ltd have launched a 32-bit multi-user microcomputer which is said to be considerably faster than many minicomputers costing ten times as much.

It owes much of its high performance to the use of Motorola's new 68020 microprocessor (described in ETI October 1984) and is the first British designed and built computer to use the chip.

The IMP-Mentor is available either as a complete super-microcomputer or as a series of VME-Bus boards which can be used in other systems. It runs several versions of the Unix operating system and IMP say that it can support thirty-two users simultaneously with virtually no degradation of processing speed.

The main board carries the 68020 and 2M bytes of RAM, expandable up to 8M bytes. There is also provision for a 68881 floating-point co-processor. Two more boards carry the disk controller and the communications controller and each has its own 68000 microprocessor. This leaves the main microprocessor free to operate at the limits of its performance, which can be as high as eight million instructions per second.

To illustrate the speed of the Mentor, IMP quote its performance on the Sieve of Eratosthenes, a test that involves calculating about 2,000 prime numbers. The Mentor takes a mere 0.6 seconds, while a DEC VAX 78 minicomputer takes 1.8 seconds and an IBM-PC XT takes 9.0 seconds.

IMP say the Mentor is ready for immediate shipment. For more details contact Integrated Micro Products Ltd, Number One Industrial Estate, Medomsley Road, Consett, County Durham DH8 6TJ, tel 0207-503481.

ETI Printed Circuit Board Service

We must again apologise to our readers for the suspension of this service.

As we explained in our last issue, the company who used to supply our PCBs have decided that they no longer wish to continue doing so. Until we find another supplier we cannot send out any boards.

At the time of going to press we are close to reaching an agreement with a new supplier but nothing has yet been signed. We would hope to be able to start sending out boards again within a few weeks of signing such an agreement.

In the meantime, we will happily refund money to those who have paid but not received boards. However, if readers prefer they can leave their orders with us and we will deal with them as soon as we are able.

We would like to thank our readers for the forebearance many have shown in this matter and once again offer our apologies for the inconvenience.

Bumble Gives Us The Moon — By Laser

A research unit at Brunel University has developed a word processing system which can convert the written word into forms better suited to the needs of blind and partially-sighted people.

The system is called BUMBLE (Brunel University Moon, Braille and Large-print Equipment) and was developed by a team led by Dr. John Gill. It consists of a sixteen-bit microcomputer, specially developed software, and a laser printer.

Because the laser printer uses a non-impact printing system it is able to cope with a wide range of type styles and sizes. The paper can then be heat-treated to produce embossed Braille characters.

The system can also print the less well known Moon language. Developed before Braille, Moon has the advantage that it is very easy to learn, but the difficulty of printing it using traditional typesetting methods has prevented its widespread adoption. The Brunel team hope that their work will lead to a revival of interest in Moon.

Bumble was originally developed for use by social service departments and voluntary associations, but the simplicity of the system should enable it to be used by a wide variety of agencies who currently make no provision for the blind and partially-sighted when preparing information. For further details contact Dr. Gill on 0895-71206.
**COOLING FANS**

Keep your parts cool and reliable with our range of COOLING FANS. These fans will guarantee maximum airflow and efficiency.

**Priced** £295.00

**Features**
- High-speed, low-noise operation
- Reliable performance
- Ideal for CPU, GPU, and power supplies

**Specifications**
- 120mm diameter
- 2500 RPM
- 38.5 CFM
- 32.8 dB(A)

**Guarantee**
- 90-day warranty

**Ordering**
- For further details and pricing, please contact us at 01-679 1866 or info@coolfans.com

---

**DISK DRIVES**

Jaguar disk drives, with their high capacity and speed, make them ideal for computer systems requiring efficient data storage and retrieval. These drives are compatible with various computer models, ensuring compatibility and ease of integration.

**Priced** £4164

**Features**
- High data transfer rates
- Large capacity for extensive storage
- Stable and reliable performance

**Specifications**
- Model: J8500
- Capacity: 2GB
- Interface: ESDI
- Speed: 5400 RPM

**Guarantee**
- Complete with manufacturer's warranty
- Limited lifetime warranty

**Ordering**
- For more information, please contact us at 01-679 1866 or sales@jaguardiskdrives.com

---

**COLOUR AND MONOPHONIC MONITOR SPECIALS**

**SYSTEM ALPHA** 14" COLOUR MULTI INPUT MONITOR

Made in the UK by the famous REDIFFUSSION Co., for their own professional computer system this monitor has all the features to suit your immediate and future monitor requirements. Two video inputs: RGB and PAL, Composite Video allows the connection to the BBC and most other monitors and VCRs. An normal speaker and audio amplifier may be connected to your systems output or direct to a VCR machine, giving superior sound quality. Many of these monitors have been specially designed with a high quality VESA connector. "Triple" stand alone monitor, Separate Contrast and Brightness - even in RGB mode. Two types of audio input, Separate Colour and audio outputs for Composite Video input, BNC, USB for composite input, 15 way 'D' plug for RGB input, modular construction etc.

**Priced** £149.00

**Ordering**
- For further information, please contact us at 01-679 1866 or sales@monitor specials.com

---

**DECCA 80 16" COLOUR MONITOR, RGB**

This range of professional quality monitors must be seen to be believed. Decca monitors are a joy to use. This model but the standard 80 display, graphics, cursor position and control, MIDI ports, RGB and composite video inputs, RS232 serial interface.

**Priced** £800

**Features**
- High quality, professional digital monitor
- RGB and composite video inputs
- RS232 serial interface
- Suitable for professional use

**Specifications**
- Model: D8016
- Display size: 16"
- Resolution: 800x600
- Controls: RGB and composite video inputs, RS232 serial interface

**Guarantee**
- Complete with manufacturer's warranty
- Limited lifetime warranty

**Ordering**
- For further information, please contact us at 01-679 1866 or sales@deccamonitors.com
Short-Range Transmitter For VCRs

Mastertronic have developed a UHF amplifier and aerial unit which will broadcast pictures from a video cassette recorder so that they can be picked up by nearby television sets.

The system has a range of about 45 feet and could be used, for example, to transmit the signal from a centrally placed VCR to a portable TV elsewhere in the house or to enable one VCR to be used with several TV sets simultaneously.

The Video + system transmits a UHF signal from the output of the VCR, amplifies it and feeds the output to a short, detachable aerial. Because the final output is only an amplified version of the VCR signal, the transmission frequency will be that to which the VCR is tuned and the programmes can be picked up on the TV channel normally used when the VCR is plugged in directly.

The nominal bandwidth of the amplifier covers UHF channels 32 to 40 with a maximum usable bandwidth extending from channel 21 to channel 60. Two touch panels on the front of the unit increase or reduce the gain, the result being shown on a bargraph type LED display. This makes it possible to select the minimum output power necessary to achieve good reception. It may come as a surprise to some readers to learn that retransmission in this way is not illegal, but Mastertronic assure us that they have had a team of lawyers working on the case and that even after contacting eighteen Home Office departments they have not been able to find any legal impediment.

Mastertronic are marketing the Video + unit with the domestic user very much in mind, but also expect it to be of use in schools, colleges, conference centres, hotels, etc. It will be sold through leading high street electrical shops at a recommended price of £149.95 including VAT, complete with mains lead, aerial and VCR connecting lead.

Mastertronic, Park Lorne, 111 Park Road, London NW8 7JL, tel 01-732 9242.

Key Note

Next time you fancy a little innocent amusement on a crowded bus or train just try clapping three times. You may be unlucky and elicit nothing more than a few odd looks on the other hand, you may be rewarded with a cacophony of high-pitched bleeps and a frenzied rustling noise as dozens of embarrassed faces disappear behind their daily papers.

For Dudley Langmead Enterprises have introduced the Key Tracer, an electronic keying which looks well set to replace the electronic alarm watch as the principal cause of unintended reaping in public places.

The Key Tracer is designed to help those who habitually mislay their keys and behaves like any other keying until activated by the sound of three claps. It then emits the aforementioned high-pitched tone, alerting the owner to its presence and passers-by to its owner's carelessness.

The social impact of such an invention may well be out of all proportion to its size. We will probably get used to seeing our public spaces filled with people who wear anxious looks and stride around clapping rhythmically, and unpopular orators will no doubt come to accept the high-tech accompaniment which starts up shortly after the first few rounds of slow hand-clapping.

However, we can only be thankful that Dudley Langmead did not go for voice pattern recognition and that we are spared the sight of distracted owners calling “Here, Keying, Keying” as they wander.

The cost of this miraculous device is surprisingly modest at £6.95 and the manufacturers are surely to be congratulated on their achievement. But please, no applause. You never know what might result.

Dudley Langmead Enterprises Ltd, 16 Bedford Street, Hitchin, Hertfordshire, tel 0462-35928.

MS Components have published a new electronic components equipment catalogue, Its 300 or so pages contain details of around 10,000 products and the company say they can despatch all orders on the day of receipt. Copies are available free of charge from MS Components Ltd, Zephyr House, Waring Street, West Norwood, London SE27 9LH, tel 01-670 4466.

Honeywell have issued the latest edition of their quarterly journal, Scientific Honeywell. It includes an article on secure computer systems which explains how sensitive data can be protected against ‘hackers’, and also has an article describing an intelligent computer program which can be used in the design of large computer systems tailored to suit particular applications. Copies of the magazine are available free of charge from the Information Desk, Honeywell Information Systems Ltd, Honeywell House, Brentford, Middlesex TW8 9DH, tel 01-568 9191.

There are still areas in which valves reign supreme, some of them very specialised. Among the companies supplying some of the more exotic types are Westinghouse, who have just published a new, sixteen page catalogue. It covers high vacuum (triode) amplifiers, high vacuum (triode) pulse amplifiers and high vacuum diodes for use in industrial, broadcasting, radar and similar applications, and the guide includes specifications and detailed scale drawings. Copies are available from Peter Collings, Westinghouse Electric SA, Industrial and Government Tube Division, 43 High Street, Marlow, Buckinghamshire SL7 1BD, tel 06284-75876.

Semiconductor Supplies are distributing an eight-page brochure which describes their range of Kaise and Eagle power supplies and test meters. The power supplies include fixed and variable voltage regulated types and also steplessly variable regulated units. Both analogue and digital meters are available, the analogue types having input sensitivities up to 100,000 ohms per volt and there is also a range of AC and DC clamp meters, isolation testers, earth testers and an analogue light meter. Copies are available from Peter Cresswell, Semiconductor Supplies International Ltd, Dawson House, 128-130 Cashalton Road, Sutton, Surrey, SM1 4RS, tel 01-643 1126.

ETI OCTOBER 1985
Cable Length Meter

MK are marketing a portable meter which will measure electronically the length of a piece of cable or the distance to a break or short circuit.

The Lacopet CL-100AU can measure cable lengths from 1 metre to 1000 metres and will work with both two-core and coaxial cables. It works by injecting a 1kHz signal into the line and then measuring the response.

In use, the meter is first calibrated using a 1m piece of cable identical to the length under test. It can then be connected to the unknown cable and a direct reading of length obtained. It could be used, for example, to measure the amount of cable on a drum without uncoiling it or the distance to a break or short circuit in a buried cable.

The CL-100AU is battery operated and has a basic accuracy of ±5% of FSD. A phono output is provided so that the 1kHz tone can also be injected into cables or equipment for signal tracing purposes.

The meter measures 163 x 100 x 47mm and weighs 300g. It comes complete with all test leads, batteries, a carrying case and an instruction manual and has a neck harness which allows it to be supported at a comfortable viewing angle in front of the user whilst leaving the hands free. Optional extra include a signal tracer which can be used to detect the 1kHz output tone.

The CL-100AU costs £199.75 plus VAT and the optional signal tracer costs £125.00 plus VAT complete with case, batteries and earphone. Also available is the CL-100AUK which is generally similar to the CL-100AU but has a measuring range of up to 5000m. It costs £445.00 plus VAT.

TMK Test Instruments, 138 Grays Inn Road, London WC1X 8AX, tel 01-837 7937.

---

Careers Advice Centre

A Careers In Engineering centre will be one of the features at the Technology Engineering Fair, to be held at the NEC, Birmingham from 8-11th October.

The centre will be staffed by representatives from leading engineering employers and technical institutes and will offer advice on career opportunities to students and engineers who are currently unemployed. Advice will also be available for engineers who are in employment but feel that their skills are not being fully used.

The centre will be opened by Sir Monty Finniston. For details contact Juliet Northage, Canvas Exhibitions Ltd, Chatsworth House, 59 London Road, Twickenham, Middlesex TW1 3SZ, tel 01-891 5051.

---

SIREN KIT
Produces a loud swept frequency tone from a 9-18V supply. Enable input for easy connection to alarm circuits. Includes 10m of feed low speaker £7.90
Mini siren (with small speaker & box) £4.30

PASSIVE IR DETECTOR
Detectors intruders body heat at up to 1m. 12Vdc supply. Output N/C connections 900 135 £45.00

BELL BOX
Bronze coloured and a degree by mile £8.50

XENON BEACON
12V 170mA duration weatherproof 930 135 £10.50

PRESSURE MASTS
25 x 125 £2.00
25 x 180 £2.60

ALARM CONTROL UNIT
4 input circuits, 2 instant delayed and 2 delayed. Adjustable entry and alarm times. Built-in test, full instructions supplied. £180 130 x 30mm £26.00

TOOLSMETRIC RING 230 990 £10.00

BATTERIES
Momentum AA 90p & Chargers

PANETTE KITS
N/C £1.50 & £2.00
Prices £1.50 & £2.00

ROSS WILKINS KITS
Free 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

Telephone orders - Access & Barclaycard RING 01-567 8910 (24hrs)

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!

FREE 28 page catalogue. Send 5s & SAE NOW!
Temperature Indicating Paint

Redpoint have introduced an improved version of their Spectratherm paint, a substance which changes colour to indicate the temperature of the surface on which it is coated. The new formula measures temperatures over the range 58-117°C and can be used to check the temperature of semiconductors, heatsinks and other electronic devices.

Spectratherm is available as a kit of three bottles, each of which has a brush built into the cap. It can be applied to any dark surface and the temperature can then be assessed by comparing the paint colour with a printed spectrum chart provided. Redpoint claim that under laboratory conditions it can be used to check the temperature to within 0.5°C.

Spectratherm works best on non-reflective surfaces but shiny semiconductor packages and similar finishes will give reliable readings if they are rubbed over with a black felt pen first.

Redpoint expect the new paint to be of interest to most electronic engineers and especially to test and quality assurance engineers. They plan to introduce an airbrush so that Spectratherm can be used for temperature mapping on large surfaces.

The three bottle kit costs £25.30 including VAT and postage and packing, and further details can be obtained from Redpoint Limited, Cheney Manor, Swindon, Wiltshire SN2 2PS, tel 0793-37861.

- NEC claim to be both a world leader in relay technology and a pioneer in fibre optic communications. To prove it they have published a 122-page guide to their relay products and a 344-page book on fibre optics, both of which are said to contain technical data, reference guides and a glossary of terms and definitions. Copies are available free-of-charge from NEC Electronics (UK) Ltd, Carlin Industrial Estate, Motherwell, Scotland ML1 4UL, tel 0696-732221.

- ECW have an easy-to-build stereo VU meter kit which uses rows of 16 LEDs to give a bargraph-type display. It operates from a 12V DC supply, has an input impedance of 10k and a sensitivity of from 100mV to 10V full scale. The kits cost £20.85 including postage, packing and VAT from Electronics & Computer Workshop Ltd, 171 Broomfield Road, Chelmsford, Essex CM1 1RY, tel 0245-262149.

- Axiom Electronics have signed an agreement with ITT Cannon under the terms of which they will distribute a wide range of Cannon connectors. They can also provide free copies of technical literature and specifications on the new product lines which include D subminiature connectors, the DIN 41612 range, Solda-D, D'U' and low cost plastic connectors, turned-pin IC sockets, chip carrier and pin grid array sockets, and IDC connectors. Axiom Electronics Ltd, Tumpike Road, Cressex Estate, High Wycombe, Buckinghamshire HP12 3N, tel 0494-442181.

---

Happy Memories

<table>
<thead>
<tr>
<th>Part type</th>
<th>1 off</th>
<th>25-99</th>
<th>100 up</th>
</tr>
</thead>
<tbody>
<tr>
<td>4116 200ns</td>
<td>.99</td>
<td>.99</td>
<td>.99</td>
</tr>
<tr>
<td>4164 150ns Not Texas</td>
<td>.99</td>
<td>.99</td>
<td>.99</td>
</tr>
<tr>
<td>4128 150ns</td>
<td>.99</td>
<td>.99</td>
<td>.99</td>
</tr>
<tr>
<td>4256 150ns</td>
<td>.99</td>
<td>.99</td>
<td>.99</td>
</tr>
<tr>
<td>2114 200ns Low Power</td>
<td>.99</td>
<td>.99</td>
<td>.99</td>
</tr>
<tr>
<td>2016 150ns</td>
<td>.99</td>
<td>.99</td>
<td>.99</td>
</tr>
<tr>
<td>6264 150ns Low power</td>
<td>.99</td>
<td>.99</td>
<td>.99</td>
</tr>
<tr>
<td>2716 450ns 5 volt</td>
<td>.99</td>
<td>.99</td>
<td>.99</td>
</tr>
<tr>
<td>2732 450ns Intel type</td>
<td>.99</td>
<td>.99</td>
<td>.99</td>
</tr>
<tr>
<td>2732A 350ns</td>
<td>.99</td>
<td>.99</td>
<td>.99</td>
</tr>
<tr>
<td>2535 40ns Texas type</td>
<td>.99</td>
<td>.99</td>
<td>.99</td>
</tr>
<tr>
<td>2764 300ns Sult BBC</td>
<td>.99</td>
<td>.99</td>
<td>.99</td>
</tr>
<tr>
<td>2712 300ns Sult BBC</td>
<td>.99</td>
<td>.99</td>
<td>.99</td>
</tr>
<tr>
<td>Low profile IC sockets:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pins</td>
<td>814</td>
<td>814</td>
<td>814</td>
</tr>
</tbody>
</table>

Available now — The ROAM BOARD for the BBC Micro. Reads Roms via a Low Insertion socket and saves their contents as files, then reloads a file into its sideways RAM as required. Full details on request.

74LS series TTL, wide stocks at low prices with DIY discounts starting at a mix of just 25 pieces. Write or phone for list.

Please add 50p post & packing to orders under £15 and VAT to total. Access orders by phone or mail welcome. Non-Military Government & Educational orders welcome., £15 minimum.

HAPPY MEMORIES (ETI),
Newchurch, Kington,
Herefordshire HR5 3QR.
Tel: (054 422) 618
STC have published the 1985 edition of The Tool Book, an 80-page catalogue of tools, service aids, storage equipment and cells and batteries. Over 400 products are listed, from screwdrivers to complete soldering/desoldering stations. Also available is The Electronics Book, a catalogue of electronic components which runs to nearly 700 pages and contains information on almost 40,000 products. Included are details of Estelle, their on-line ordering and information system which is available to anyone with a computer and modem. Both books are available free-of-charge from STC Electronic Services, Edinburgh Way, Harlow, Essex CM20 2DE, tel 0279-26777.

The Institute of Electrical Engineers are planning to produce a Guide for Industry on the Design and Achievement of Testability in engineering products. They say that it is debatable whether some of today's sophisticated micro-electronics designs can be tested completely (see our article in this issue for more on this) and hope the Guide will help designers to incorporate test procedures to help overcome the problem. Anyone who feels they have anything to contribute should contact the IEE, Savoy Place, London WC2R 0BL, tel 01-240 1871.

PSP have updated their free-form literature which contains photographs and information on their range of connectors. They are distributors for ITT Cannon, Thomas & Betts, Transradio, ITT Pomona, Panduit and Souriau and their range covers just about every conceivable application. PSP Electronics Ltd, Unit 2, 2 Bilton Road, Perivale, Greenford, Middlesex UB6 7DX, tel 01-988 9061.

Transformer Design Service

Avel-Lindberg have set up a new department which can produce small quantities of toroidal transformers designed to the requirements of individual customers. The Small Quantities and Prototype Department can produce transformers in batches of from one to twenty units. They say they can tackle anything within the limits imposed by winding machine and wire technology and offer ratings from 10VA to 3kVA. Finishing options range from Mellenextape winding through to full impregnation and resin filling and they can cope with most special requirements regarding insulation and magnetic shielding. Transformers can be constructed to meet all specifications, including Defence Standard 05-24.

Avel-Lindberg use a computer to speed up the design process and can execute the simpler jobs in a few hours. In practice, they feel that most such requirements will be catered for in their standard range and expect the new service to be used mainly for more complex jobs, some of which may need to be passed back and forth between them and the customer before the design is perfected.

Avel Lindberg Ltd, South Ockenden, Essex RM15 5TD, tel 07080-853444.
DIARY

Electronics for Peace: London Group Meeting — September 5th
London New Technology Network, Camden, London, 7.30 pm. For details see September '85 ETI or 'phone 01-541 1825.

Vacation School On Cable Television — September 9-13th
Leeds Polytechnic. For details see September '85 ETI or 'phone 01-240 1871 extension 270.

RAE Course Enrolment - September 10th
Bradford & Ilkley Community College, Bradford. For details see September 1985 ETI or contact P. Nurse, Bradford & Ilkley Community College, Great Horton Road, Bradford, West Yorkshire BD7 1AY.

Interconnection Europe — September 10-12th
Cumberland Hotel, Marble Arch, London. For details see February '85 ETI or 'phone 0582 - 417438.

Alarm Training Seminars — September 24-27th
Castle Alarms, Windsor. Four one-day training seminars covering the basic technology, avoiding false alarms, system design and specification and business study. Aimed at engineers, security staff, management and surveyors, the cost is £85 plus VAT per day including lunch and refreshments. Castle Alarms and Electronics, North Street, Winkfield, Near Windsor, Berkshire SL4 5YV, tel 0344-886446.

Programming in C: A Hands-On Workshop — September 24-27th
London: venue to be announced. For details see July '85 ETI or contact ICS at the address below.

Computer Graphics Course — September 24-27th
Venue to be announced. For details see July '85 ETI or contact ICS at the address below.

Semiconductor International — October 1-3rd
NEC, Birmingham. For details see August '85 ETI or contact Cahner's at the address below.

System Security Conference — October 2/3rd
Tara Hotel, London. For details see August '85 ETI or contact Online at the address below.

Offshore Computers Conference & Exhibition — October 8-10th
Aberdeen Exhibition & Conference Centre. Conference devoted to the use of computers in petroleum exploration. Thirty-seven papers from seven countries will be presented and the costs range from £160.00 + VAT for one day to £390 + VAT for the full event. Entry to the associated exhibition is free. Contact Offshore Exhibitions and Conferences Ltd, Rowe House, 55-59 Fife Road, Kingston upon Thames, Surrey KT1 1TA, tel 01-549 5831.

Technology Engineering Fair — October 8-11th
NEC, Birmingham. For details see August '85 ETI or contact Cahner's at the address below.

Internecon UK — October 10/11th
Metropole Hotel and Brighton Centre, Brighton. For details see August '85 ETI or contact Cahner's at the address below.

Computer Graphics '85 — October 15-18th
Wembley Conference Centre, London. For details see August '85 ETI or contact Online at the address below.

Electronic Displays '85 — October 29-31st
Kensington Exhibition Centre, London. For details see September '85 ETI or contact Network Events at the address below.

Addresses:
Cahners Exhibitions Ltd, Chatsworth House, 59 London Road, Twickenham, Middlesex TW1 3SZ, tel 01-891 5051.
ICS Publishing Co (UK) Ltd, 3 Swan Court, Leatherhead, Surrey KT22 8AD, tel 0372-379211.
Network Events Ltd, Printers Mews, Market Hill, Buckingham MK18 1JX, tel 0280-815226.
Online Conferences Ltd, Pinner Green House, Ash Hill Drive, Pinner, Middlesex HA5 2AE, tel 01-868 4466.

DIGITAL ELECTRONICS

SUPERKIT £22.00
SUPERKIT II £16.00
(£35.00 if bought together)

The SUPERKIT series introduces beginners to practical digital electronics.
SUPERKIT (SUP I) is the first kit, which contains an instruction manual, a solderless breadboard, and components (7 Integrated Circuits, Switch, Resistors, Capacitors, LEDs and wire). It teaches Boolean Logic, gating, flipflops, shift registers, ripple counters and half adders. SUPERKIT II (SUP II) extends SUPERKIT. It contains an instruction manual and components (10 integrated circuits, 7-segment display, resistors, capacitors and wire), and explains how to design and use registers, adders, subtractors, counters, registers, pattern recognisers and 7-segment displays.

DIGITAL COMPUTER LOGIC

£7.00

DIGITAL COMPUTER DESIGN

£9.50

MICROPROCESSORS & MICROELECTRONICS

£6.50

The SUPERKIT series is backed by our theory courses. DIGITAL COMPUTER LOGIC (DCL), the beginners course, covers the use and design of digital circuits and flipflops and registers. DIGITAL COMPUTER DESIGN (DCD), a more advanced course, covers the design of digital computers both from their individual logic elements and from integrated circuits. MICROPROCESSORS and MICROELECTRONICS (MIC) teaches what a microprocessor is, how it evolved, how it is made and what it can do.

GUARANTEE: If you are not completely satisfied, return the item to us in good condition within 28 days for a full refund. All prices include worldwide surface postage. Please enclose a cheque or bank draft drawn on a London bank.

CAMBRIDGE LEARNING LTD
Unit 15, Rivermill Site, FREEPOST,
St. Ives, Huntingdon, Cambs PE17 4BR, England.
Telephone: 0480 674466.

Please send me (initial letters used):

SUP I DCL
SUP II DCD
SUP I + II MIC
£22.00 £7.00
£16.00 £9.50
£35.00 £6.50

full details of all your courses [please tick] I enclose a cheque/PO payable to Cambridge Learning Ltd, for £

Please charge my credit card.
Name
Credit Card

No. Expiry date

Telephone orders from credit card holders accepted on 0480 674466 (24 hrs).

CAMBRIDGE LEARNING LTD
Unit 15, Rivermill Site, FREEPOST,
St. Ives, Huntingdon, Cambs PE17 4BR, England.

ETI OCTOBER 1985
ACORN COMPUTER SYSTEMS
BBC Model B Soclad offer... £300 (a)
BBC Model B + Ethernet... £335 (a)
BBC Model B + DFS... £395 (a)
BBC Model B + DFS + Ethernet... £409 (a)
UPGRADE KITS... £35 (d)
ACORN ADD-ON PRODUCTS
6502 2nd Processor... £176 (a)
Tactel Adaptor... £190 (b)
Music 500... £175 (b)
RH Light pen... £29 (d)
SWIVEL STAND... £7.50 (d)
TORCH UNICORN products including the IBM Compatible GRADUATE in stock
For details of any of the BBC Firmware/Peripheral listed here or information on our complete range please write to us.

PRINTERS
EPSON
RX80FT + £220 (a)
RX80FT + £210 (a)
LX80 the new NLQ printer £224 (a)
FX90 + £245 (a)
FX100 £345 (a)
FX100 £345 (a)
JX80 £49 (a)

ACCESSORIES
32K Internal Buffer £99 (b)
Serial Interface: 8143 £28; 8148 with 2K £99 (a)
Paper Roll Holder £17 (d)
FX60 Tractor Attachment £25 (e)
Ribbons: FX/PU/PU/PU/PU 365 (c)
RX/FX80 Dust Cover £64.50 (a)
KAGA TAXAN
RS232 with 2K £25 (a)
KP810/10 Ribbon £86 (d)
JX80 £100
RS232 with 2K £25 (a)
KP810/10 Ribbon £86 (d)

MODEMS
— All modems listed below are BT approved

MIRACLE WS8000:
The ultimate world standard modem cover all common D/T/T/T standards outside the UK up to 1200 Baud. Allows compatibility with U.K. Acorn computer system in the world. The optional AUTO DIAL and AUTO ANSWER facilities are available on the modems powered £150 (b), Auto Dial Board/Auto Answer Board £50 (d) each. Parallel cable £35, software £60.50.

NEW SERIES MODEMS
WS8000 V12/19 (V102) £69 (a) any of the BBC Firmware/Peripheral listed here.

QUALITY DISCS

3M 5" FLOPPY DISCS
High quality discs that offer a reliable error free performance for life. Each disc is individually tested and guaranteed for life. Ten discs are supplied in a sturdy cardboard box.

SPECIAL OFFER
276-625... £2.50
27128-25... £25.00
6264LP-15... £6.00

CONNECTOR SYSTEMS

EDGE CONNECTORS

AMPHENOL CONNECTORS

TELEPHONE CONNECTORS

RIBBON CABLE

DIL SWITCHES

MICS/COMBS

14 ETI OCTOBER 1985
Holey Filing System

Dear Sir,

It is now over a year since I submitted an item for your Tech Tips feature. I can only presume it is among the lost. I shall not moan about not hearing from you, etc — let him with the perfect filing system cast the first stone. But please, please, let me hear from you soon. I can even take a rejection letter. Of course, I would much rather take that cheque for I am only a poor preacher (as you would realise if you had heard me).

Yours sincerely,
Alan Sharp (Rev.)
Aberdeen

Fear not, Reverend Alan, for that which was lost has been found and is even now among the chosen, in that heavenly place which men doth call the EITI Tech Tips feature. And great shall be your reward (well, almost) for your name is written in the book (in our accounts department) and a small slice of mammon will shortly be winging its way to you.

Thinking Along The Right Lines

Dear Sir,

Further to the article Trains of Thought in the September issue, I find Roger Amos' dual controller intriguing.

I would like to experiment along these lines and would appreciate a sight of his circuit. Perhaps we could have a further article on the subject?

Yours faithfully
C.W. Davies
Cardiff

I'm sure a lot of readers would like to experiment along these lines, so as soon as we track down Roger we'll pass on your comments.

Some Cases For John Linsley Hood

Dear Sir,

I read Dr P.A. Joiners letter in the August edition of ETI with great interest, because I have been trying since February to get a copy of Newrad's well advertised catalogue.

I have written on three separate occasions sending a large stamped addressed envelope as instructed. I have also made countless phone calls only to be answered by a phone answering system. I left my name and address and a message. On one occasion the phone was actually answered by a human being and I was told "our catalogues are being printed and you will receive one in two weeks" that was two months ago. Do these people want any customers?

Yours faithfully
M.B. Blicting
Basingstoke

Dear Sir,

I greatly enjoyed reading John Linsley Hood's constructional series on his 80W amplifier design. However, for those of us who can't afford to build this design (or who do not require the power output), would it not be possible to persuade him to resurrect and update his simple Class-A design?

If the design could be updated to 15 or 20 watts and the high sensitivity input of the 80W design retained, life would be wonderful.

Yours faithfully
Colin Shelbourn
Winchermere

The Class A amplifier (a design which was not originally published in this magazine, incidentally) would require significant modification before it could offer the sort of power levels you are talking about and even then the increase in volume level would be negligible. We will pass your comments on to JLLH, of course, but he may not have much time to consider them since he is busy working on his next ETI design!

Dear Sir,

I have recently built the Linsley Hood 80 watt amplifier, not from a kit but by etching my own boards and buying in components from suitable suppliers. I am generally pleased with the results and can confirm the claims for the quality of the sound. The treble is more open and free from the 'tinselly' sound of my previous amplifier, and the overall sound is more detailed.

I do feel that I must take issue with Mr Linsley Hood on his choice of input sensitivity. The amplifier seems to be too sensitive and I have found it impossible to get rid of the hum induced from the input leads. I feel certain that this problem could be overcome by reducing the sensitivity to 774mV into 600Ω for full output.

I have tried to do this using a potential divider at the input in place of the volume control (I have a volume control in my pre-amplifier) but the hum problem remains. The most obvious solution would be to increase the negative feedback but I do not have the experience to do this. Would it be possible to prevail upon the designer to produce an alternative input arrangement, with a sensitivity tailored to 774mV at 600Ω?

I think that, if you consider the sources available today, this is a more realistic input requirement. Compact disc players have a standard output of about 2 volts, and I am sure that anybody who has one will agree that they are the highest quality source available. Radio sources can quite easily be amplified up to the level, and with the passage of time we may well see tuners produced which match the output of CD. The poor old vinyl disc section won't suffer from a bit of extra amplification, the quality being so obviously inferior anyway!

Yours faithfully
D.I. Field
Bath

It seems unlikely that hum problems should arise from JLLH's choice of input sensitivity and impedance. After all, if the input is too sensitive, simply turn the volume control down. If you still suffer from hum problems when the system is used at normal listening levels, the problem is not one of excessive sensitivity.

Too high an impedance can lead to hum pick-up, but the Audio Design amplifier has input impedances of approximately 47k into the disc stage and 100k into the main buffer stage, and both of these figures are perfectly standard. The 600Ω professional standard does have distinct advantages in the electronically noisy environment of a stage or recording studio (particularly when, as is usual),
the lines are also balanced to ground, but its advantages in a domestic environment are minimal and changing to the system is most unlikely to cure your hum problem. And even a change of input impedance and reduced sensitivity likely to produce a solution, increasing the negative feedback would not be the best way of going about it. Changing the level of negative feedback in a carefully designed amplifier is guaranteed to have far-reaching and almost certainly unpleasant effects.

It seems more probable that your problem is caused by a hum loop or some similar wiring problem. If in doubt, why not send our Auntie Static a few more details of the problem with a diagram of the present wiring arrangements?

International Electronics
Dear Sir,
Greetings to all Electronics Today magazine staff. Please allow me to say something about myself. My name is Rodney Dulce and I'm 16 years old. I'm studying to be an electronics technician here in the Philippines.

I really like to read Electronics. Today because it helps me with the school work. I have used the magazine as a reference for my school assignments and I consider it to be the best of its kind. It's very educational.

Unfortunately, most of the copies of ETI! that I see are long out of date and are only borrowed. I would really like to have my own copy each month but I just cannot afford to buy it. My country has been facing an economic crisis for more than a year now and we are greatly affected by it. If I could spend enough on basic needs and I am just hoping that I can continue to attend the school.

The reason I am writing to you is that I would like to ask a favour. If possible I would like to have some back numbers of your magazine because I believe they would really help me. Even better would be to have a free subscription. I'm really ashamed at having to ask this but I do believe your magazine could help me a lot. I ask for your kindness and understanding.

Thank you so much and all power to the magazine. Very respectfully yours, Rodney Dulce
Cebu City, Philippines

We have sent a parcel of back issues off to Rodney, but we are unable to help him with a free subscription. As you might imagine, we get a lot of requests for such favours and we cannot afford to help all of them, nor have we the time or the ability to determine which are deserving cases and which are not. Instead, it occurred to us that some of our readers might like to help. If anyone is interested in writing to Rodney and sending him their old copies on a regular basis, we would like to hear from them. It might be best if a group of individuals got together, or perhaps an electronics class in a school or college, and shared the postage costs.

Rather than risk having Rodney buried under a mountain of letters which he might then feel obliged to reply to, we have not printed his address but ask readers to write to us in the first instance. We will then sort through the response and pass on his address to those who seem best placed to help him. — Ed.

Newrad Instrument Cases Ltd
Unit 19, Industrial Estate, Gorse Road
New Milton, Hants BH25 0GJ
Tel: New Milton 0463 021118

19 inch Rack Mounting enclosures complete with chassis and top and bottom covers. Front and rear panels are aluminium and flat for easy machining. These panels are located with heavy duty aluminium extrusions. Front and rear panels are satin anodised. Covers are finished in cream.

4U heights and depths of 400mm are available in minimum quantities of 10.

PRICES ARE EXCLUSIVE OF VAT. P&P £2.50.

Please call or write:
SME Limited, Steyning, Sussex, BN4 3GY
Telephone: 0903 814321 Telex: 877808 G
Dear Auntie,

I am at present building a hi-fi pre-amplifier which I hope to make remote-controllable, using the Plessey ML920 remote control receiver. Since I would like the amplifier to be the hi-end of fi I would appreciate your advice on the following:

1) What would be the best means of input selection? I had thought of using a pair of LM1037 audio switches, but the specified THD of 0.04% seems rather high. Would using individual FETs or DTL relays be more advantageous?

2) Can you suggest an appropriate IC to decode the 5-bit binary program selection output of the ML920?

3) Is the Mullard TDA1074 of high enough quality to be used as a volume and balance control?

Yours sincerely,
David Tich
Sandton
South Africa

Your letter raises all kinds of interesting questions. On your first point, I can't tell you whether or not a THD figure of 0.04% will be suitable for your purposes — that is for you to decide — but a few general comments may help you to make up your mind.

If you look at the data sheet for the LM1037, you will find that 0.04% is a 'typical' distortion figure measured with a 1kHz 1V RMS input signal. Now, we all know that audio components tend to perform better towards the middle of the audio frequency range than at either end — distortion at 10Hz or 10kHz could well be much higher — but something even more misleading has crept in. What on earth is a typical distortion? If you buy an LM1037, can you be sure that the distortion will be 0.04% even at 1kHz? No, of course you can't.

Look again at the data and you'll find a maximum distortion figure of 0.1% quoted (again at 1kHz 1V RMS). This is a better figure to work with. If you design an amplifier expecting results based on this figure, the chances are you'll do better than you expected, but if you use the typical figure you could be very disappointed. It is just a meaningless number which helps the manufacturer to sell ICs. There is not even a standard way of calculating 'typical' performance figures. Is the mean of a batch of measurements? The median? Or just a figure chosen at random? I know where I'd place my bets.

You may think I'm rather labouring the point, but 'typical' performance figures are creeping in all over the place, so be on your guard! Engineers will always work with worst case figures — if they can. They base their knowledge on that basis, any additional performance is a bonus. Taking 'typical' figures is just taking a gamble on whether or not the equipment will perform adequately. Having got that off my chest I will return to the best means of input switching. As it happens, the distortion figures for the LM1037 are fairly constant from 20Hz to around 10kHz, obtained if putts from 100mV RMS to 5V RMS. For good signal-to-noise figures, very small signals from record cartridges and such like should, of course, be amplified before being applied to the switch.

The LM107 is a bipolar switch, if the circuit schematic is to be believed. It consists of a long-tailed pair for each input, the switching being achieved by turning the tail current sources on or off. You may well be able to achieve better distortion figures by using FETs, or the type of analogue switch consisting of FETs and switching logic in all one package. The results you will achieve with this type of device will depend as much on your design skills as on the device itself as the performance depends to a great extent on how it will interact with other components in the circuit.

If you use relays, it is generally frowned upon to introduce unecessary mechanical switching into the path of an audio signal. As hi-fi is an area where designers seem to support their own pet theories, as much as people of different inclinations might support a football team, I think it best to attempt to ascertain whether this is a genuine engineering problem or just another piece of esoteric nonsense that surrounds hi-fi in general. After speaking to a number of relay manufacturers and audio engineers, the picture seems to be like this. First of all, new relays don't cause problems. You use cheap 'n' cheerful relays, however, odd things can happen as they age. Silver contacts can end up with a coating of silver sulphide and unsoldered type will gather dust and all kinds of grit from the environment on their contacts. The result is that if very small signals are applied, the contacts can rectify to some extent, appear to have a high resistance, or even fail to conduct at all.

Remembering that today's bog standard is yesterday's state of the art, engineers ten years ago would have found relays troublesome. One answer that seems to have been used was to apply a DC 'wetting' current to the contacts and to superimpose the audio signal on top of this. You can then use the tiniest relays and other noises that would be heard from the speakers any time the relay contacts opened or closed. Naturally enough, relays were generally avoided when possible. Sad to say, instead of keeping up with technology, the idea that relays are no good for audio systems has entered hi-fi mythology as a rule to be followed come what may.

I am assured that a modern sealed relay with precious metal contacts that has been designed for signal switching is as good as, and often better than, solid state switches. There are even cases for demanding applications such as monocouple switching where the signal is likely to be a few mV at the expense of a 5A and no thermal cycle on the relay's own contact material. Can be tolerated. If you buy any old relay the chances are you'll have problems. If you buy the designed for signal switching, you won't.

Now to your second question. The ML920 is one of a series of remote control ICs from Plessey. The transmitter, SI490, responds to a switch matrix by generating one of 32 possible output codes according to the switch pressed. These codes are transmitted via an infra-red or ultrasonic link.

At the receiving end, the ML920 is one of a number of possible decoder/program selection engines. The AT921 decoder IC is a 5-bit binary code decoder which translates the 8 bits of the ML922, a 5-bit decoder and the control signals (from the ML922), and various other combinations of analogue and digital outputs.

Any further decoding you do will depend on the details of your circuit. The digital outputs are CMOS compatible (but not TTL) so any CMOS ICs can be used. You may choose to ten line decoder with the ML922, for instance. I can't really be more specific than that.

Now for the TDA1074. Not having any data on this IC, I can only give you the previous thing and phonod Mullard. They claimed that it is indeed suitable for hi-fi, and since they were honest enough to say that some of their newer ICs were not up to the mark, you may choose to use it. Otherwise, I suggest you get hold of a data sheet and judge for yourself — Auntie.
For help with Reading and Writing

01-405 4017

Since 1975, 350,000 adults have been helped to read and write better. If you want help look for this sign.

For further information
Adult Literacy & Basic Skills Unit
PO Box 213 London WC1V 7ET
THE REAL COMPONENTS

John Linsley Hood brings his series to a close with a look at digital logic ICs.

The world of electronics is becoming dominated, increasingly, by digital devices and techniques. I suspect that some of my fellow electronics engineers, brought up in a far off time when all things were — more or less — linear, feel a little like medieval knights, beleaguered in their castles and surrounded by a sea of advancing black plastic caterpillars.

For myself, I do not complain. There seems nowadays to be a certain scarcity value in understanding how to handle signals that change gradually and irregularly from one voltage to another. However, I think that it is essential to understand the competition, if only so that it may be made to work for oneself as well. One can, even, make digital ICs function in a linear mode — not marvellously, perhaps, but they are certainly inexpensive. Such are the economies of scale for devices made in very large numbers.

However, to begin at the beginning.

Evolution

From their earliest days — and I can remember when a logic gate was a flip-flop made up from a 6SN7 valve — the desirable qualities of logic gates have been the same. A good gate should operate at high speed, have low current consumption and power dissipation, a good speed/power/product, the ability to source and sink a reasonable amount of current, equality of output rise and fall times, good fan-out (the ability to drive many other similar gates), low-noise susceptibility, and low noise generation. They should also be cheap!

Resistor-transistor logic (RTL) was one of the earliest forms of IC logic element and derived from the days when such devices were hard wired from discrete components. RTL ICs were created by the simple process of transferring the whole circuit on to the surface of a silicon slice. I have shown a typical circuit block which will operate as a 3-input NOR gate in Fig. 1.

The snags are that it is slow, has poor input noise immunity in the sense of being able to decide when the input signal is a 0 and when it is a 1, and the on-chip resistors are of such a value that they occupy a large chip area. This is now an obsolete system.

Diode-transistor logic (DTL) represents an improvement over RTL in that the number of resistors has been reduced and the input signal selection is performed by diodes, which don't occupy nearly as much space on the chip.

A typical 3-input NOR gate circuit of this type is shown in Fig. 2.

This style of logic gate is still pretty slow and inefficient in terms of power consumed. This is because the maximum pull-up speed at the output, referred to in the data books as $T_{on}$, is limited by the presence of inevitable output stray (PCB) capacitances, usually in the range 15-50pF. Their effect can be minimised by making R3 very small, but this uses a lot of current in the 'on' condition. They do have a reasonable noise immunity; however, and although obsolescent are still available for direct replacement purposes.

High noise immunity logic (HNIL) is also known as high threshold logic (or HTL), and is of the form shown in Fig. 3. This is a version of DTL in which the input 'on' threshold has been lifted by the inclusion of the zener diode, ZD1. Since there are better ways of achieving the threshold requirement, this type of circuit is also obsolete.

Transistor-transistor logic (TTL) in its 54 (military

Fig. 1 A three input NOR gate using RTL (resistor-transistor logic) circuitry.

Fig. 2 A three input NOR gate using DTL (diode-transistor logic) circuitry.
temperature range) and 74 (commercial temperature range) versions, is, or was, the mainstay of low complexity logic ICs. I have shown a typical circuit, again for a 3-input NOR gate, in Fig. 4. This is quite fast, and avoids the use of an output transistor collector load resistor (R4 in Fig. 1 or R3 in Fig. 2) by replacing it with another transistor (Q3). The output stage has what is described as a totem pole layout, in which, when Q2 is on, Q4 is on and Q3 is off. The only reason R4 is there at all is because the output has to charge stray capacitance in the load and also because, for hole storage reasons, Q4 can be turned on very much faster than Q3 can be turned off. Therefore, in the absence of R4, the peak current on switching transitions could be very high, which would lead to very high dissipations. This brings one immediately up against the fact that there has to be a trade-off between speed and dissipation, and leads to the manufacturers offering several alternative logic forms for different applications. For example, the 74H00 series offers higher speed than the standard 7400 series but has higher current consumption.

**Schottky TTL**

This is a modification to the standard TTL circuit which includes a Schottky diode, based on a metal-silicon junction of the type shown in Fig. 5, connected between the case and collector junctions of each of the TTL transistors. This has the effect of greatly speeding up the switching times by eliminating hole storage in the transistors. The process is illustrated in Fig. 6.

When a bipolar junction transistor is driven very hard into conduction, the collector voltage will fall to a very low forward value which is normally much below the voltage actually applied to the base junction. In this condition, the transistor is said to be driven into saturation. Its recovery time, the amount of time it will take to turn off again, is limited by the need for the electron-hole pairs generated in the depletion region to recombine or be swept out of the junction zone.

This process is greatly assisted by the inclusion of the Schottky diode, as shown in Fig. 7. The diode is very fast in operation, and has a forward voltage in the 'on' state which can be as low as 0.2V. This means that if the transistor of Fig. 7 is turned on by a positive input signal and if the collector voltage seeks to fall 0.2V lower than the applied base potential, the Schottky diode will conduct and feed the base drive current straight through to the collector which prevents the transistor from saturating. Also, while the diode is conducting in the brief period after turn-off, it provides a low impedance return path for the stored charge.

**Emitter Coupled Logic**

ECL takes the form shown in Fig. 8, and is the fastest commercially available logic system. The output signals are taken from the emitters of transistors and developed across relatively low value emitter resistors. Because the transistors act as emitter followers they are, by definition, non-saturating. In addition, because the output impedance of an emitter follower is very low, as a result of the internal negative feedback, the switching transition times are very fast.
In the particular circuit shown, a 3-input OR/NOR, the input transistors Q1–3 act with Q4 as an input
long-tailed pair, in which, if the input goes positive,
Q1–3 collectors will fall in potential and that of Q4
will rise. Q5 and diodes D1–2 just act to hold the base
of Q4 at a fixed potential. It is fairly typical of ECL that
both inverting and non-inverting outputs are
provided.
ECL also has the distinction of being the logic
system which uses the largest amount of power per
gate of all the normal types, and also requires a nega-
tive powersupply line. The symbol for this type of logic
distinguished by the arrows on input and output, as
shown in Fig. 9. The commonly used logic units have
the symbols shown in Fig. 10.

Complementary MOS

CMOS is one of the most useful and versatile of all
the logic types, and is as much liked by the manufac-
turers as it is by me. One of its advantages is a very
high input impedance, which means that there are no
problems over input drive capability from other logic
elements or from outside signal sources. It requires
very little operating power — static values of the order
of 0.01µW/gate are quoted — and it is also quite
tolerant about the supply line voltage. It will accept
a supply anywhere in the range +3V to +15V, and I
have occasionally had circuits survive careless applica-
tion of 20–25V!
As with any other logic IC, it is prudent to lessen
the possibility of unwanted gate triggering from
spurious voltage spikes on the DC supply lines. This is
done by liberally strewing small, non-inductive
capacitors (ceramic disc or similar) along the +ve rail
to decouple this to the ground plane, as close as
possible to the supply input to the IC.
Its popularity with the manufacturers is due to the
fact that CMOS gates are very easy to fabricate, and
use nothing other than P-channel and N-channel MOS
transistors. No diodes, no zeners, no resistors! As an
example I have shown a simple inverter stage in Fig.
11, and a 2-input NOR in Fig. 12.

Fig. 8 A three input OR/NOR gate using ECL (emitter-
coupled logic) circuitry.

Fig. 9 The circuit symbol for an ECL three input OR/NOR
gate.

Its disadvantages are its relatively slow switching
speed and its susceptibility to unwanted signal pick-
up due to its high input impedance gate characteris-
tics. However, unless you are in the world of main-
frame computers, its relatively slow propagation
speed is unlikely to be a major problem. The CMOS
gate inputs are, however, a little static sensitive,
though often the makers protect them by the incor-
poration of the diodes D1–4 shown in Fig. 12.
In the 18 or so years since these devices became
available, I do not know that I have ever damaged one
by careless handling — though I wouldn't go so far as
to say that none have ever given up the struggle
because I inadvertently wired them up in some par-
ticularly idiotic fashion.

Fig. 10 Standard symbols for logic gates. More complex
digital devices such as flip-flops, counters, registers, etc are
shown as rectangular boxes.

Construction Methods

To illustrate the advantage of the CMOS structure, I
have shown in Fig. 13a some cross sections of a
bipolar IC (eg. TTL), showing three of the various cir-
cuit elements. At least nine of these would probably
be needed to make a functioning gate. In Fig. 13b, for
comparison, I have shown the cross section of a com-
plete CMOS inverting buffer.
The more elements there are in an IC, the larger
the chip area and the more costly it will be. Also, the
more complex the IC is, the greater will be the failure
rate for that IC type. Because of this it is understand-
able that a lot of effort has been put into developing
further the simple and compact CMOS structure,
which gives good yields and high profits.

Fig. 11 An inverting buffer using CMOS (complementary
metal oxide silicon) circuitry.
Both Schottky TTL and CMOS types have benefited from a lot of recent development work. In the case of Schottky, the first stage was to reduce the power consumption to something nearer the 1mW/gate figure of low power TTL (74L00), but without the slow response of the 74L00 types (33ns/gate transition). In the event the 74LS00 (Low-power Schottky) types achieve some 9-13ns/gate with a 1mW power outlay.

A further development along these lines has been the Advanced Low Power Schottky types (known as ALS or Fast), which achieve 3-4ns transition speeds and yet only consume 1-2mW/gate.

On the CMOS front, development has involved replacing the aluminium metallising of the gate electrode with polycrystalline silicon. This can be more precisely deposited, in narrower regions, which allows a considerable reduction in the parasitic gate capacitances. The resulting gate propagation delay is of the order of 7-10ns, which is very similar to low power Schottky and faster than the standard 7400 TTL. The poly gate CMOS (74HC00) is specified for operation in the 4.75-5.25V TTL supply range.

**Performance Data**

I have summarised the performance characteristics in terms of speed and current consumption in Tables 1 and 2, and I have provided a pecking order list for the various types in Table 3. However, there are some things which must be borne in mind when reading such data, mainly related to the gentle art of specification writing.

I think the statistics quoted for digital ICs are pretty honest (well, relatively so!). This may have something to do with the fact that the digital circuit fraternity tend to be young, and the writers are, perhaps, not yet steeped in guile. Certainly in the field of linear ICs I...
sometimes get the feeling that the specifications are written by temporarily unemployed science fiction authors.

With regard to the CMOS ICs, the main thing to remember is that the gate propagation delay will be worse at the lower voltages, so the specifications will usually quote the gate delay at 10 or 15V where it is better. There are two types of CMOS IC, the 7400 pin compatible 74C (and now 74HC) varieties, and the generally non-compatible 4000 series. The 4000 series devices will usually be specified for an output (stray capacitance) load value of 15pF, whereas, in practice, 20-40pF is probably nearer the truth. The

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Series Code</th>
<th>Maximum Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low power TTL</td>
<td>74L00</td>
<td>3MHz</td>
</tr>
<tr>
<td>Standard CMOS (5V)</td>
<td>74C00</td>
<td>15MHz</td>
</tr>
<tr>
<td>Standard CMOS (15V)</td>
<td>74C00</td>
<td>15MHz</td>
</tr>
<tr>
<td>Standard TTL</td>
<td>74ALS00</td>
<td>15pF, 60MHz</td>
</tr>
<tr>
<td>Low Schottky</td>
<td>74S00</td>
<td>125MHz</td>
</tr>
<tr>
<td>High speed TTL</td>
<td>74H00</td>
<td>50MHz</td>
</tr>
<tr>
<td>High speed CMOS (5V)</td>
<td>74HC00</td>
<td>50MHz</td>
</tr>
<tr>
<td>Standard Schottky</td>
<td>74ALS00</td>
<td>200MHz</td>
</tr>
<tr>
<td>Advanced low power Schottky</td>
<td>74ALS00</td>
<td>200MHz</td>
</tr>
<tr>
<td>Emitter coupled logic</td>
<td>MC10100</td>
<td>500MHz</td>
</tr>
</tbody>
</table>

Table 1 Contemporary logic IC types ranked according to maximum operating frequency.

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Gate Propagation Delay (per gate)</th>
<th>Power Consumption (per gate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low power TTL</td>
<td>33ns</td>
<td>50pF, 1mW</td>
</tr>
<tr>
<td>Low power Schottky</td>
<td>26ns</td>
<td>15pF</td>
</tr>
<tr>
<td>Low power Schottky</td>
<td>13ns</td>
<td>50pF, 2mW</td>
</tr>
<tr>
<td>Low power Schottky</td>
<td>9ns</td>
<td>15pF</td>
</tr>
<tr>
<td>Advanced Low power Schottky</td>
<td>3-4ns</td>
<td>50pF, 1-2mW</td>
</tr>
<tr>
<td>Standard TTL</td>
<td>15ns</td>
<td>50pF, 10mW</td>
</tr>
<tr>
<td>Standard Schottky</td>
<td>10ns</td>
<td>15pF</td>
</tr>
<tr>
<td>Standard Schottky</td>
<td>4.5ns</td>
<td>50pF, 20mW</td>
</tr>
<tr>
<td>Standard Schottky</td>
<td>3.3ns</td>
<td>15pF</td>
</tr>
<tr>
<td>Standard Schottky</td>
<td>1.5ns</td>
<td>50pF, 20mW</td>
</tr>
<tr>
<td>Standard CMOS (10V)</td>
<td>20ns</td>
<td>50pF, Negligible</td>
</tr>
<tr>
<td>High speed CMOS (5V)</td>
<td>15ns</td>
<td>50pF, Negligible</td>
</tr>
<tr>
<td>High speed CMOS (5V)</td>
<td>10ns</td>
<td>15pF, Negligible</td>
</tr>
<tr>
<td>High speed CMOS (5V)</td>
<td>7.5ns</td>
<td>15pF, Negligible</td>
</tr>
</tbody>
</table>

Table 2. Comparison of the speed and power consumption of contemporary logic IC types. Note that buffered devices will always have greater propagation delays.

<table>
<thead>
<tr>
<th>Logic Family</th>
<th>Speed</th>
<th>Power Dissipation</th>
<th>Fan Out</th>
<th>Noise Immunity</th>
<th>Noise Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTL</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>TTL</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>LS</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>ALS</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>AS</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>ECL</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>NMOS</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>CMOS</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>HCMOS</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 3 A league table of logic IC performance. A '1' indicates the best performance and a '6' the poorest.

![Fig. 14 The propagation delay through a CMOS gate for differing values of load capacitance and supply voltage.](image1)

74C types are a bit faster, and are specified for a 50pF output load, but usually at 10V supply voltage.

Another factor which must be remembered is that one gate does not make a logic IC (with the exception perhaps of an inverting buffer). So, IC types quoted at 15ns/gate, such as the 4000 series, may still introduce a considerable delay. For example, the delay from data to output in a CD4013 dual D-type flip-flop operated from 5V is 200ns. The 74C74 is marginally faster at 180ns. The 10V figures are better, at 80ns and 70ns respectively.

The way in which CMOS propagation delay varies with output capacitance and supply voltage is shown in Fig. 14. There will be no significant effects inside the device because the internal circuit capacitances will only be 1-2pF. I have also shown the input/output voltage transfer characteristics of a typical CMOS

![Fig. 15 Transfer characteristics for a CMOS inverting buffer.](image2)

![Fig. 16 Using a CMOS inverting buffer as a linear amplifier with a gain of 100. If R1 is removed, the circuit will function as a squarer.](image3)
inverter, such as the CD4009 or 74C04, in Fig. 15. As these characteristics suggest, it is possible to use the device in a linear amplifier mode, as shown in Fig. 16. This particular kind of circuit is useful in amplifying AC signals of up to 10MHz or so, although the output waveform won't be very square above a few kilohertz due to the absence of the higher harmonics.

A point which must be watched in all CMOS logic ICs is that unused gate inputs must not be left to float. All unwanted inputs should be tied either to the OV or the +Vcc line. Unless this point is remembered, endless problems can arise.

Also, while CMOS dissipates very little power when used in static or low frequency switching applications, as the clock frequency rises more and more power will be required to charge and discharge the output load (stray) capacitance, so the gate dissipation will also increase. I have shown a graph of dissipation versus clock frequency for a CMOS gate in Fig. 17. Other logic systems will follow a similar pattern at the higher frequency end of the curve.

**Cost**

This is a major factor in the use and choice of ICs and is influenced, to a dramatic extent, by the popularity of the IC in question.

This means that if an IC has been overtaken in performance by a competitive type, not only will the cost of the competitive IC decrease as more are made or as a promotional ploy by the makers, but the price of the IC which it replaces will now increase as the numbers sold decline. So, although I have listed the relative costs of various forms of the same logic IC (a quad 2-input NAND gate) in Table 4, these relative costs are changing as time passes. In a year's time, the dearest may no longer be available and the cheapest may no longer be the cheapest.

**Large Scale Integration**

LSI is the great success story in the digital IC field, allowing very complex functions to be achieved on a single chip by joining together very large numbers of relatively simple logic gates.

LSI devices are made from developments in MOS technology, although bipolar Integrated Injection Logic ICs have simplification transistor circuitry of the type shown in Fig. 18 has had some success in computer work. However, the main need was for simple, low chip area circuitry with very low power dissipation per gate, and this was provided most effectively by MOS technology, either as NMOS with further NMOS devices acting as load resistors, or, more recently, with CMOS.

Many small personal computers, such as the one on which I am typing this article, are based on NMOS LSI single-chip microprocessor ICs, like the Z800 and the 8080A. However, advanced poly silicon gate CMOS offers higher operating speeds and reduced power consumption, often as little as 5% of that for the equivalent NMOS circuitry.

I have listed some of the current applications of LSI ICs in the CPU/RAM-ROM types in Table 5, in increasing order of chip complexity.

---

**Table 4** Comparative cost of different types of quad two input NAND gate.

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Series</th>
<th>Cost (1 off) 1985</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMOS</td>
<td>CD 4011</td>
<td>34-88p</td>
</tr>
<tr>
<td>LS</td>
<td>74L500</td>
<td>40-80p</td>
</tr>
<tr>
<td>HCMOS</td>
<td>74HC00</td>
<td>40-123p</td>
</tr>
<tr>
<td>ALS</td>
<td>74ALS00</td>
<td>49-70p</td>
</tr>
<tr>
<td>TTL</td>
<td>74F00</td>
<td>57-111p</td>
</tr>
<tr>
<td>CMOS</td>
<td>74C00</td>
<td>60-110p</td>
</tr>
<tr>
<td>ECL</td>
<td>74AS500</td>
<td>71p</td>
</tr>
<tr>
<td>S</td>
<td>74S00</td>
<td>160p</td>
</tr>
<tr>
<td></td>
<td></td>
<td>176p</td>
</tr>
</tbody>
</table>

**Table 5** Typical applications for single-chip LSI (large scale integration) devices ranked according to degree of complexity.

<table>
<thead>
<tr>
<th>Calculators Controllers</th>
<th>Process controllers Automatic instruments Data loggers Games Automotive</th>
<th>Smart terminals Billing/Accounting Point of sale hardware</th>
<th>Mini-</th>
<th>Minicomputers Advanced instruments</th>
<th>Intelligent terminals</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROM</td>
<td>1-2K</td>
<td>1-4K</td>
<td>1-6K</td>
<td>8K+</td>
<td>4K++</td>
</tr>
<tr>
<td>RAM</td>
<td>32-128</td>
<td>64-256</td>
<td>128-64K</td>
<td>128+</td>
<td>5+</td>
</tr>
<tr>
<td>I/O Lines</td>
<td>10-32</td>
<td>20-64</td>
<td>32-200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peripherals</td>
<td>0-1</td>
<td>0-3</td>
<td>1-8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 17** Supply current demand per CMOS gate as a function of operating frequency.

**Fig. 18** An integrated injection logic (IIL) gate.
POWER AMPLIFIER MODULES

After years of extensive tests and empirical research, Crimson have developed the ultimate in Bipolar Power Amplifier Modules, making Crimson Power Amplifiers the most sophisticated and highly protected modules available today.

All of these modules now incorporate the following:
- **HP Protection** — Automatic shutdown to prevent damage from unstable signal source.
- **Thermal Protection** — A Thermal Sensor which again causes the amplifier to enter the Shutdown Mode before any danger is reached.
- **Power Supply Protection** — Diodes have been added to the P.C.B. to prevent reverse polarity damage.

### PRICE INC.

<table>
<thead>
<tr>
<th>MODULE</th>
<th>POWER/LOAD (W)</th>
<th>V.A.T.</th>
<th>P&amp;P</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE608</td>
<td>60</td>
<td>£21.00</td>
<td></td>
</tr>
<tr>
<td>CE1004</td>
<td>100</td>
<td>£24.50</td>
<td></td>
</tr>
<tr>
<td>CE1008</td>
<td>100</td>
<td>£27.50</td>
<td></td>
</tr>
<tr>
<td>CE1704</td>
<td>170</td>
<td>£35.00</td>
<td></td>
</tr>
<tr>
<td>CE1708</td>
<td>170</td>
<td>£35.00</td>
<td></td>
</tr>
</tbody>
</table>

CRIMSON ELEKTRIK STOKE
PHOENIX WORKS, 500 KING ST, LONGTON, STOKE-ON-TRENT, STAFFS. PHONE 0782 330520

You can depend on

ELECTROVALUE
to supply the fine range of test & measurement gear by thandar

FREE 44 PAGE PRICED AND ILLUSTRATED CATALOGUE ON REQUEST
- Over 6000 items stocked

ELECTROVALUE LTD 28 St. Jude's Road, Englefield Green, Egham, Surrey TW20 9FB Phone Egham (0784) 33603. Telex 264475
North Branch, 583 Burnage Lane, Manchester M19 1NA Telephone 061 432 4945
Please mention this publication when replying

BRITAIN'S FOREMOST QUALITY COMPONENT SUPPLIERS

HIGH QUALITY ELECTRONIC MODULES
- 100W Mono & Stereo professional amplifiers shown in last months issue £98 & £140.
- Disco Lighting Module 750 watts per chan, 4 chan, forward reverse chase £15.40.
- Disco Sequencer Module 1024 sequences, 1000 watts per chan 1/4 chan, selectable, zero cross and inductive load £40.85.
- Amplifier Modules Mos-fet Low Distortion 0.06%, on board protection fuses and power supply requires only transformer & heatsinks, saves ££E's.
- Amplifier chassis from 100W Mono to 250W Stereo, Professional Mos-fet for O.E.M. from £36.95. All amplifiers are fitted with redpoint black on heatsinks for reliability. Input impedance 47K ohm, input sensitivity 0.775 volts, Total harmonic distortion 0.06%, Damped factor > 400, frequency response DC - 40KHZ & Slew rate 30 v/us.
- Heatsinks Ex Stock, 2.1 c/w redpoint heatsinks £2.50.
- Send 20p and a large S.A.E. for specifications & price list on above products and more!!

Send to: TECHNOCROWN LTD 42 Fallowfield, Luton, Bedfordshire LU3 1PX Tel: 0582-598167 Mail order only.

Postal charges per order £1. Welcome schools, colleges, and Trade - Securicor £10.00 delivery.

ETI OCTOBER 1985
THE SAMPLE LIFE

Paul Chappell tests the water and gives some samples of the problems and solutions facing the designer of a low-cost digital sound sampler.

Several years ago I remember seeing a Tomorrow's World programme which featured a new kind of musical instrument. It looked like an ordinary electronic organ, but instead of generating its own sounds it borrowed them from the outside world. The sound of a violin, say, would be recorded into the instrument’s memory through a microphone. Pressing a note on the keyboard would then give the sound of a violin at the appropriate pitch, by varying the speed at which the sampled sound was played back.

Commercial Sound Samplers

Leaving aside instruments such as the Fairlight, which will set you back more than £20,000, and the Emulator at around £7,000, you can now buy a self contained sampler and keyboard, the Ensoniq Mirage, for a mere £1700. To get anything cheaper, you’ll have to supply some odds and ends yourself. For instance, the Akai S612 polyphonic sampler at £800 or so has no keyboard, you’ll have to provide one, and if you want to store the sounds you’ve sampled you’ll also need a disc drive. Powertran’s MCS1 costs around £600 as a kit, but is only monophonic. The MCS1 and S612 can be controlled by a BBC micro, or any computer with a MIDI interface.

At the budget end of the market there are some very low cost devices. The sound quality and features you can expect from these bear very little relation to the price tag, so it’s worth taking a good look at the spec sheets to see just what you’ll be getting before breaking open your piggy bank. One possibility is the Logitech sampler at £200, a low budget sampler with a low budget sound if the reviews are to be believed. Then there is the Greengate DS3, an add-on for the Apple computer. The sampler box and software will cost you £280 and the music keyboard (as opposed to the computer keyboard) is another £280 on top of this.

The main differences, apart from how many extras you will have to buy, are in sound quality, sound manipulation and editing facilities, and the number of notes you can play at once. The simplest devices, such as the Logitech, use 8-bit linear sampling which implies poor dynamic range and high quantisation noise. They can only play one note at a time. The DS3 also uses linear sampling, but has good editing facilities and is 4-note polyphonic. If ‘dynamic range’ and ‘quantisation noise’ are mysterious concepts to you, hold your breath a moment.

Build Your Own

These days it is not particularly difficult to build your own sampler as an add-on for a home computer. A very basic design for the Spectrum appeared in a music magazine not so long ago. It consisted of four ICs for A-D and D-A conversion and address decoding. The Spectrum RAM was used to store the sample. There was no filtering of any kind and the sound would hardly have been super-fi, but no doubt it was fun to experiment with, which was all it was really intended for.

So what is the ETI design to be? A single chip add-on for the ZX81 or a Fairlight look alike that will still leave you with some change from a second hand Ford Cortina? After much debate (‘What do you think we should do, Alfi? ‘Search me!’) we eventually decided on a Spectrum add-on. At the moment you can pick up a brand new Spectrum for the price of a cup of coffee, so there’s no excuse for saying you haven’t got one. As for the circuit itself, our efforts have been directed towards getting the sound right rather than adding extra gadgets. Constructional details will begin next month, all being well, so have your soldering irons warmed up and ready for action.

General Principles

The hardware used to translate analogue signals to digital form and back again has recently been described in the pages of ETI (August, 1985), so I won’t go over the same ground again. What this feature on A-to-D and D-to-A conversion didn’t mention, however, were the practical consequences of performing the translation. The waveform that is
recovered from a digital sampling process is never quite the same as the waveform that went in. Sampling, by its very nature, breaks continuous waveforms into discontinuous elements. The trick is to get it as close as possible to the original. Without taking any special precautions, you will certainly end up with a sound that is recognisable, but it will be noisy and distorted. Why does it happen, and what can be done about it?

First of all, we have the problem that a fixed number of 'quantisation levels' are available according to the number of bits that will represent the sample digitally. We would like each sample to equal the exact value of the analogue signal at the time. Instead, we must round it up or down to the nearest level for which a digital code is available. A 2V signal, for example, would be okay for an 8-bit sampler, but 2.005V would not.

![Fig. 1 (a) Input to compressor, (b) Output from compressor](image)

The result of the rounding process is known as quantisation noise and sounds very much like the kind of thermal noise hiss that any audio equipment will make to a greater or lesser extent. Intuitively, you can see why it sounds like noise by thinking of the difference between the true value of the audio signal and its quantised value as an extra and unwanted signal that is superimposed on the input.

For an arbitrary input, the value of this extra signal at each sampling will be random, in the sense that it will not be related in any obvious way to the harmonic structure of the input, will not repeat, and so on. There are certain inputs for which this will not be the case, but for general audio signals it's a reasonable way to look at the situation. The main difference between quantisation noise and thermal noise is that quantisation noise is only present when the signal is being reproduced, while thermal noise is there in the background all the time.

For an 8-bit word length, which we are more or less stuck with if we want to make use of Spectrum's memory for storing the samples, the signal-to-noise ratio will be 48dB for a signal which is large enough to make use of all 256 available quantisation levels. This is certainly not hi-fi, but could be tolerated; a cheap domestic tape recorder will give similar results.

Unfortunately, the signal-to-noise ratio degrades very quickly as the amplitude of the input signal drops. For an input 20dB below the overload point (the point at which the A-D converter runs out of codes) the S/N ratio is a mere 28dB. Not too good. The reason for the degradation is fairly obvious; in the extreme case the input may be so small that it only alters the least significant bit in the binary code. The resulting variation between two possible output levels would not track all the nuances of the input with any degree of precision.

**Comping**

The simplest solution to this problem is to ask the user to adjust the input so that the ADC is operated as close as possible to its overload level without actually exceeding it. Not very practical, you think? Just take a look at the Greengate sampler, which does exactly this.

Assuming that the sound to be sampled can be repeated a few times to allow the input level to be adjusted, we are still left with the problem that as the sound decays the noise will increase. A piano note, for example, will begin with a high amplitude as the hammer strikes the string. The amplitude will then drop away quickly to a much lower sustain level. A sampler adjusted to accept the initial level would not give very good results during the sustain period.

Another possibility is to adjust the sound level electronically. Devices which do this are called companders (compressors/expander) and are available ready made in the form of ICs. In essence, the compressor section will reduce the amplitude of signals that are above a certain pre-defined level and increase the amplitude of small signals, so that the range of amplitudes is close to a constant level (Fig. 1). Thus output will have a substantially reduced, or compressed, dynamic range and the signal can be kept close to the overload point of the sampler at all times. The expander section returns the dynamic range to normal after the signal has been translated back into the analogue form.

![Fig. 2 There is a compromise between choosing too small a time constant, as in (b), and too long a time constant, as in (c) and (d).](image)

This is all very well in theory, but companders work by taking an average of the signal level and using this average to control a VCA which modifies the output...
level. The averaging process involves rectifying the input and integrating the result. A short time constant on the integrator will give an accurate average but will result in a good deal of ripple on the VCA control signal, while a long time constant gets rid of the ripple but will make the circuit slow to respond to amplitude changes (Fig. 2).

As rapid changes of gain in the VCA cause considerable distortion, compander circuits tend to err on the side of a slightly longer time constant. The resulting amplitude changes cause an effect often described as ‘breathing’.

As (b) shows, the waveform described the changes in the signal on the whole.

A circuit of this nature is not easy to construct as the inverse circuit must be very precise match to the compressor. I have a feeling that something along these lines could be made by passing out the integrating capacitors on a compander IC, but I haven’t really looked into it. If anyone would care to try, please write in and let me know how it turns out.

A circuit I have tried involves using the base-emitter junctions of a pair of transistors to simulate the curved sections (Fig. 4) with a bit of trickery to carry the function across the circuit. The results were encouraging, but much more difficult to compensate for the temperature variations than I had anticipated. Log amplifiers exist in IC form (with temperature compensation) but they only work in two quadrants: you get the right hand side of Fig. 4 or the left, but not both. Perhaps something could be done with two of them if you have a hot soldering iron and time on your hands ....

However, all this is short-circuited by the fact that a similar kind of compression can be performed by the ADC. Just tuck the previous ideas away in the back of your mind for a moment because I’d like to approach the idea of ‘digital companding’ from a slightly different angle.

Short but Sample

The obvious way to increase the dynamic range of the sampling process is to use a high resolution ADC. A 12-bit ADC will give 4096 quantisation levels and a S/N of 72 dB at best; for a 16-bit ADC we have over 65,000 levels and a maximum S/N ratio of 96 db. If we’re using 8-bit words to store the data we can’t use a 12 or 16-bit ADC (assuming we could afford to buy one in the first place in the case of the 16-bit devices) and using two words for each sample would halve our sample time. Bearing in mind that we want to avoid the degraded S/N for low signal levels, suppose we do this instead:

Around the 0V level, we pretend we’ve got a 12-bit ADC and space the quantisation levels accordingly so that they are 0.025% of full scale apart. After the first eight levels, 0.05% of full scale apart. The next eight levels will be 0.1% FS apart, the next eighth 0.2% FS, and so on. The resolution around 0V is now excellent. The penalty is that in the final section which takes care of the wave peaks the resolution is only equivalent to a 5-bit ADC. There are two very strong points in favour of this as opposed to linear conversion. First of all, audio signals generally have an amplitude spectrum concentrated in small signals rather than large ones and will often have crest factors (the ratio of peak to RMS amplitude) of five or more. Secondly, the human ear is much more sensitive to any inaccuracies of the wave around the zero-crossing point than it is to slight variations in the peaks. At the end of the day, the justification for this type of conversion is that it sounds so much better!

In IC form, there are two versions of the companding DAC. The first follows a law known as µ255, developed by Bell Laboratories. The idealised law is:

\[ Y = 0.18 \ln(1 + \mu X) \]

where \( \mu \) has the value 255 for an 8-bit converter. This law is approximated by seven ‘chords’ which double in step size as described above. The rival system, the A-law, approximates the function:

\[ Y + 0.18 \text{ for } 0 < X < 1 \]

Where A has the value 87.6 for an 8-bit converter.
In both these cases, \( X \) is the analogue signal level as a fraction of full-scale. The formul\ae\ give the magnitude of the signal levels; a sign bit in the DAC is used to say whether they are above or below zero.

The main difference between the two laws is that the approximation of the A-law results in the first two `chords' having the same step size, so the maximum resolution is only equivalent to an 11-bit linear DAC.

This is OK for explaining how it might occur, but not much good for deciding what to do about it. A more enlightening view of the situation is to consider the frequency spectrum of the sampled wave, or the output from the DAC.

Two points before we start. First of all, the following discussion assumes that the output from the DAC represents the exact level of the input at the time of sampling. Any practical inaccuracies we have already put into the `noise' pigeon-hole, and there they can stay for the time being. Secondly, it doesn't matter a damn whether we use linear or log conversion. What we are getting out of the DAC is a stream of voltage levels representing the instantaneous value of the sampled wave, no matter what black magic was used to stuff it into the memory in between.

We'll start off with an analogue input which has a frequency spectrum as shown in Fig. 6a. After sampling at 30kHz, the output from the DAC will have a frequency spectrum as shown in Fig. 6b. No doubt you've seen similar diagrams before. To get a feel for why it should be so, take a look at Fig. 7.

First of all we have a series of sampling pulses of zero duration. Not very practical! OK, I admit it, it's a mathematical fudge. But bear with me for a moment. It so happens that a string of pulses like that has a frequency spectrum consisting of evenly-spaced sine waves all with the same amplitude. Now, if I took just one of these sine waves and amplitude modulated it, remembering your AM theory, you'd expect to see sidebands on either side, right? And varying the amplitude of the sample pulses in accordance with the amplitude of the input is pretty much like amplitude modulation. So Fig. 6b shows all the `sidebands'. The argument has as many holes as a string vest, but the conclusions are OK.

So what happens when the DAC output consists of real pulses that have a finite width? Well, if I can lean on the previous rickety argument a little more, the unmodulated output spectrum from the DAC will now be a series of sine waves which diminish in amplitude as their frequency increases. So what we'd expect to see is the amplitude of the higher frequency `sidebands' of the modulated spectrum decreasing in amplitude, too, as their frequency increases. This is exactly what happens.

The original spectrum of Fig. 6a is all we want to end up with, so it won't cause us any great sadness that the upper frequencies diminish in amplitude. We're going to filter them out anyway. What would
cause us concern would be any alteration to the amplitude of the original spectrum, the part we want to keep.

At this point the intuitive argument collapses under the strain and we must take account of the results of a full mathematical analysis. Yes, the amplitude of frequency components of the part of the spectrum we want to keep will diminish. The wider the output pulses from the DAC, the more significant this effect becomes. With a stair-step output from the DAC, which retains the previous output until another digital code comes along, the frequency response will gently roll off until, at half the sampling frequency, the output will be down by about 4dB. No need to panic, but it should be taken into account. Remember that this has got nothing to do with any filtering or whatever, we're just looking at the raw output from the DAC.

It seems sensible that if we're looking for perfection, the best thing to do would be to return the DAC output to zero in between sample outputs. Sad to say, this can cause more problems than it solves.

We've been looking at nice clean sterilized theory up to now. Unwanted odds and ends creep in, but they stay in their proper place and behave themselves and we know just what to do about them. When you actually come to build a circuit in real life, the results are much less predictable. For instance, DACs don't instantly jump to a new output level when a digital code is applied, they have a certain settling time and what happens at the output during that settling time is anybody's guess. Additional frequency components will be generated and they won't be in predictable places.

The answer is to make them small in comparison with the spectrum we want, which in essence means making the output hold time long in comparison with the settling time. In general, it is often better to put up with a predictable fall in performance that can be compensated for rather than to try correcting it at the expense of introducing factors that can't be removed.

To return to Fig. 6, although there is no frequency component at the input which is above half the sampling frequency, there are already unwanted frequencies from the DAC which occur within the audio range. If we could block off all frequencies above 10kHz at the input, the unwanted frequency spectrum would at least be above 10kHz. This is not very sensible. The unwanted frequencies could burn out tweeters or beat with the bias oscillator of a tape recorder and produce audible products, for instance. There is the more obvious problem of losing bandwidth for no particular reason. Output filtering is the answer here.

Figure 8 shows the situation when frequencies above half the sampling frequency are present at the input. The overlap of wanted and unwanted frequencies is our alias distortion. The practical result is a kind of harshness or coarseness in the reproduced sound. These frequencies could also be eliminated by filtering at the output, at the expense of a good deal of usable bandwidth. Far better to have a filter at the input which eliminates half the sample rate entering the system in the first place.

The result of all this is that although we could, at a pinch, get away with filters just at the input or output, the maximum system bandwidth and best possible sound will be achieved by filtering both. Obvious, you think? Well, maybe, but a design for a fairly expensive self-contained unit was recently published with no input filtering whatsoever and a pathetic and totally inadequate 2-pole filter on the output. The author claims it can 'also be used as a treble control'. Surprisingly often, designers of commercial equipment, who really ought to know better, try to get away with inadequate filtering or even no filters at all.

So, how much practical difference does it make? The answer is that it depends very much on the sampling frequency. At sample rates of 15 to 20 kHz, which are often used in 'sample stretch' or 'double time' commercial devices, the distortion will be very noticeable indeed. We're talking about the potential sound quality of good AM radio as opposed to the achieved quality of a noisy telephone line. At higher sampling frequencies the distortion is still present, however, and is quite obvious when the sampled sound is compared with the original. To extend the previous analogy, you would be settling for AM radio quality without adequate filtering when the system is capable of FM quality sound. The results with a fairly high sample rate can, in some circumstances, sound quite acceptable, but will have as much in common with the original sound as a banana milk shake has in common with bananas.

Pre-emphasis

Yet another way to improve sound quality is to apply pre-emphasis to the input signal. The theory is much the same as that employed in Dolby systems and the like. The higher frequencies of the passband are selectively amplified before A-D conversion, then attenuated after D-A conversion, taking a portion of the noise spectrum with them.

Circuits for this purpose are frequently tacked on to sample almost as an afterthought. Often the degree of pre-emphasis is limited because the designer has realised that it will mess up the anti-alias filtering. The designer has gone to a lot of trouble to give a nice sharp cut-off to higher frequencies, and here's a circuit amplifying them all up again! There's no doubt that pre-emphasis can be effective, but it must be a part of the overall frequency tailoring, not an add-on.

These are a few of the considerations that led to the design of the ETI sampler. Will it be a revolution in sound sampling, or just another variation on the theme? You'll have to wait and see. 'What do you think, Alf? 'Dunno.' Well, that about sums it up.

ETI

ETI OCTOBER 1985

FEATURE: Samplers

![Figure 8](https://example.com/feature_samplers.png)

Fig. 8 The frequency spectrum of an input signal containing components above half the sampling frequency and the corresponding spectrum of the DAC output.
ETI SORCERER STRING SYNTHESIZER

Having unravelled the circuit diagrams, Graeme Durant wraps up the project and ties up the loose ends.

Construction of Sorcerer should prove to be quite straightforward, especially if the suggested PCB layouts are used.

Each board requires a number of wire links to be fitted, these should be tackled first. If you are playing safe and using IC sockets, fit these next. Sockets are recommended for the MOS devices, especially the expensive delay-line chips. Now you can solder in the passive components, remembering that all 213 diodes must go in the correct way round! Note also that some resistors must be mounted vertically. Finally, insert the presets and the panel mounting potentiometers. Since the latter are PC mounting, ensure that they are all straight, so that they will go into the front panel cutouts first time.

After scrubbing off all that nasty flux on the backs of the PCBs, with meths, it is time to fit the boards into the main case, which has by now been drilled and punched to accept them. Note that the VCO board and the envelope board are fixed in only by their front panel potentiometers; they require no further fixing, unlike the other PCBs, which must be bolted into the case. It is recommended that the boards are fitted with Veropins or similar terminals, prior to encasing them, to ease the job of interwiring in situ.

All power connections should be made from each board to a common point at the power supply board. If power connections are strung from board to board, all manner of nasty noise will be the end result. The power supply itself should be connected to mains via a suitable panel on/off switch and a 500mA fuse. Be careful to insulate all points at mains voltages with sleeving. If a metal case is being used, a connection should be made between it and earth, using a bolt and solder tag.

Interconnections must be made between the two chorus boards using tinned copper wire (Fig. 10). Connections to the power supply should be made as shown, using Veropins, but with the interconnection wires still soldered underneath. The chorus boards are stacked and bolted, but plastic spacers must be used to avoid accidental short circuits occurring across the closely spaced tracks on the boards. As a last resort (and I mean a last resort!) use empty plastic biro tubes.

Connections to the front panel switches should be made from the various boards (Fig. 11). The front panel 'Attack LED' is wired between 0V (cathode) and the attack LED pin on the envelope board. Note that none of the connections in Sorcerer are critical and they can all be safely made using ordinary hook up wire.

The keyboard is built on two boards...
boards. The keyboard interface PCB is the small one, and when complete is stacked about 12mm above the copper side of the main keyboard PCB using spacers and bolts with its copper side up, too. Connections are made to the large board using eleven vertical tinned copper wire links, as on the chorus boards. If the keyboard is to be housed separately to the main electronics, five connections (+5V, 0V, gate, trigger and key voltage) must be made between it and the main unit. In the prototype a five pin DIN lead was used with corresponding DIN sockets, but any suitable method could be employed.

The actual insertion of components is similar to the rest of the boards apart from resistors R60 to R96 and diodes D3 to D39 on the main board. These are soldered together in pairs, in series before insertion into the PCB. (Fig. 12). This was necessary for space reasons.

The keyboard case for the prototype was made from wood and required only simple carpentry skills. The reverse side of the actual keyboard surface of the main PCB was glued, using a contact adhesive, to a strip of chipboard some 12mm thick, the full depth of the keys. From this base, simple wooden ends were glued on, to form the case sides; then a thin strip to form a front edge, to cover up the chipboard, and a rear wider strip to form a back panel, were added. Another thin strip formed the back edge of the keys themselves; then two painted aluminium plates were used as a top and bottom panel. These were fixed using wood screws to allow removal and access to the circuits inside. Finally, four rubber feet were added to make a stable construction. So, the case is actually built around the main PCB, and should be done carefully after inserting the components.

Modifications

The more serious musician aiming to use the Sorcerer string synthesiser will no doubt prefer to use a real keyboard with moving keys. This will enable the musician to play faster and more reliably, as well as giving a familiar feel.

Such a modification would be quite straightforward. IC9 to IC18 would no longer be required. Instead, a three octave keyboard unit, fitted with single pole ‘make’ and ‘break’ contacts, would be used. One connection to each switch would be connected to all the other similar ones, and connected to 0V. Each of the other connections to each switch should be soldered to the appropriate key on the solid-state keyboard PCB. Then, to bypass the spaces left by IC9 to IC18, wire links should be inserted, connecting the tracks which originally went to the op-amp non-inverting inputs, to the tracks which went to their outputs. The result is that each row in the diode matrix can be effectively grounded by pressing a key, thus setting up the keycodes as before. Resistors R20 and R56 pull each row up to five volts when that key is unpressed. These resistors could be reduced in value to 10K, for less susceptibility to noise and faster matrix switching.

The rest of the keyboard circuitry could remain as before, with perhaps a couple of component value changes. R97 to R112 and C7 to C14 can stay, to debounce the mechanical contacts. IC19a and IC19b detect the presence of more than one key being pressed, and having altered the type of keyboard switching, the sensitivity of this detection circuit must be altered to suit. Simply alter the value of R58 until the output of IC19b goes low for two or more keys pressed, but high otherwise — this could be achieved by fitting a 220k potentiometer. The setting could be measured using a multimeter on the ohms range, and a fixed resistor then put in its place.

Finally, the value of R122 could be experimentally reduced, to allow faster keyboard response. Now that the square pulse signals of the touch detectors have been removed, the reaction delay can be safely reduced whilst still maintaining a reliable response to keys pressed.

Setting Up And Use

Sorcerer contains seven preset potentiometers, so requires a little setting up. Although no test gear is essential, access to an oscilloscope is useful. After having built up all the PCBs, checked for faults and wired up everything except the connections to the power supply outputs, it is time to plug the PSU into the mains. Check that the PSU outputs are at the correct voltages, then make the final connections between each PCB and the power supply.

Connect the keyboard unit to the main box of tricks and a pair of headphones or an amplifier/speaker set at low volume to the output. Ensure all seven presets are set to their midway positions. Select the middle octave range on the switches, turn off the chorus effect and apply the power. A sound of some kind may be audible, if it is, do not worry. Press a key. The Attack LED should light, and the sound should get louder.
with an envelope according to the attack and release control settings. If not, turn off. Check your wiring. Check to see if a signal is being produced by the VCO. Check the keyboard output voltage and timing pulses.

If all is OK, try the other octave switches. Try the sustain on/off switch, and different setting of the attack and release controls. Check the vibrato controls work, and the glide and tune functions. Finally, check that the chorus mode has at least some effect (but do not worry about the din it is probably making).

Once you are convinced that all the functions have some effect, it is time to set the presets. Switch off the chorus effect, and set the attack and release controls to minimum. Turn up the amplifier volume control until you can hear the signal breaking through the envelope shaper, then adjust RV8 on the envelope board until the minimum signal is heard.

Switch out all the octave ranges, then, with the sustain set to off, press a key. A sharp click will probably be heard. Turn RV9 also on the envelope board, until

---

**NOTES:**

D3/R60-D39/R96 = STARRED

D40-D196 = SINGLE DIODES IN MATRIX

R60-R96 AND D3-D39 MUST BE SOLDERED TOGETHER AS SHOWN BEFORE INSERTION INTO THE MAIN PCB

---

*Fig. 13 Component overlay for the VCO board*

*Fig. 12b Component overlay for the keyboard. Note that it is shown here at considerably less than its full size.*
pressing a key produces the minimum effect. The envelope shaper is now set up.

Now, reduce the amplifier volume to a reasonable level, and set the attack and release controls about midway. Switch in all the octave ranges. Select the chorus mode, and hold down a note on the keyboard. Turning RV10 through the hole in the top chorus board should, at one extreme, fuzz the sound and, at the other, stop the signal. RV10 sets the operating point of the delay-line chips and should be in the middle of its undistorted range of travel. Finally, we set up RV11, 12, and 13 on the top chorus board. If an oscilloscope is unavailable, set these midway — they are not too critical. Their function is to cancel out some of the high frequency clock signals imprinted onto the outputs of the delay line devices. If an oscilloscope is to hand, connect its input to the slider of RV11, and adjust until the minimum high frequency noise appears on the signal. This may be easier to see with all the octave ranges switched off. Repeat for RV12 and RV13. This completes
the setting up of the chorus board.

The last preset to deal with is RV5, on the VCO board. This simply acts as a coarse tuning control. Set the front panel tune control to its central position, then turn RV5 until the instrument is in tune with a known reference.

The line output is about one volt peak-to-peak and so should drive most amplifiers, but if it is too high, fit an attenuator. The touch keyboard should work in most environments, provided there is enough mains hum around the place. If problems are encountered, try planting both feet firmly on the floor (I am serious, it does work). If the problems persist, try removing the 10Mohm input resistors on the keyboard, to increase its sensitivity. Also check earth continuity and connection to the 0V line.

### PARTS LIST

#### VCO SECTION

<table>
<thead>
<tr>
<th>RESISTORS</th>
<th>(all 1/4W, 5% unless otherwise stated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1,8</td>
<td>1k</td>
</tr>
<tr>
<td>R2,3,4,7,12</td>
<td>100k</td>
</tr>
<tr>
<td>R5</td>
<td>47k</td>
</tr>
<tr>
<td>R6,9</td>
<td>390k</td>
</tr>
<tr>
<td>R10,11,15,17,18,19</td>
<td>10k</td>
</tr>
<tr>
<td>R13,16</td>
<td>680 1% metal film</td>
</tr>
<tr>
<td>R14</td>
<td>2k</td>
</tr>
<tr>
<td>RV1</td>
<td>100k log. PC mounting</td>
</tr>
<tr>
<td>RV2</td>
<td>10k lin. PC mounting</td>
</tr>
<tr>
<td>RV3</td>
<td>47k lin. PC mounting</td>
</tr>
<tr>
<td>RV4</td>
<td>2k lin. PC mounting</td>
</tr>
<tr>
<td>RV5</td>
<td>4.7k Cermet preset</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CAPACITORS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>3u3 16V tantalum</td>
</tr>
<tr>
<td>C2</td>
<td>150n polycarbonate</td>
</tr>
<tr>
<td>C3</td>
<td>10u 16V tantalum</td>
</tr>
<tr>
<td>C4</td>
<td>47uf mylar</td>
</tr>
<tr>
<td>C5</td>
<td>2n2 polycarbonate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SEMICONDUCTORS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IC1,4</td>
<td>LF351</td>
</tr>
<tr>
<td>IC2</td>
<td>741</td>
</tr>
<tr>
<td>IC3</td>
<td>LM321 or RC4151</td>
</tr>
<tr>
<td>IC5</td>
<td>LM324</td>
</tr>
<tr>
<td>IC6</td>
<td>4024</td>
</tr>
<tr>
<td>IC7</td>
<td>4011</td>
</tr>
<tr>
<td>IC8</td>
<td>4081</td>
</tr>
<tr>
<td>D1</td>
<td>IN4001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MISCELLANEOUS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PCB: solid tinned copper wire; control knobs; veropins.</td>
<td></td>
</tr>
</tbody>
</table>
**PROJECT: Synth**

### PARTS LIST

#### KEYBOARD

<table>
<thead>
<tr>
<th>RESISTORS</th>
<th>(all 1/4 W 5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R20 to 56</td>
<td>10M</td>
</tr>
<tr>
<td>R57,123</td>
<td>470k</td>
</tr>
<tr>
<td>R58,60 to 104,113</td>
<td>100k</td>
</tr>
<tr>
<td>R59</td>
<td>330k</td>
</tr>
<tr>
<td>R105 to 112</td>
<td>820k</td>
</tr>
<tr>
<td>R114 to 121</td>
<td>2M2</td>
</tr>
<tr>
<td>R122</td>
<td>10k</td>
</tr>
<tr>
<td>R124</td>
<td>390R</td>
</tr>
</tbody>
</table>

#### CAPACITORS

<table>
<thead>
<tr>
<th>C6,23,24</th>
<th>220n polycarbonate</th>
</tr>
</thead>
<tbody>
<tr>
<td>C7 to 22,25</td>
<td>100n polycarbonate</td>
</tr>
<tr>
<td>C26</td>
<td>10u axial electrolytic</td>
</tr>
<tr>
<td>C27</td>
<td>1n0 polycarbonate</td>
</tr>
</tbody>
</table>

#### SEMICONDUCTORS

<table>
<thead>
<tr>
<th>IC9-18</th>
<th>LM324</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC19,20</td>
<td>40106</td>
</tr>
<tr>
<td>IC21</td>
<td>ZN428</td>
</tr>
<tr>
<td>IC22</td>
<td>4093</td>
</tr>
<tr>
<td>D2 to 204</td>
<td>1N4148</td>
</tr>
</tbody>
</table>

### MISCELLANEOUS

PCBs; solid tinned copper wire; IC sockets; plastic spacers; Veropins.

### ENVELOPE SHAPER

<table>
<thead>
<tr>
<th>RESISTORS (all 1/4 W 5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R126,128,130,134,137</td>
</tr>
<tr>
<td>R127,129,131,132,135,135,143,144</td>
</tr>
<tr>
<td>R133</td>
</tr>
<tr>
<td>R136,140,141</td>
</tr>
<tr>
<td>R138</td>
</tr>
<tr>
<td>R139,145</td>
</tr>
<tr>
<td>R142</td>
</tr>
<tr>
<td>R146</td>
</tr>
<tr>
<td>R147</td>
</tr>
<tr>
<td>RV6</td>
</tr>
<tr>
<td>RV7</td>
</tr>
<tr>
<td>RV8</td>
</tr>
<tr>
<td>RV9</td>
</tr>
</tbody>
</table>

### CAPACITORS

<table>
<thead>
<tr>
<th>C33,34</th>
<th>33n polycarbonate</th>
</tr>
</thead>
<tbody>
<tr>
<td>C35</td>
<td>220n polycarbonate</td>
</tr>
</tbody>
</table>

#### SEMICONDUCTORS

<table>
<thead>
<tr>
<th>IC23</th>
<th>4093</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC24</td>
<td>LM324</td>
</tr>
<tr>
<td>IC25</td>
<td>4066</td>
</tr>
<tr>
<td>IC26</td>
<td>CA3080</td>
</tr>
<tr>
<td>IC27,28</td>
<td>741</td>
</tr>
<tr>
<td>Q1</td>
<td>BC557</td>
</tr>
<tr>
<td>Q2</td>
<td>BC108</td>
</tr>
<tr>
<td>ZD1</td>
<td>2V7 400mW zener diode</td>
</tr>
<tr>
<td>D206-212</td>
<td>1N4148</td>
</tr>
</tbody>
</table>

#### MISCELLANEOUS

PCB; solid tinned copper wire; control knob; Veropins.

### CHORUS CIRCUITS

<table>
<thead>
<tr>
<th>RESISTORS (all 1/4 W 5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R148,155,160</td>
</tr>
<tr>
<td>R149,156,161</td>
</tr>
<tr>
<td>R150,151,157</td>
</tr>
<tr>
<td>R152,158,161,171</td>
</tr>
<tr>
<td>R173,175,182,183</td>
</tr>
<tr>
<td>R184,196,197,202</td>
</tr>
<tr>
<td>R203,206,209,215</td>
</tr>
<tr>
<td>R237,236,239,240</td>
</tr>
<tr>
<td>R153,154,159</td>
</tr>
<tr>
<td>R162,163,165,181,188</td>
</tr>
<tr>
<td>R198,201,204,207</td>
</tr>
<tr>
<td>R210,213,241,242</td>
</tr>
<tr>
<td>R165,166,167,168,170,171,172,173</td>
</tr>
<tr>
<td>R187,200,206,212</td>
</tr>
<tr>
<td>R219,221,225,227</td>
</tr>
<tr>
<td>R231,233,235,236</td>
</tr>
<tr>
<td>R172,174,176</td>
</tr>
<tr>
<td>R179,180,181</td>
</tr>
<tr>
<td>R186,192,216,217</td>
</tr>
<tr>
<td>R222,223,228,229</td>
</tr>
<tr>
<td>R189,191,193,194,195</td>
</tr>
</tbody>
</table>

### SEMICONDUCTORS

<table>
<thead>
<tr>
<th>IC29</th>
<th>LM1458</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC30</td>
<td>LM324</td>
</tr>
<tr>
<td>IC31,32,33</td>
<td>4046</td>
</tr>
<tr>
<td>IC35,36,37</td>
<td>MN3010</td>
</tr>
<tr>
<td>IC38,39,40,41</td>
<td>741</td>
</tr>
</tbody>
</table>

### MISCELLANEOUS

PCBs; solid tinned copper wire; IC sockets; plastic spacers; Veropins.

### PSU CIRCUIT

<table>
<thead>
<tr>
<th>CAPACITORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>C28,29</td>
</tr>
<tr>
<td>C30,31,32</td>
</tr>
</tbody>
</table>

#### SEMICONDUCTORS

<table>
<thead>
<tr>
<th>BR1</th>
<th>W005 or similar 1A</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC43</td>
<td>7805</td>
</tr>
<tr>
<td>IC44</td>
<td>7910S</td>
</tr>
<tr>
<td>IC45</td>
<td>7810S</td>
</tr>
<tr>
<td>D205</td>
<td>1N4148</td>
</tr>
</tbody>
</table>

#### MISCELLANEOUS

T1 9V-0-9V, 8VA PC mounting transformer.

PCB; solid tinned copper wire; mains on/off switch; fuseholder and 500mA fuse; case; cable and connectors to go between keyboard and main unit; five single pole changeover switches (chorus sustain, three octave select); hook up wire; mains lead; nuts, bolts, etc.

---

**Fig. 17 Component overlay for the PSU.**
MODULAR TEST EQUIPMENT

Mike Meakin considers the curious case of the expensive electronics project and suggests a solution.

A look at the average home constructor's workbench will usually reveal a motley collection of test equipment, built as necessity dictated and often in the obligatory biscuit tin with pencilled calibrations! Low cost test equipment is available but often contains little more than an industry standard IC used in the manufacturers' application circuit, and the cost of acquiring a complete system can be daunting.

But where does the cost come from? Have you noticed when budgeting for new projects that the electronics cost very little but the cases, front panels, knobs, hardware and power supplies all add up to a horrifying sum? If these costs could be dispensed with, more money could be spent on the electronics with a consequent improvement in the performance and hence the usefulness of the equipment.

The ETI Workstation has no case, no front panel, and no knobs. It consists of a series of printed circuit boards, each carrying one test instrument and designed to interconnect to form a complete system. The modules include a bench power supply, a pulse generator, a universal counter-timer and a logic probe cum analogue indicator, and as well as providing voltages for equipment under test the power supply also drives the other modules. This removes the need for individual power supplies on each board and so helps keep costs down.

The constructor can choose to build any or all of the modules as required, if necessary assembling the system over a period of time as finances allow. In theory, the power supply has to be built before any of the other modules can be used, but there is no reason why an existing power supply could not be pressed into service, or even batteries as a temporary measure if one of the other modules is to be built first and the power supply later.

The boards all have a depth of 100mm (or just over 200mm in the case of the power supply) which allows a neat finished unit to be assembled using plastic guides. To avoid the need for external controls and panels, all of the potentiometers mount directly onto the PCB and are of the enclosed preset type with integral knob. PCB mounting switches have been used throughout and the counter-timer display and power supply LEDs are also mounted directly onto the board. The only part of the system not mounted on a board is the mains transformer, which for safety reasons is housed in a small metal case with only the low voltage AC output fed to the power supply PCB.

Since the power supply is the logical starting point in this project, its design and construction will be dealt with in this first article. The other modules will form the subject of further articles in subsequent issues.

Power Supply Board

The power supply board is of conventional design and provides both fixed voltage supplies for the modules and variable supplies for bench use. Additionally a voltage reference of 10.00V and a constant current source of 10.00mA are available. The voltage reference can be used whilst prototyping circuits and even checking DVMs whilst the current source is most useful for checking LEDs and zeners and can of course be used for ramp generators during breadboarding.

A 4BA screw mounted on the board provides a 0V reference point and something handy to which crocodile clips can be attached. Connection to the fixed supplies for the modules is made by soldering to the underside of the board on the thick bus bars. This may not be particularly elegant but it is simple and above all cheap.

The mains transformer is housed in a small metal case along with a fuse, mains on-off switch and neon indicator. The low voltage AC is taken via a DIN connector to the power supply PCB. Housing the mains transformer separately...
The 9V AC supply from T1 is bridge rectified and fed to reservoir capacitor C20. A 5V regulator provides the fixed 5V supply at a maximum current of 1A for the modules and an LED indicates that the supply is present.

The unregulated supply is also fed to IC9, a variable voltage regulator which has additional components around it to provide protection against misuse. The supply can be set to voltages within the range 1.2V to 6.0V by variable resistor RV5. Capacitor C24 provides additional ripple rejection while capacitors C25, C26 and C36 stabilize the IC and improve transient load response. Diode D6 provides a discharge path for any large capacitors that may be hung on the output when the input supply voltage is removed. Diode D9 discharges C24 on switch off and D10 protects the regulator if reverse voltages are fed into its output. An LED again indicates when the supply is present. The input voltage and heatsinking allow this regulator to supply up to 500mA before thermal shutdown.

The operation of both the fixed and variable plus and minus 15V supplies is similar to that of the 5V supplies described above. However the current drawn from the variable supplies should be limited to about 250mA (dependent on the output voltage) because of heatsinking limitations.

The unregulated positive supply is also fed via D1 to an additional smoothing capacitor C4 to provide supplies for the constant current source and the voltage reference. This arrangement gives some isolation of transient loads on the main 15V supply. A low power 15V regulator supplies IC4 which is configured in a classic buffered zener arrangement. The bandgap voltage is amplified to give an adjustable 10.0V reference voltage at IC4 output. As both output and reference voltages are fixed a constant current flows through the reference voltage. The inputs of IC4 operate at 1.2V above 0V and a 3140 or TL091 op-amp must be used in this position. A 317L regulator is used for the constant current source and is set to 10.0mA under short circuit conditions by RV1.
Fig. 2 Component overlay for the power supply PCB.
PARTS LIST

RESISTORS
(all 1/4W 5%)

R1, 5, 8  1k0
R2  100R
R3  1k5
R4  8k3
R6, 9, 11, 13  390R
R7, 10  820R
R12  270R

RV1  50R, 20-turn, 1/8" cermel preset
RV2  500R, 20-turn, 1/4" cermel preset
RV3, 4  47k carbon track preset with integral knob
RV5  1k0 Carbon track preset with integral knob

CAPACITORS
C1, 13, 20  4700u 25V axial electrolytic
C2, 5, 7, 12, 14, 19, 21, 26  100n 100V multilayer polyester
C3, 9, 15, 16, 22, 23  470u 100V multilayer polyester
C4  470u 25V axial electrolytic
C6, 11, 18, 25  10u 35V tantalum or radial electrolytic
C8  1u 35V tantalum or radial electrolytic
C10, 17, 24  10u 16V tantalum or radial electrolytic

SEMICONDUCTORS
IC1  7815
IC2  78L15
IC3  LM317L (100mA)
IC4  3140 or TL091
IC5, 9  LM317M (500mA)
IC6  7915
IC7  LM337M
IC8  7905
D1-10  1N4001
ZD1  ZN423
LED1, 2  red LED
LED5, 4  green LED
LED5, 6  yellow LED
BR1, 2  K8L02 or other 3A, 200V bridge rectifier

MISCELLANEOUS
FS1  500mA anti-surge fuse and panel mounting holder
LP1  mains neon, panel mounting
PL1  6-pin DIN plug
SK1  6-pin DIN socket
SK2-4  4-way 10A PCB mounting screw terminals
SW1  DPDT mains toggle switch
T1  17-0-17V (or 15-0-15V — see text)
50VA plus 9V 20VA mains transformer

PCB: case for transformer; 8-pin DIL IC socket; heatsinks, 6 off; four-core screened cable, heavy duty, for AC connections to power supply board from transformer; mains plug, cable and strain relief bush to suit; 6BA nuts, bolts and washers for heatsinks; 4BA nut, bolt and washer for 0V tag.

and feeding only low voltages to the boards is an essential safety requirement if the system is to be used, as intended, without a case.

Construction
Whilst care has been taken to make the modules easy to construct, the usual precautions are necessary. Frequent reference should be made to the PCB layout diagram and attention to the polarity of diodes, LEDs, capacitors and ICs is very important. A socket is recommended for IC4 and LEDs should be spaced away from the surface of the board before soldering. It is not necessary to fit insulating kits on the heatsinks but a little thermal grease should be smeared around each IC tab before mounting to ensure efficient heat transfer.

The mains transformer should be installed in a small metal case, the exact size of which will be determined by the transformer or transformers you choose. Ideally a single transformer with separate 0-9V and 17-0-17V windings should be used, but these are not widely available. Two separate transformers will work just as well but will, of course, require more space. If a 17-0-17V transformer cannot be found a 15-0-15V one can be used in its place, but this will lead to a loss of regulation if the power supply is used at full load.

Take care with the mains wiring inside the box and make sure that the incoming mains cable is secured by a good strain relief bush. Solder leads from the secondary of the transformer to a six-pin DIN socket mounted in the opposite end of the box to the mains wiring. In view of the exposed nature of the test equipment boards, it is most

ETI OCTOBER 1985

www.americanradiohistory.com
important that there is a good earth connection to the boards. To this end, make sure that the incoming mains earth, the transformer box (if present), the box metalwork and the DIN socket are all reliably connected together. Similar attention should be paid to the DIN plug and lead which carry the transformer output to the power supply board.

**Testing**

The transformer box should be tested on its own before plugging in the board. Double check the earthing arrangements and then switch on. If all is well, connect to the power supply board and switch on again. You should be rewarded either by twinkling LED's or smoke! If the latter then rapid disconnection of power is recommended. Otherwise, check that the fixed supply voltages are correct to within plus or minus 5%, then check the variable supplies.

Finally, adjust the voltage reference against the best DVM you can borrow and adjust the current source under short circuit for 10.00mA.

---

**BUYLINES**

The resistors and capacitors are all widely available and so are most of the semiconductors. The exception is IC3, the LM317L 100mA variable voltage regulator. The only supplier we know of for these is RS components (stock no. 303-179), who will only accept orders from trade and professional customers.

Crew-Alan & Co of 51 Scruton Street, London EC2 will maintain RS parts for you on payment of a small handling charge, but you may prefer to use another LM317L instead. There is no harm in using the higher-rated device and it should not be too difficult to bend the pins to fit.

RS are also the only source we know of for the moulded presets with integral knob used in the RV3/4 and S positions (stock no. 184-344 and 184-222 respectively). Different types from other suppliers could be used but the PCB may have to be modified slightly to accept them.

We do not know of anyone who stocks a single transformer offering the required voltages, but the LM338 have a multi-tapped type which gives 17-0-17V at 2A and RS can supply a 4.5-4.5V type rated at 2.2A (stock no. 207-122). Electrovalue have a 9V 2A type which could be used at a pinch. Some manufacturers of toroidal transformers claim that their products can be used with the secondaries in parallel, in which case a 0-9 + 0-9 30VA toroid could be used. However, we have our doubts about this practice, so unless it is specifically recommended by the manufacturer we advise against it.

The PCBs will be available from our PCB Service, for details of which see the note in News Digest. Please note that, to save costs, they will not be screen printed as are the prototypes shown in this article.
AUTOMATIC TEST EQUIPMENT

Love it or 'ate it, automatic test equipment is here to stay.
W.P. Bond begins a short series in which all will be revealed.

Automatic test equipment has been around in one form or another for nearly three decades. In recent years, the introduction of LSI and VLSI circuits has totally changed the requirements for ATE, especially since the equipment and procedures must meet the needs of volume production. Cost is perhaps the most important consideration today, and this must be understood in relation to the two general types of test procedure: functional and in-circuit testing.

Functional testing looks at all the functions of a circuit — taken in isolation from a whole system of which the circuit may be a part. The circuits involved (and, of course, the test procedures) can be digital or analogue. Digital — or logic — circuits are simpler than analogue circuits from the viewpoint of automatic functional testing. There are simple 'go/no-go' results obtainable with logic circuits, while analogue devices need to be tested within a broad range of acceptable performances. It makes sense to begin an examination of ATE with logic circuits.

Some Logical Steps

There are four main categories of logic circuit:
- Combinational Logic (outputs are dependent solely on the present inputs).
- Sequential Logic (outputs are dependent on present inputs and on previous outputs: circuits with memory or feedback).
- Bus Structured Logic (combined circuitry of the above types on MPU-type boards with components connected by a bus-structure).
- Random Logic (combined circuitry without a bus-structure).

The testing procedure for any given circuit or circuit assembly will depend on the category it belongs to.

There are a number of other considerations that have to be borne in mind when devising test procedures, apart from the categorisation of the circuit concerned. Even in simple cases, functional testing may have to be uneconomically elaborate in order to detect all possible faults. The 8-input gate in Fig. 1 would require 256 test patterns if all input conditions were to be covered. In general, a combinational logic circuit with n inputs requires $2^n$ test patterns for 100% truth-testing. Such 'exhaustive testing' (ET) very quickly becomes unwieldy — even with straightforward combinational circuits.

Most circuits are not straightforward. One particular problem is caused by the presence of redundant logic, often built-in for reliability. The circuit in Fig. 2, for example, includes a redundant gate (G2) — which can be shown by simplifying the output function, $A\cdot C + B\cdot C + A\cdot B$, using Boolean algebra or Karnaugh mapping. In this case, a fault in the redundant gate may 'mask' faults in the non-redundant circuit elements. For example, in this case the output from the redundant gate is permanently low ('stuck at 0' or SA0), it will have no effect on the network output. But if it is permanently high ('stuck at 1' or SA1), then the network output will be permanently high regardless of what's happening on the other gates. In effect, the SA1 condition on the redundant gate masks any faults on either of the other gates.

The typical test points are shown in Fig. 3 for a sample circuit. From Fig. 4, it should be clear that the same symptoms can follow from a variety of faults. An SA0 pin fault on the B input to the NAND gate in the figure will be indistinguishable at the output from an SA1 node fault — the same input test patterns will result in the same outputs. To locate faults successfully, it is important to test the circuit in question at more points than its inputs and outputs. Figure 5 shows a small logic circuit with redundancy in which...
an SA1 pin fault would go undetected if the circuit were tested at inputs and outputs only. This sort of fault would be seen where an open circuit existed at the pin, since open circuit inputs float high. Because of this, inputs tied to Vcc are sometimes classified as 'undetectable' for fault-finding purposes.

Fig. 4 Different fault, same truth table.

It's worth noting that there are two kinds of redundancy in circuits: fault-masking and self-checking. In the first, faults are masked by multiple circuits performing the same task. In the second, faulty circuits are switched out of the system and good circuits switched in to take their places.

.Sequential logic presents the test procedure with yet more problems. Figure 6 shows a circuit configuration in which there is no direct path between the fault (SA0 at input 1) and any output. Here again, the importance of good 'test-pointing' becomes obvious. This kind of fault is described as latent and its detection requires a series of test-patterns to 'walk' it to an output pin. The example shown would require three consecutive test-patterns to clock it through gates G2 and G3. With less than three test-patterns, the fault would simply not appear at any output. The number of patterns required to propagate the fault to the output is called the degree of latency.

Changing inputs can give rise to their own problems. The commonest is called racing. Race hazards take the form of unwanted transients (signal spikes) caused at the output to a logic circuit when two or more inputs change at the same time. These are often known as glitches. In Fig. 7, for example, inputs A and B are meant to change simultaneously from 1 and 0, respectively to 0 and 1. If B reaches the 1 state slightly before A reaches the 0 state, then the output will display the negative-going spike shown. (Such glitches often occur in latching circuits with feedback — dividers, for example). Testing at the output can lead to spurious results in this situation. The simplest solution is to build-in a time delay at the output test point greater than the propagation delay of the gate.

Untestability Is Detectible

Testability must be designed into electronic modules if they are to be properly tested in the first place. Obvious though this sounds, it is all too often overlooked by circuit designers — perhaps because 'testability' itself is an awkward and ill-understood notion.

Fig. 7 Generating glitches in a NAND gate.

Testability implies not only the possibility of testing a module or circuit but also the existence of a set of guidelines aimed at maximising test efficiency. Because of the specialized nature of individual complex analogue designs, I will limit the present discussion to functional testing of static digital circuits — although the principles do not lose in generality. (It's worth noting that functional testing, although perhaps more easily understandable, is actually more rigorous than in-circuit testing and as much as ten times more costly).

Test procedures can be considered to have three main aspects: initialising, observing and controlling. For a circuit to be testable, each of these aspects must be catered for.

★ Initialising. This is the process by which all nodes of the unit under test (UUT) are set to known states after power-up and before test patterns are applied. Initialising (or initialisation) is essential for reliable and meaningful testing.

★ Observing. In the context of ATE, this means minimising the amount of human intervention needed to identify faulty components. Observing entails the correct monitoring of a circuit and involves the provision of suitable 'test points' in the design. Observability is the key to maximising the effectiveness of ATE.

★ Controlling. For proper functional testing, the ATE must be capable of controlling the UUT — usually by means of an edge-connector. If all functions of the UUT cannot be exercised, then testing will be inadequate.

In the Beginning

LSI designs are most commonly sequential and the failure to initialise can mean testing circuits in forbidden or indefinite states. There are four main factors in designing-in the ability to initialise a circuit:

★ There should be access to deep sequential circuits — which is a criterion of observability.

★ There should be a means of isolating or breaking feedback loops.

★ There should be access to reset and preset lines in memory elements.

★ In certain cases (for example, VLSI devices where there is no access to reset or preset lines), it should be possible to use 'software initialisation'.

Figure 8 shows a simple sequential circuit — a counter or shift register, for example — without and with testability built-in. If appropriate test points have not been provided on power-up all the memory elements, f(1) to f(n), will be in an unknown state (an x-state). The output will also be in an x-state. Without
access to reset or preset, a ‘homing sequence’ would have to be provided by the tester. Further, if a fault existed the failure could be observed at the output, but without the use of a guided probe routine and suitable test points fault isolation would be impossible. This is a failure of observability or diagnostic visibility.

In the lower diagram, test points and a reset line have been provided. Since the reset line, in particular, is no longer hard-wired to Vcc we need only apply a clear signal to initialise the circuit rather than go through the elaborate motions of a homing sequence.

In Fig. 9, a feedback loop has been introduced into the sequential circuit. Even if test points and the reset line are accessible, so that initialisation — at least — does not require a homing sequence, the problem of fault diagnosis remains. Because of the feedback loop, a fault may be propagated to all points around the loop. To overcome this, the loop must be breakable. The lower diagram shows how this is done — when the control point goes low, the loop is broken.

set all nodes to a predetermined state. Initializing sequential circuits is always more complicated since such circuits contain x-states after power-up. These must be flushed out of the system before testing can begin. Since ATE programs must themselves be tested by means of a computer simulation or model circuit, a further problem is encountered. The model circuit will almost certainly power-up into a different state from any other — model or real — circuit.
Figure 11 shows a standard divide-by-two circuit. While the right diagram illustrates a simpler arrangement — from a test point-of-view — in which initialisation would require only a single-step synchronizing sequence (reset or preset directly), the left diagram shows a simpler circuit which can be handled by use of an AHS.

The following algorithm would provide a suitable sequence:

1. Set CL to 0
2. Set CL to 1
3. If Q is 0, then go to step 1
4. Return to test (output Q, known to be 1).

Bad design is the bane of the tester's life. An example of unhelpful design is shown in Fig. 12 — a section of an actual circuit used in a currently operational ship's navigation system. Basic principles should immediately suggest that it was bad practice to tie J, K and the preset inputs on IC1 (the 7476). Even though the reset lines are available to the tester, close examination reveals another problem. Reset on the 74163 is asynchronous — which is to say, it works independently of the clock — while reset on the 74163 is synchronous — which is to say that it needs an appropriate clock pulse to operate.

**Fig. 12 An actual unhelpful design.**

Since the clock pulse for the 74163 is derived from the 7476's Q output, the '163 will never receive a clock pulse when the '76's reset line is low. In other words, in this design configuration it is impossible to reset both ICs at the same time. To make matters worse, there were no direct outputs available from the '163. All of which makes it very difficult to initialise the circuit.

**Now You See It**

As has been suggested, the observability aspect of testing and the ability to initialise circuits are not totally separable. Observability is really a way of talking about the effectiveness of ATE, which is clearly influenced by the position with respect to initialisation. It's already been shown how feedback loops and the lack of circuit isolation can make it impossible to achieve the desired degree of diagnostic resolution — to use the jargon.

There are three ways in which the circuit designer can improve observability:

★ By partitioning circuitry (for example, by function)
★ By providing ways to break feedback loops.
★ By providing means of isolating faults (for example, the inclusion of suitable test points).

**Walking The Dog**

Functional testers are, in practice, 'edge connector oriented' and good controllability demands careful attention to the board design of any circuit. Effective ATE must be able to readily and properly exercise every component on the board. Good design, from the test point-of-view, will reduce the number of steps that need to be taken in order to cover all detectable faults.

The control functions that need to be available to the ATE can be grouped under five headings:

★ 1) Reset and preset inputs.
★ 2) Tri-state control lines, enable and disable signals.
★ 3) Feedback disable.
★ 4) Isolation and control inputs for free-running devices, in particular clocks.
★ 5) Synchronization signals, especially where microprocessor based modules are being tested, so that the UUT and the ATE may be synchronized.

Reset and preset lines should never be tied together or hard-wired to VCC or GND. They should be 'soft-wired' by use of pull-down or pull-up resistors, to which test-points are connected. CMOS input can be pulled high or low through an appropriate resistor, because CMOS requires only a very small bias current (about 1µA) to establish logic high or low states. TTL, however, can only be successfully pulled high through a resistor, because it requires quite a high sink current (about 2mA) to establish a logic low state. Active pull-downs should be used, if over-driving is required, as illustrated in Fig. 13. Passive resistors would have to be of too low a value for the ATE's drivers to source a high on to the input. For example, pulling four TTL inputs low would demand a resistor passing 8mA across a maximum potential drop of 0.8V. It would have to be approximately 1000ohms.

**Fig. 13 Pulling down and pulling up TTL**

Access to tri-state control lines is particularly important when testing memory boards or bit-slice processors in which circuit operation depends on ROM contents. Without access to the tri-state lines, it may be very difficult to control the circuit since the ROM contents may make it impossible to exercise all the circuit nodes. The ATE must be able to override such memory-based constraints.

Feedback loops have been dealt with above and the preferred method, shown in Fig. 9, requires no operator intervention but can be handled entirely by the ATE software. Of course, switches or links could be used instead.

Control of free-running devices and synchronization can be treated as two sides of the same problem, since one relates to situations in which the ATE must control the UUT — perhaps, to single-step through a sequence of states — and the other to situations in
which the ATE must simply proceed in step with the UUT.

In the first case, serious synchronization problems will in any case occur where a clock-controlled circuit is operating at a greater rate than the fastest operation of the ATE. Figure 14 shows one way of controlling free-running devices. Under normal operating conditions G1 and G2 would both be allowing the clock pulse through. Under test, control point 1 would disable the clock when taken low by the ATE, allowing an ATE controlled clock to be injected in to control point 2. This is the preferred method, although the same effect could be achieved manually by the use of switches or links.

![Fig. 14 Asynchronous circuit control.](image)

Synchronization itself is best achieved if the use of multiple clocks is avoided whenever possible. This subject will be dealt with more fully later in this series, when we come to the topic of ‘signature analysis’. Multiple-phase clocks present no problems, but multiple clocks cannot be synchronized with. If a multiple clock system cannot be avoided, it should derive each clock signal from a master clock, divided down. This allows a common sync point for the ATE to latch on to.

**On The Buses**

When testing bus-structured circuits, synchronization alone is not enough. The ATE must be able to force the circuit's controlling microprocessor to relinquish control of its address and data buses.

If an MPU is used in conjunction with a ‘direct memory access’ (DMA) device, the DMA device must be capable of instructing the MPU to release its buses so that I/O or memory block transfers can take place without involving the MPU. Suitable control signals are available on many common MPUs which enable them to put their bus outputs into a high impedance state. Normally, a DMA controller would be used to handle the procedures involved.

The Z80, for example, features a bus request line, BUSRQ, and the 8085 features a similar HOLD line which are used to flag the MPU when the DMA device is about to make a data transfer. On the next cycle, the MPU will finish its present task and flag the DMA device that it has released its buses using — in the above examples — the BUSAK or HOLDKL lines. The DMA device then takes control of the buses. MPUs that do not contain built-in tri-state buffers on the bus lines (for example, the 6502) must be augmented by external tri-state devices if they are to be used with DMA devices or, indeed, with ATE.

**Cost comparison for various testing procedures**

In the case of MPU-controlled bus-structured circuits, effective testing can only be achieved if the ATE has direct memory access either through control lines on the MPU itself or through enable/disable lines on external tri-state buffers.

**The Story So Far...**

The requirements for testability apply equally to manual and automatic testing. While manual testing can proceed even with a badly thought-out and laid-out module or circuit by the application of a little ingenuity, automatic testing is often impossible with inadequate circuit design. In essence, the circuit designer's responsibility is to provide all the necessary test-points and control lines to enable the ATE to track down all possible faults.

So far, we have only dealt specifically with the functional testing of digital boards. This makes the most rigorous demands on the circuit designer. In subsequent issues, we will turn our attention to in-circuit testing and to analogue circuits and, most importantly of all, to actual test techniques and procedures.

The author and ETI would like to thank the following ATE manufacturers for their help and co-operation in the preparation of these articles. Factron-Schlumberger provided us with the cartoons used in the series and with some valuable information. Zehntel Performance Systems, Genrad Inc., and Hewlett Packard have given permission to re-print details of products and software — Zehntel's Columbia 2000 and their 'timing emulation' technique; Genrad's 'memory emulation' technique; and HP's DTS-70 and 3065 machine simulation techniques and 'Safeguard' in-circuit software package.
Do you ever get the feeling that rising would be a lot easier if it weren’t for the shine? Margaret Blake describes a project to lighten your mornings — gradually!

Picture the scene: it is 7.30 am on a cold and dark Monday morning in winter. The previous evening you were out celebrating with friends and are a bit under the weather. The radio alarm clock switches on and you are awakened gently by its melodic outpourings. All is well until a lone hand ventures from beneath the warm blankets to switch on the table lamp... AAAAAARG!!!

The advent of the clock-radio removed the sudden noisy start to the morning, but what about the switch-on of the bedroom light? Couldn’t something be done to remove that shock too?

This article describes the construction of a unit which will gradually illuminate a mains-powered lamp when it is triggered by an alarm clock or other input. The lamp will take several minutes to progress from darkness to full brightness and will then remain on for either 16, 32, 64 or 128 minutes as desired or until the mains supply is switched off. The circuit is so arranged that the lamp can still be switched on at full brightness in the normal way when required.

The control circuitry is completely isolated from the mains and operation is triggered by a 1.5V pulse to an Enable input. This allows the unit to be used in other applications, for example, in an animal hutch, with a simple switch being used to trigger the lamp brightening process. With a few simple modifications the circuit can also be arranged to dim progressively when triggered instead of brightening.

If the unit is to be built as a self-contained alarm clock, some sort of timing circuitry and display will be required. Rather than use separate timing ICs or a single clock chip which would then have to be interfaced to a display, the prototype was built around a complete clock module. This consists of a liquid crystal display with an integral clock circuit and comes complete with a mounting bezel. It costs around £16.00 plus VAT but this is probably not a lot more than the cost of using individual components and construction is made a lot simpler.

The module requires a supply of 1.5V DC. It is advisable to...
The clock module includes an incandescent back-light to illuminate the display. This also operates at 1.5V but draws rather more current than the clock. Since the lamp brightener would normally be plugged in overnight ready for the following day, the backlight needs to be connected to the lamp brightener's supply via a suitable dropper arrangement. The light would then also operate at night when it is most needed. This facility was not included on the prototype but should be simple enough to add.

**Construction**

The lamp brightener components all mount onto the PCB with the exception of the mains transformer, the LED and, of course, the lamp itself. A separate mains power supply could be incorporated but the clock consumes so little current that it would be a very long time before the supply paid for itself in saved battery costs.

**HOW IT WORKS**

The incoming mains is stepped down by T1 and then full-wave rectified by D2 and D3 before being applied to the voltage divider chain, R1 and R2. The voltage at this point consists of a series of positive half cycles at the mains frequency. A proportion of this voltage is fed from the divider chain to the Schmitt trigger, IC1a, which squares-off and inverts the signal to produce a positive pulse each time the mains goes through zero. The full-wave rectified voltage, meanwhile, is fed to C1 which produces a smooth DC output while D3 prevents the action of this capacitor affecting the voltage on the divider chain.

The pulses from IC1a are fed via diode D4 to the network consisting of C2, R3 and RV1. At switch on, the DC supply voltage will appear across R3 and RV1 and the junction of C2 and D4 will be more or less at the same potential as the supply rail. As C2 charges, however, more and more of the voltage will appear across the capacitor instead of the resistor and the voltage at the junction will fall towards zero. When the mains next passes through zero and a pulse is delivered by IC1a, the capacitor will be discharged and the process will be repeated. The voltage appearing at the inverting input of IC3 will therefore be a series of ramps synchronised with the mains frequency.

R5, R6, C3 and IC2 form an integrator whose voltage will rise linearly with time over a period of several minutes. When the Enable input is taken above a volt or so, Q4 will start conducting and pull down the input of IC1c. The output of this Schmitt will then go high and illuminate LED1. The input of IC1d will also be taken high causing its output to go low and this will turn off Q1. The output of IC2 will then start to rise. IC3 acts as a comparator of the signals from IC2 and the ramp signal from IC1a and D4. The output of this IC will go high when the voltage coming from D4 is below the voltage from IC2. IC3's output will be mostly low at first, but as the voltage from IC2 rises steadily IC3 will go high earlier in each mains cycle. IC1b is another Schmitt trigger and acts to sharpen up the transient of IC3, its output switching cleanly between the positive supply rail and ground.

R8, R9, Q2, Q3 and R10 provide the drive for the LED which is contained within the opto-isolator, IC4. The other half of the opto-isolator is a small triac which, when triggered by a current through the LED, conducts and causes current to flow from R11 and R12 into the gate of the main triac, SCR1. Thus, as the voltage from IC2 rises steadily, the triac will conduct for a longer percentage of each half-cycle and the lamp will slowly brighten. Swapping over the two inputs to IC3 will cause the lamp to dim gradually instead.
## PARTS LIST
### LIGHT BRIGHTENER

### RESISTORS (all 1/4W, 5%)
- R1, 9, 14: 10k
- R2, 3, 13: 100k
- R4, 8: 4k7
- R5: 1M0
- R6: 3M3
- R7, 10, 15: 1k0
- R11: 47R
- R12: 100R
- RV1: 1M0

### CAPACITORS
- C1: 470u 25V electrolytic
- C2: 10n
- C3: 47u 25V electrolytic

### SEMICONDUCTORS
- IC1: 4093
- IC2, 3: 741
- IC4: MC1020 opto-isolator
- Q1: BC109
- D1, 2: 1N4001
- D4: 1N4148
- LED1: red LED with panel-mounting bush
- SCR1: TIC246D

### MISCELLANEOUS
- FS1: 1.5A fuse and PCB-mounting holder
- SW1: DPDT mains toggle switch
- T1: 9-0-9V 100mA chassis-mounting mains transformer
- PCB; case; IC sockets if desired, 1 off 14 pin and 3 off 8 pin DIL; four-core mains cable and either four-pole plug and socket or strain relief bush to suit; three-core mains cable and strain relief bush to suit; heatsink for triac (used only if heavy load is being driven); nuts and bolts; veropins; PCB stand-off pillars; connecting wire, etc.

## BUYLEINES
Most of the parts are widely available from our advertisers and the usual mail-order suppliers and few of the component values are critical anyway. The opto-isolator is available from Watford Electronics and Maplin stock four-core mains cable and plugs and sockets to suit. The clock module is an RS part and can only be obtained directly by trade and professional customers, but Crewe Allan of 51 Scrutton Street, London EC2 can obtain it for you on payment of a small handling charge. Other clock modules which offer similar functions and operate from a 1.5V supply should be suitable, and there is no reason why a unit built up from individual parts or an existing electronic alarm could not be used provided a 1.5V signal can be obtained from them to drive the brightener circuit. The PCB will be available from our PCB Service, for details of which see the note in News Digest.

---

**Fig. 2** Component overlay for the lamp brightener PCB.
and the mains wiring. Use a four-core mains cable for the output to the table lamp and route it through a grommet and some kind of strain relief arrangement in the rear panel. Alternatively, if you don't want the table lamp to be permanently attached to the lamp brightener, a four-pole socket can be used on the rear panel and the table lamp fitted with a matching plug. Wire up the LED on the front panel and temporarily attach a bayonet lampholder and bulb to the end of the four-core cable.

Temporarily short the two pins at the timer input on the PCB and then connect the unit to the mains and switch on. The LED should light up to show that the circuit has triggered and the light bulb should come on slowly over the next few minutes. Don't get too worried if nothing seems to be happening early on — even after two minutes the lamp should still only be glowing faintly and it should take a further five minutes to reach full brightness. If that seems a long time, remember that Murphy's law states that five minutes in the morning is longer than five minutes at any other time of the day! If all is well, switch off to reset the circuit then switch on again and set the initial brightness as desired by adjusting RV1.

Disconnect the unit from the mains and install the clock module, the battery and the push buttons which select the clock functions. SW2, SW3 and SW4 should be mounted on the rear panel and SW5 and SW6 should be on the front panel. The connections to the clock module are shown in Fig. 3.

Break the temporary short circuit across the PCB timer pins and connect the CNT lead from the module to the Enable pin. Don't forget to provide a connection from the negative side of the clock battery to the negative rail of the brightener circuit and the mains earth. The parts all fitted fairly tightly into the case used for the prototype, so if a similar case is used a degree of care is essential if the wiring is not to become a real mess.

The final stage in the construction is to re-wire your table lamp with a four-core lead. The connection arrangement is shown in Fig. 1. The only mains rated four-core
cables we know of are all 8.5mm diameter or more — rather larger than the three-core leads fitted to many table lamps. Because of this you may have to enlarge the cable entry on the lamp and provide a new strain relief bush. Don’t be tempted to use any thinner four-core cables you might happen to have in the junk-box; many of these are only intended for signal applications and are rated at 60V or so maximum.

With all the wiring complete, begin the final tests by setting the time on the clock module. SW2 sets the minutes and SW3 the hours, and SW4 must be switched on while the setting is taking place.

The inclusion of this switch prevents the time being accidentally altered if either of the other buttons are knocked.

Set the mains switch at off, plug in the lamp brightener and check that the table lamp can be switched on and off in the normal way using its own switch. Now switch on the brightener and press SW6 until the LED comes on. The table lamp should come on at the previously-set minimum and then progressively brighten until it is fully on.

<table>
<thead>
<tr>
<th>6/3</th>
<th>6/12</th>
<th>Timing Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>+1.5V</td>
<td>+1.5V</td>
<td>16 minutes</td>
</tr>
<tr>
<td>+1.5V</td>
<td>0</td>
<td>32 minutes</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>64 minutes</td>
</tr>
<tr>
<td>0</td>
<td>+1.5V</td>
<td>128 minutes</td>
</tr>
</tbody>
</table>

Table 1 Connecting the 6/3 and 6/12 pins on the clock module to select the lamp ‘on’ period.

In use, the alarm time is set by pressing SW5 and then using SW2, SW3 and SW4 in the normal way. Pressing SW5 at any other time will display the alarm time set. The brightener should be plugged in before retiring at night and will then operate at the preset time in the morning. Pressing SW5 will cancel the alarm.
TECH TIPS

COLUMN LOUDSPEAKER DESIGN

Rev. A. Sharp Aberdeen

Column loudspeakers consist of a number of individual loudspeaker units arranged in a vertical line. They are highly directional and when used in a PA system can be pointed away from the microphone to reduce the risk of feedback. The directional characteristics are enhanced if the units are wired so that the central loudspeaker gives the highest output power and the level tapers off towards the ends. The principle was described in an article by David Hornsby in ETI November 1982. This arrangement uses seven 5 watt loudspeakers instead of the five 10 watt ones suggested in the article. This allows cheap 16R car radio loudspeakers to be used and, because of the increased efficiency, still gives almost as much output as the original arrangement. The total impedance of the network is 11.8R. The circuit has proved very effective in a church PA system.

NOVEL INPUT STAGE AND GAIN CONTROL

P. Day Newcastle

The circuit shown can be used as a general purpose input stage and enables a number of apparently conflicting requirements to be met. It can handle input signals with a wide range of voltage levels without suffering from the noise and overload problems usually encountered.

The potentiometer acts as two rheostats, controlling both the input level and the negative feedback. When the slider is near A the input is heavily attenuated, allowing high signal levels to be handled without running into overload. The feedback is high so the circuit noise level is low.

When the slider is at B the input signal suffers negligible attenuation. The op-amp has a high gain and the impedance is also high. With the component values given the maximum gain is 30 dB.

I have built and tested a number of these circuits and have been using them as the input stages of a mixer.

ADVANTAGES:
- Handles high input levels without overload
- Low noise output at maximum gain
- High maximum gain
- High input impedance at maximum gain

DISADVANTAGES OF SOME CONVENTIONAL INPUT STAGES

- Low input impedance if R is low
- Low gain if R is high
- Noisy at minimum setting
- Overloads on high level signals

ETI OCTOBER 1985
'Well, winter's coming back again.'
'I didn't notice it had ever gone away.'
'Oh, you can always tell.'
'How?'
'The weather...'
'Yes...'
'And the days get longer in the summer...'
'Yes...'
'And the names of the months change.'
'Okay, you've convinced me. But how do you know it's coming back?'
'Well the names of the months change...'
'Yes...'
'And the days get shorter...'
'Yes...'
'And the weather...'
'Why do you keep going on about the weather? It's terrible.'
'Of course, there's another way of telling when winter's on its way.'
'Oh, what's that?'
'Well, ETI publishes an issue that's absolutely jam-packed with projects.'
'Oh, yes. The November Ten Project Special.'
'That's the one. Gives you enough projects to keep you occupied all year at a rate of one per month.'
'Hold on. There are twelve months in a year.'
'I know that and you know that, but whatever you do don't tell ETI.'
'Why not?'
'If they find out, they'll have to have this whole page printed again.'

THE TEN PROJECT SPECIAL
This year, the November issue offers more variety than ever before.
Among the ten projects lined-up for your delectation are:

The Memory Scope Display
An add-on unit for any oscilloscope which uses digital techniques to slow down the trace and lets you freeze the display. Slow-changing waveforms like sound envelopes and charge-discharge characteristics of capacitors can now be captured and examined without the need to resort to expensive storage devices or long-persistence phosphors.

Switch Mode Regulator
The first project in a series intended to demonstrate the virtues of discrete circuitry, this regulator delivers 5V at up to 1A and hardly gets warm. A perfect replacement for any 7805 with a heat sink large enough and hot enough to fry an egg on.

Rhythm Chip
This canny device uses an EPROM as a metronome or to measure beat-rates directly. All you need to do is tap out a rhythm and the Rhythm Chip will tell you how many beats per minute there are.

Millifaradometer
A voltage window detector, a simple clock and an electro-mechanical counter are the ingredients of this ingenious instrument which will give reliable readouts of the actual value of large capacitors.

PLUS:
Digital Sound Sampler ... Electron Interface ... Chorus Unit ... Exposure Meter and more.
Oh, we nearly forgot to mention the features, but perhaps we'll leave them until next month.

NOVEMBER TEN PROJECT SPECIAL EDITION OF ETI.
ON SALE OCTOBER 4TH.
SO YOU KNOW WHAT SEASON IT IS.

Articles described here are at an advanced stage of preparation. However, circumstances beyond our control may dictate changes to the list of contents.
The foil pattern for the Sorcerer chorus audio board.

The foil pattern for the Sorcerer chorus clock board.

The foil pattern for the Sunrise light brightener.

ETI OCTOBER 1985
The foil pattern for the Sorcerer power supply board.

The foil pattern for the Sorcerer VCO board.

The foil pattern for the Sorcerer envelope board.

The foil pattern for the Sorcerer keyboard interface board.

The foil pattern for the Sorcerer keyboard is too large to print here (it measures about 500 x 230 mm). It is also too large for us to photocopy. We can prepare clear film copies photographically but the cost is likely to be between £15.00 and £20.00. All in all, it will probably be easier for you to purchase a ready made board from our PCB Service (when it becomes available!)
The foil pattern for the modular test gear PSU board.
Enquiries

We receive a very large number of enquiries. Would prospective enquirers please note the following points:

- We undertake to do our best to answer enquiries relating to ETI projects. In particular non-working projects, difficulties in obtaining components, and errors that you think we may have made. We do not have the resources to adapt or design projects for readers (other than for publication), nor can we predict the outcome if our projects are used beyond their specifications.

- Where a project has apparently been constructed correctly but does not work, we will need a description of its behaviour and some sensible test readings and drawings of oscillograms if appropriate. With a bit of luck, by taking these measurements you'll discover what's wrong yourself. Please do not send us any hardware (except as a gift).

- Other than through our letters page, Read/Write will not reply to enquiries relating to other types of article in ETI. We may make some exceptions where the enquiry is very straightforward or where it is important to electronics as a whole.

- We receive a large number of letters asking if we have published projects for particular equipment. Whilst some of these can be answered simply and quickly, others would seem to demand the compiling of a long and detailed list of past projects. To help both you and us, we have made a full index of past ETI projects and features available (see under Backnumbers, below) and we trust that, wherever possible, readers will refer to this before getting in touch with us.

- We will not reply to queries that are not accompanied by a stamped addressed envelope (or international reply coupons). We are not able to answer queries over the telephone. We try to answer promptly, but we receive so many enquiries that this cannot be guaranteed.

- Be brief and to the point in your enquiries. Much as we enjoy reading your opinions on world affairs, the state of the electronics industry, and so on, it does detract from our ability to answer electronics service to have to plough through several pages to find exactly what information you want.

Subscriptions

The prices of ETI subscriptions are as follows:

UK:
- £16.30 Overseas:
- £18.30 Surface Mail
- £24.00 Surface Mail (USA)
- £43.30 Air Mail

Send your order and money to: ETI Subscriptions Department, Infonet Ltd, Times House, 179 The Marlowes, Hemel Hempstead, Hertfordshire, HP1 1B\R (cheques should be made payable to ASPL Ltd). Note that we run special offers on subscriptions from time to time (though usually only for UK subscriptions, sorry).

ETI should be available through newsagents, and if readers have difficulty in obtaining issues, we'd like to hear about it.

Backnumbers

Backnumbers of ETI are held for one year only from the date of issue. The cost of each is the current cover price of ETI plus 50p, and orders should be sent to: ETI Backnumbers Department, Infonet Ltd, Times House, 179 The Marlowes, Hemel Hempstead, Hertfordshire, HP1 1B\R. Cheques, postal orders, etc, should be made payable to ASPL Ltd. We suggest the reader telephones first to make sure there are still stocks of the issue you require: the number is (0442) 48432. Please allow 28 days for delivery.

We would normally expect to have adequate stocks of most back numbers, but obviously we cannot guarantee this. Where a backnumber proves to be unavailable, or where the issue you require appeared more than a year ago, photocopies of individual articles can be ordered instead. These cost £1.50 (UK or overseas surface mail), irrespective of article length, but note that where an article appeared in several parts each part will be charged as one article. Your request should state clearly the title of the article you require and the month and year in which it appeared. When an article appeared in several parts you should list these individually. An index listing projects only from 1972 to September 1984 was published in the October 1984 issue and can be ordered in the same way as any other photocopy. If you are interested in features as well as projects you will have to order an index covering the period you require only. A full index for the period from January to March 1977 was published in the April 1977 issue, an index for April 1977 through to the end of 1978 was published in the December 1978 issue, the index for 1979 was published in January 1980, the 1980/81 index in January 1982, the 1982 index in December 1982, the 1983 index in January 1984 and the 1984 index in January 1985. Indexes should be ordered from: ETI Photocopies, Argus Specialist Publications Ltd, 1 Golden Square, London W1R 3AB. Cheques, postal orders etc should be made payable to ASPL Ltd.

Write for ETI

We are always looking for new contributors to the magazine, and we pay a competitive page rate. If you have built a project or you would like to write a feature on a project that interests ETI readers, let us have a description of your proposal, and we'll get back to you to say whether or not we're interested and give you all the boring details. (Don't forget to give us your telephone number).

Trouble With Advertisers

So far as we know, all our advertisers work hard to provide a good service to our readers. However, problems can occur, and in this event you should:
1. Write to the advertiser with your complaint and asking for a reply. Quote any reference number you may have (in the case of unsatisfactory or incomplete fulfilment of an order) and give full details of the order you sent and when you sent it.
2. Keep a copy of all correspondence.
3. Check your bank statement to see if the cheque you sent has been cashed.
4. If you don't receive a satisfactory reply from the supplier within, say, two weeks, write again, sending your letter recorded delivery, or telephone, and ask what they are doing about your complaint.
5. If you exhaust the above procedure and still do not obtain a satisfactory response from the supplier, then please drop us a line. We are not able to help directly, because basically the dispute is between you and the supplier, but a letter from us can sometimes help to get it sorted out. But please, don't write to us until you have taken all reasonable steps yourself to sort out the problem.

We are a member of the mail order protection scheme, and this means that, subject to certain conditions, if a supplier goes bankrupt or into liquidation between cashing your cheque and supplying the goods for which you have paid, then it may be possible for you to obtain compensation. From time to time we publish details of the scheme in our classified ads, and you should look there for further details.

OOPS!

Corrections to projects are listed below and normally appear for several months. Large corrections are published just once, after which a note will be inserted to say that a correction exists and that copies can be obtained by sending in an SAE.

Audio Design Buffer (September 1984)

There has been some confusion due to the cases of the various transistors (Fig 4, p.61). Q1 and Q11 are T092F (gate, drain and source for pins 1, 2 and 3), while Q2 and Q12 are T092F (type, gate, drain and source). Q3, Q4, Q13 and Q14 should be 'L' types with T092A (base, collector and emitter). The pin positions marked on the overlay are correct. The pins themselves may need to be bent to fit the PCB.

Spectrum Centronics Interface (December 1984)

Pin 18 of IC3 on Fig 1a (page 57) should be marked pin 17. The mistake seems to have been carried over to the PCB (p.58). The tracking lead from pin 18 to the 0V rail should be cut. A correspondent informs us that he has had success with only this modification — in other words, with pin 17 left floating.

Single Board Controller (March 1985)

There were a number of errors in the parts list. RM2 is listed as a 10K SIL pack but is actually four separate resistors, and the same applies to RP3. RP4 is also listed as a SIL pack but should consist of seven, as mentioned. R13 is always required, not just when a cassette interface is used as stated.

The Real Components (May 1985)

In Fig 1 on page 20, the components for the Texas L and 2N transistors are incorrectly shown. They should read B, C and E from the top.

Heat Pen (June 1985)

The instruction in the penultimate paragraph on page 49 should read.../adjust RV2 for 2.73V.../not 2.37V as stated.

Low Cost Audio Mixer (June 1985)

In Fig 6 on page 39, the PCB foil pattern has been incorrectly shown as though from the copper side. The board is shown correctly from the copper side in the foil pattern pages. In Fig 10 on page 40, the position of the parts should be the same as shown to pin 8 of the TL072/IC1-3.

Noise About Noise (July 1985)

In Fig 5 on page 24, no connection should be shown between the cathode of the diode and the negative side of the 470μ capacitor.

Printer Buffer (July 1985)

The case specified is actually larger than the used for the prototype. It will, of course, work perfectly well, but if you want to a compact unit use a Verocase 202-21038H (180 x 120 x 65mm) rather than a Verocase 202-21035. The regulator IC17 should be soldered to the back of the case to prevent overheating and, alternatively, fitted with a TO220 heatsink.

Please note that the designer, Nick Sawyer, has been in touch to inform us that the refresh problem we mentioned last month (page 2) is dealt with in the printer buffer software. In this case the user need not replace the TMS 4416 dynamic RAMS, although as far as we know the replacement parts (Hitachi HM4416 DRAMs) will cause no problems. The full text of Nick Sawyer's letter will appear next month. Meanwhile, our apologies for any confusion caused.

Intel 8254 Data Acquisition Unit (September 1985)

It should be apparent from the text page 35 that an actual program has been omitted. This program is for use with the SDX 8065 kit only, and copies may be obtained from us on receipt of a stamped addressed envelope.
A GUIDE TO PRINTED CIRCUIT BOARD DESIGN

Book

Charles Hamilton
The Butterworth Group, Borough Green, Sevenoaks, Kent TN15 8PH.

price: £7.50.

Could there be anything useful here for our own PCB design? That was my first thought on seeing this book. Let's face it, just like you lot out there in hobby land, we at ETI have to turn our hand to everything from metal bashing to screen printing and a few tips from the experts are always welcome.

As it turns out, the book is aimed at those who intend to make a career of PCB layout in a large company drawing office and much of the information is not possible to apply to the occasional PCB layout.

The first chapter is a guide to understanding circuit diagrams, which I sincerely hope ETI readers can do already. Next we have advice on how to compile a file of component shapes and sizes - useful in a company that standardises its component stocks, but not much good if you're going to build a circuit with odds and ends from your spares box.

Chapters on the design layout and master artwork have one or two useful hints, but on the whole they are geared to company procedures. For one thing, we wouldn't produce a design layout (with component placing and interconnections all on the same artwork) in the first place. We just plunge straight into the master artwork, and it usually turns out alright on the night.

Other short chapters cover computer-aided design (the book assumes you already have £50,000 of CAD equipment and explains how to provide the input), preparing assembly drawings, flow soldering (we use a soldering iron), and so on.

By all means buy the book if you are thinking of making a living from PCB design, but for the general reader I don't think there is enough relevant information to make it worthwhile.

Paul Chappell

INTRODUCTION TO MICROCOMPUTER ENGINEERING

Book

D.A. Fraser et al.
Ellis Horwood, Market Cross House, Cooper Street, Chichester, West Sussex, PO19 1EB


There are six authors credited for this one book. Since there are nine chapters, either some authors worked harder than others or they wrote 1/9 chapters each. Perhaps each author wrote every sixth word? Anyway, no matter how it was written the authors have come up with a very useful book indeed.

There are chapters on four of the most popular 8-bit microprocessors: the 8085, Z80, 6800 and 6502. There is enough detail for the reader to be able to use these devices in relatively simple systems without reference to any other data - a point I thoroughly approve of. Electrical specifications and timing limits are not included, but unless you're trying to squeeze every ounce of performance from the device you can probably do without them.

Sixteen-bit microprocessors are dealt with in considerably less detail, all in one chapter. Devices mentioned include the 8086, 28000, 68000 and several others. If you want to use these devices you will certainly have to seek further information from manufacturers data sheets, but the book may help you select the best one for your purposes.

The rest of the book consists of a mixed bag of odds and ends, some of which are not often included in a book of this type. You will find descriptions of the IEEE 488 and S100 buses, some useful ideas on the use of interrupts and DMA, a brief description of fault signature analysis, and much more. If there is any fault in these chapters it is lack of detail, which is understandable in a book that covers so much ground. You get a taste of everything from video graphics to operating systems (CP/M and UNIX) without enough to satisfy you once your appetite has been whetted. However, there is a bibliography of books for further reading at the end...

Paul Chappell

ALF'S PUZZLE

History tells of many men of genius who failed to achieve recognition in their own lifetimes. This could so easily have been the case with Alf. Some of you may know of him as the inventor of the lithium raincoat, or perhaps as the founder of the Snipe Nosed Pilots Owners Club, a very exclusive organisation which to this day has only one member (Alf). To many of you he will be completely unknown.

How can this be when he has been beavering away in the basement of ETI headquarters for the past 15 years, barely taking the time to snatch forty winks in the broom cupboard each night before he's back at the workbench again?

The great tragedy of Alf's life is that none of his designs ever quite work. The circuit pictured here is one of his finest efforts. The idea is that as soon as the switch is turned on, an LED lights up to remind you to turn it off again. Sad to say, what actually happens is that the LED turns on for a few seconds and then stays off.

We can't let such a brilliantly conceived idea go to waste, so can any of you fathom out what's wrong with it? If you can, please don't write in because it would only upset Alf and distract him from work on his welly-bootstrap circuit. We'll let you know our solution next month and you can see if it agrees with your own.
PLAYBACK

Whenever some new development comes along which might become a money-spinner for the makers and a fact of life for the rest of us, it is usually launched with vigor and determination in at least two incompatible formats. We have the many world TV standards, the various cassette audio tapes (though fortunately all have fallen by the wayside except the now standard compact cassette) and the still active three video formats.

Now that the CCR (Camera Cassette Recorder) has come along to oust the cumbersome separate camera/recorder outfits, a full-scale format war is once more under way. This has given rise to all the old problems, not least of which is indecision on the part of potential buyers. First-generation CCRs used standard VHS and Beta cassettes and were pretty hefty to lug around, so JVC produced their Compact VHS system. This uses half-inch tape in a tiny cassette, but can be played in a standard VHS machine by means of an adapter shaped like a normal VHS cassette.

That was back in 1981, the year after Sony announced their 8-mm system. Sony obtained the signatures of some 130 manufacturers to give them manufacturing rights and thereby virtually established it as the standard CCR system. However, many of these companies signed just to avoid being left out of the act and were not enthusiastic about the appearance of yet another video system.

When C-VHS appeared, many felt that the Sony system would die. It hasn't, and the new CCD-V8 camera recorder from Sony which fairly bristles with advanced features will undoubtedly ensure that 8-mm video will at least co-exist if not supersed the C-VHS system.

Metal particle tape is required to record video on such a narrow tape-width. There have been problems with metal tape in the past but it seems that these are being overcome. High-quality FM sound is a standard feature of the 8-mm system but may or may not be used with C-VHS, just as with standard VHS. Cassette running time is up to 90 minutes for 8-mm compared with 60 minutes for C-VHS.

So what about the incompatibility of 8-mm Sony have overcome this one and at the same time upsetged JVC adverts by making a CCR which plugs directly into an any TV or video monitor. You don’t need another recorder to play their tapes back. JVC’s claim that their system has 8 million advantages over 8-mm (these being the number of compatible VHS recorders in use) is therefore trumped by Sony’s reply that they have 15½ million, which is the number of colour TV’s in the UK. And that, they add, is only counting those who pay their licences.

Those of us who do not have £1000 to spare, — which I suspect is more than a few — can just sit back and enjoy the fun. Can’t help thinking though, that an awful lot of effort is being wasted in these skirmishes.

Vivian Capel

GONE TO THE DOGS: the separate camera/recorder system has had its day, but strile dogs its successors.
TRAINS OF THOUGHT

To the railway modeller, the equivalent of the Holy Grail is a system that allows independent control of several trains simultaneously on the same layout. The two most frequently encountered methods are command control and cab control.

Command control makes the entire layout permanently live - normally with AC although DC systems have been developed - and each locomotive is equipped with a module which is effectively an on-train controller. This responds to instructions superimposed on the traction voltage by a master control unit. Probably best known is Hornby's Zero-1 system. This makes extensive use of Texas Instruments TMS-1000 4-bit microprocessors in both the modules and the master control units. Up to 16 trains can be controlled at any of 16 speeds, forwards and reverse. A large number of trackside accessories can also be operated, drawing both power and data requirements through which all signals are superimposed on the square-wave traction supply.

In contrast to the advanced digital techniques employed by Hornby's system, the Airfix MTC (Multiple Train Control) uses some subtle analogue circuitry. Each on-train module is essentially a radio receiver responding to a pulsed radio-frequency carrier superimposed on the sine-wave traction supply. Again up to 16 trains can be used (though only four at a time), the 16 frequencies being digitally synthesised in the master control. Train direction is determined by the polarity of the traction supply during the RF pulses and speed by the duration of the pulses.

Both systems are reliable and easy to install, except that it can be awkward finding room for the modules in some smaller model locomotives. A disadvantage is that the system is not compatible with conventional operation - an unmodified locomotive will emit real smoke in a matter of seconds in the absence of the command control track. To adopt the system you must make the changeover and modify all your locomotives at once.

Switching Cabs

The alternative is cab control. In its simplest form this is not electronic but simply an arrangement of switches. The layout is divided into a number of control zones each of which can be connected by switches to any of several conventional (rohestat or electronic) controllers. As the trains progress around the layout passing from zone to zone, the switches are thrown manually so that each train keeps the same controller (or cab) for the whole of its journey.

However, with the availability of reliable train detection systems (discussed in the second article of this series) an automated method of cab control is feasible. This is called progressive cab control. Its implementation is tedious rather than difficult, requiring banks of logic circuitry where the complexity is proportional to the square of the number of controllers), but it should be possible to arrange for a microcomputer to perform the bulk of the logic. The computer would need a large number of input/output ports - an Apple IIe or BBC Micro with backplane suggest themselves - and also an interface unit containing the train detectors and relays to switch the controllers between control zones as time and money permit.

Roger Amos

OPEN CHANNEL

A number of press releases landed on my desk recently from British Telecom, announcing the launch of their advanced digital communications service. The service, says the press release, sets a new standard in business communications, with such benefits as:

- an A4 page sent by facsimile in six seconds
- telephonephotographic-quality colour pictures on videotex
- slow-speed television
- greater reliability

The new service is called integrated digital access (shortened, thankfully, to IDA). It is part of British Telecom's advancing programme of communications technology which will eventually lead to a digital telephone network providing all these facilities to every business or household in the nation. The complete network is called the integrated service digital network (shortened, again thankfully, to ISDN), and will be accessible by the user through the IDA service. So, you'll have gathered, British Telecom wants every user to have an IDA point through which all digital communications facilities will be routed, in much the same way that existing telephone points allow facilities such as computer communications (via modems), videotex services (Prestel), answering-phones etc.

IDA will be operated initially from the first System X exchange, opened recently at Baynard House in the City of London. It will cover Euston, the West End, the City and Southbank in London as well as parts of Bracknell, Bristol, Croydon, Reading and Slough. More local exchanges, in Lancashire, the Midlands and South Lancashire, are expected to be linked in to the network by the end of the year. By the end of 1987, British Telecom hope to have IDA available at 190 centres throughout Britain.

So what advantages are being forced upon us? Well, in the ISDN all communications are digital. That is, the actual telephone which the user speaks into and listens to converts the analogue audio signals directly into digital ones ready for transmission through the network. Contrast this with the existing telephone network where most signals are analogue and only some (over main trunk routes) are digitised for part of the journey. In theory at least, a digital network should provide a more reliable, higher quality and, best of all for the user, a cheaper service.

Anyway, that's the theory. And certainly, I for one, always thought it was too good to be true. But I was looking forward to high quality speech and data communications and was ready to apply for an access point as soon as it became available (I live in one of those expensive two-bedroom houses which is not the service by the end of the year). I'm pretty fed up with having to shout down my telephone mouthpiece so that the other party can hear what I'm saying whenever I make anything other than a local call. As a freelance journalist I would also find the data transmission aspects of the network useful to download copy to editors, ready for publication. Perhaps readers have similar feelings. However, the same press release which brings the good news about IDA also gives prices - and these aren't so good.

For example, the cheapest IDA access consisting of a digital telephone with on-hook calling, (known as version NT1 in a key pad, a display, and one data port which can be configured to support a variety of terminals, will be installed for £890. It then costs £710 per year to rent. And if that's not all, customers outside the London Fringe phone areas are subject to an out-of-area connection charge of either £350 (within the *A’ rate call charge area) or (like me) £700.

Excuse me for being so pessimistic, but if British Telecom thinks it can sell ISDN and IDA to potential customers at these prices, I believe it will have to think again. If the economic benefits of a digital network which British Telecom will derive (ie, lower maintenance costs, lower call costs etc) can't be passed on to the customer in the form of cheaper rentals and reasonable installation charges, then I can't see many potential customers buying the service. I'll certainly shut down a scratchy analogue line and post my copy to editors if it means I don't have to pay telephone bills of that order. British Telecom can, as the saying goes, stick it!

And There's More!

If you're a typical telephone user and use the 'phone quite regularly, you'll probably just dial a number you want to contact without thinking where the call is going to. However, the far end of the country has a cost per unit of only about 5p. At standard rate times this amounts to only about 16p per minute. However, bear these two numbers in mind: 0860 and 0836. If the number you're about to ring is prefixed by either of these, then consider carefully the cost of dialling before you actually do it. These two prefixes indicate national numbers that belong to cellphones, i.e., telephones which are linked by a radio connection on one of the two existing cellular radio telephone systems. The cost per unit charge when making a call to a cellphone remains the same, but the call is charged at the same rate as it would be if it were a call to the Irish Republic, about 43p per minute for standard rate calls! Its for yoo-hoo. I'll just reverse the charges.

Keith Brindley
SCRATCH PAD
by Flea-Byte

My most profound apologies for my unexplained absence last month. Many of you may have thought that, like most of the other giants of British electronics, I too had been swept under by the encroaching tide of Japanese goodies, the fickle dollar exchange rate, the ridiculous posture that passes for economic policies in the Cabinet and the general subterranean level of competence among that noble breed - the British manager. No such luck! While the share tumbled, companies teetered, the Daily Maxwell played footsie with Uncle Clive and Sir Kenneth Corfield toppled his recent failure to win the British Electronics Personality of the Year award by an even more astonishing failure to steer STC through the stormy seas of his own chairmanship, good ole Flea-byte was taking a well-earned rest from the sodden and the sweat in a small but reasonably well-appointed guest house somewhere on the Costa Packet.

Fortunately, the Sun journalists were too busy identifying miscarriages evading the formerly long arm of the law to recognise me. Almost certainly, were I not such a master of disguise, I would have been whisked back to the height of the English summer to rescue Thorn-EMI, STC, GEC, Acorn and Sinclair Research - all of whom, should it have escaped your notice, sailed perilously close to the rocks during the balmy July days. Now refreshed after many pleasant days spent discussing tax shelters with a man who introduced himself to me as 'A. Bank Robber', I have returned to the fray. To avoid misunderstanding, I must make it clear that, following Sir Kenneth's untimely departure from the helm of STC, I shall not be available to mount one of the economic rescues for which I am so deservedly unknown.

It's not that I have any principled objection to helping STC out of a scrape. On the contrary, Sir Kenneth Corfield's chairmanship has resulted in this company becoming a flagship for British industry. Among his more notable achievements - to be counted with the acquisition of ICL and the promise that shareholder dividends would be maintained at a time when share prices were going through the floor and profits were disappearing into the negative zone - was his audacious acceptance of a 48% pay-rise in 1984. In case you think the labourer should be worthy of his hire, let me tell you that Sir Kenneth's salary at that point amounted to £297,000 a year. Any company that pays that sort of money is alright by me!

No, my reason for not wishing to shoulder the burden of STC's undoubted recovery is simply that I feel it would be far too partisan of me. After all, there are so many companies in need of a guiding hand that to devote all my considerable talent to just one would, I fear, be selfish. Thorn EMI's downturn in profits had already led to the departure of chairman Peter Laister before Corfield announced his resignation. GEC have remained profitable, thanks largely to their legendary cash-mountain (a billion or more pounds just collecting interest). Even so their recent profit announcement revealed disappointing figures. Acorn and Sinclair seem to have one foot permanently inside the bankruptcy court.

Looking at the way all this news has given the entire British electronics industry the shakes, duty dictates that I remain on the side-lines, egging the teams on to greater things. Readers can rest assured that Flea-byte will not take another holiday until confidence is restored and our electronics industry returns to its former glory. Well...

• • •

Crystal Balls

I notice that a company in North America has just reached the first all-British, electronic time machine. Anthony Bassett of Number One Electronics claims that the machine generates 'electromagnetic waves' which, apparently, encourage visions of the past to spring before your 'third eye' (that's the one we all have in the middle of our foreheads, you know!). Such machines have, of course, been known for some

Even so there were a number of interesting new electronic instruments and sound modifying boxes there. For yonks I have wondered why musicians on stage don't make more use of radio microphones and guitar transmitters. Maybe their popularity will increase with the introduction of an economically priced guitar transceiver by TOA. They also do a more expensive version with two receiving antennas to remove the problem of RF dead spots. Trantec have produced an even lower cost one, priced at a mere £300.

Home recording addicts are being well looked after these days. Up to four instruments can be recorded at a time, it says, on the new Teczon Multi Dub 4x4 home recorder, and up to thirty three instruments recorded by bouncing from one track to another and overdubbing. It costs £492 from John Hornby Skewes. They were also showing off an Audio Technica machine called the AT-RMX64, four track, six input cassette recorder. Being more moderately priced at £1100, it's probably aimed at professionals or very serious home recordists.

There were lots of new amplifiers, but the most interesting innovation is the Peavy Digital Power Conversion Amplifiers. Does this mean class D (switched...
time - but they only used to work during the summer months when there were less companies trans-
mitt nothing but repeats. By the way, Number One's previous
big seller is a crystal ball or, in the
technical jargon, gas-filled light-
bulb.


A Knight To Remember

The saga of Sir Clive continues
unabated. I'm afraid. Undaunted by
the Daily Maxwell's strange
will-he won't-he dance routine
with Sinclair Research, unruled by
a 'Whitch' report on the C5 which
demonstrated that it would get you from A to B, as long
as B was downhill and downhill of A and as long as the traffic
fumes and towering juggernauts
didn't get you first, the pter,
ging-legged guilf heard, people
tend to have been observed setting up
a new company. Another new
company.

My usual reliable sources in
the Goaf and Feathers tell me that
this one will be different. Sinclair
Research's Nigel Searle says that,
'the company will exist to
provide services to Sinclair
Research, which will primarily be
the availability of Sir Clive him-
self.' Sir Clive, of whom it has been
said that availability is his
strongest suit, is currently facing
the world that the Maxwell's
departure from the scene is probably
a blessing in disguise. Apparently,
several other parties are interested
in the possibilities Sinclair
Research holds out for losing
a great deal of money. Dixon's -
the high street store - have just
agreed a deal with Sinclair and
the Spectrum is selling well. In
the Goaf and Feathers, we nible
on such announcements with our
beer - they're saltier than
chips.

Confirmation of Sir Clive's fore-
sight, however, can be obtained from
the gaze of a special one he made
earlier this year to the Radio,
Electronic, and Television Retailers
Association (RETRA). The assembled
high street dealers heard him
say that they could sell as many
C5's as video recorders and a
portable TV would soon be selling
over two million units a year and that
the future of the computer mar-
tet would be portable with a 'real TV
screen'. Sir Clive thinks the
Japanese have got it all wrong
with their concentration on LCD
screens. 'The Japanese will fail,'
he said, 'because they have con-
tinued to back LCD's.' At Sinclair
Research, they have big plans for
the 'non-compromise' portable
-packet-sized, rodbust, featuring
a high resolution colour monitor
and all powered by a single PP3.
Well, where would we be if it
weren't for our dreams?


Old Guard?

The editor tells me an appealing
little story about Conserva-
tive Central Office, whom he
phoned in order to get hold of
some pictures to illustrate an ETI
article. The pictures in question
were photographs of John Butcher,
Parliamentary Under Secretary
at the Department of Trade and
Industry, and Geoffrey Pattie,
Minister with special responsi-
ibility for Information Technol-
oy. The photograph of Butcher
was not too much of a problem,
despite the fact that it arrived
with a rubber-stamp mark threat-
ing to engulf the Under Secre-
tary. Pattie was another matter,
however. The man at Central
Office wasn't even sure they had
a photograph of him. When he
length he managed to dig one up
it proved to be ten years old,
badly focused and scratched.

The Minister was shown in pre-IT
days - desporting himself with a
small group of Tories from the
Chersey constituency party.
Some might say this demonstra-
tes the low regard in which
Pattie and, by association, In-
formation Technology are held
by the Conservative Party. I prefer
the word nothing to do with IT
or Pattie's position, but rather
reflects the man. Butcher, you see,
is young, reasonably good-
looking and decorated with a full
head of hair. Poor Geoffrey Pattie,
on the other hand, is old, bald and
distinctly odd of aspect. Not at all
the image of a Thatcher man!


Say That Again

Wading through the accumu-
lated press releases on my desk,
I came across this shining exam-
ple of English as she is spoken. This
JMS Drum Unit produces sounds
which are indistinguishable, and
in some cases better, than the real
thing. Presumably, this means
that some real drum sounds are
indistinguishable from their syn-
thesized equivalents and, at the
same time, noticeably inferior.
And now for the grammar...


It's easy to
complain about
advertisements.
But which ones?

Every week millions of advertisements
appear in print, on posters or in the cinema.
Most of them comply with the rules
contained in the British Code of Advertising
Practice.

But some of them break the rules and
warrant your complaints.

If you're not sure about which ones they
are, however, drop us a line and we'll send you
an abridged copy of the Advertising Code.

Then, if an advertisement bothers
you, you'll be justified in bothering us.

The Advertising Standards Authority.

If an advertisement is wrong we're here to put it right.

ASA Ltd, Dept 2 Brook House, Tarrington Place, London WC1E 7HN

This space is donated in the interests of high standards of advertising.

Andy Armstrong
LOWEST PRICED TOP QUALITY fire and intruder alarm equipment, etc. S.A.E. for catalogue. Security Services, 162 High St, Hythe, Kent CT2 1 SJR.

POWER SUPPLIES

150W SWITCHMODE PSU + 5V @ 4.4A, + 12V @ 4.8A, + 24V @ 1.7A. -12V @ 0.2A. Perfect working order over £70 in Henries Radio £29 + Carr. 0224 90027 after 6.00pm.

HEATHKIT U.K. Spares and service centre. Cedar Electronics, Unit 12, Stallon Drive, Bredon, Tewkesbury, Glo. Tel: 0684 73127.

COURSES

CONQUER THE CHIP...Master modern electronics the PRACTICAL way by SEEING and DOING in your own home. Write for your free colour brochure, now to: British National Radio & Electronics School. P.O. Box 7, Teignmouth, Devon TQ14 0HS.

TEST EQUIP.

TOP PRICES PAID for surplus electronic test equipment
ALWAYS a good selection of SIG-GENS, METERS, and SCOPES for sale. Phone 0862-871430.

POWER SUPPLY REPAIRS. We offer a fast repair service on most makers of DC power units in the range of 1amp to 30amps. We do bass, treble, stereo, and more fitted. Full details ring: 0536 743 496.

ETI OCTOBER 1985
AMAZING ELECTRONIC plans, lasers, gas, ruby, light shows, high voltage tests, van de Graaf generators, microchips, pyrotechnics, new solar fuel cells, 150 more projects, catalogue. S.A.E. Plancentre, Old String Works, Bye Street, Ledbury HR8 2AA.

RESISTORS, CAPACITORS. 1,000 mixed carbon film 1/4W, 1/4W, 1%, 2%, 5%, 10% resistors £2.95 + 50p P&P SAE for details to: D.J. Hooker, Romney Marsh, Electronics, Black Road, Greatstone, New Romney, Kent TN28 9PB.


VAST RANGE of products from many branches of science and technology. High specification components, labware, lasers, instruments, chemicals, optics, computer supplies and much more. SAE with details of your specific requirements or for catalogue, Science and Technology Products (ET2), PO Box 192, Poole, Dorset, BH15 4AL.

BRIDGE RECTIFIERS 600/35A, Ideal MScycles £4.20. Electronics 400/2 10/25 1/63 10/63 10p. 1500/2.5 100/0.3 150/40 64/63 15p. 2500/2.5 100/2.5 100/10 20p 3200/ 4 470/35 35p. 1000/16 640/25 470/40 250/64 30p. Polyester 0147/250 10p. P&B 30p per order. Robin Electronics, Greenway, Monkton, Taunton TA2 8NQ.

EPROMS 27128-250ns. SAE with Trade Price List Spectrum Radio & Electronics, 36 Slater St., Liverpool L1 4BX. 051-709-4628.

J. Linsley Hood Designs
Distortion Analyser Kit £25.00 £1.00
Mothman Kit £12.25 £0.30
Case and Panel for above £12.00 £1.00
ETI Model 3 A/D £51.00 £1.80
Audio Signal Gen. £22.50 £1.80
Audio Signal Gen. £33.00 £2.50
Fixed Res. £12.00 £1.00
Case for above £9.00 £0.75
Reg. P&P: £1.15/each for £12.00 £1.00
S.A.E. for full list.
TEL-RADIO ELECTRONICS
325, Fore Street, London N1 OPE. Tel: 027-7178

PRINTED CIRCUIT BOARDS and PLANS TO BUILD: Head-light activated switches, timers, metronomes, sirens etc. Two ready drilled boards £2.85 p&p 50p. Send to: Chataignes Products, Green Lane, Great Horkesley, Colchester, Essex, CO6 4HO.

MINIATURE TRANSMITTER
Transmits all voices and sounds to any VHF/FM radio up to 5 miles away, size 2½" x 4½". £4.95. Some templates to suit various makes of VHF/FM radio. Send cash/cheque/PO: TECTRONIKS 23 Lambardes N.A.O. Nr Dartford, Kent DA1 9HS.

MICROCOMPUTER REPAIRS
ZX SPECTRUM. Vic20, C64, BBC, QL 15 40/41, Commodore computers, printers and floppy discs. Send faulty machine to: Trident Enterprises Ltd., 37 Linden House, Comron Road, Langley, Slough, Berkshire. Tel: (0753) 48783.
electronics today international
BOOK SERVICE

How to order: Indicate the books required by ticking the boxes and send this page, together with your payment to: ETI Book Service, Technical Book Service, Oak House, Cannock Road, Cannock, Staffs. W.S. Please make cheques payable to Technical Book Service. Payment in sterling only. All prices include P & P. Prices may be subject to change without notice.

BEGINNERS GUIDE

- Beginner's Guide to Basic Programming
  - Stephenson
  - £5.85

- Beginner's Guide to Digital Electronics
  - £5.85

- Beginner's Guide to Electronics
  - £5.85

- Beginner's Guide to Integrated Circuits
  - £5.85

- Beginner's Guide to Computers
  - £5.85

- Beginner's Guide to Microprocessors
  - £5.85

- Beginners Guide to Microcomputing
  - £5.85

COOKBOOKS

- Microprocessor Cookbook
  - M. Horschild
  - £10.85

- Active Filter Cookbook
  - Lancaster
  - £14.95

- TV Typewriter Cookbook
  - Lancaster
  - £12.95

- CMOS Cookbook
  - Lancaster
  - £13.95

- TTL Cookbook
  - Lancaster
  - £12.95

- Micro Cookbook Vol.1
  - Lancaster
  - £15.30

- MC 6809 Cookbook
  - £7.25

ELECTRONICS

- Electronic Devices & Circuit Theory
  - Boylston
  - £15.95

- Principles of Electronic Instrumentation
  - De Sa
  - £11.45

- Giant Handbook of Computer Software
  - £12.95

- Giant Handbook of Electronic Circuits
  - £22.95

- Giant Handbook of Electronic Projects
  - £13.60

- Electronic Logic Circuits
  - £8.45

- Analysis and Design of Analogue Integrated Circuits
  - £42.50

- Circuits Gray
  - £13.00

- Basic Electronics Graf
  - £23.00

- Lasers, the Light Fantastic
  - £12.90

- Introduction to Digital Electronics
  - £8.25

- Electronic Testing and Fault Diagnosis
  - £12.25

- Basic Electronics A-Z Guide
  - £7.50

- Microelectronics
  - £16.05

- Power FETs and their application
  - £41.00

- Electronic Drafting and Design
  - £26.55

- Electronic Fault Diagnosis
  - £8.25

- Digital Systems
  - £14.25

- Master Handbook of Telephones
  - £12.95

- Gower J. Optical Communications System
  - £17.95

- Encyclopedia of Electronic Circuits
  - £30.45

- Microprocessors
  - £16.35

- Senior J. Optical Fibre Communications
  - £16.35

- Trole.
  - Principles & Practice
  - £14.15

- Electronic Troubleshooting
  - £15.70

- Wilson/Hawkes Optoelectronics
  - An introduction
  - £15.70

COMPUTERS & MICROCOMPUTERS

- From BASIC to PASCAL
  - £11.30

- Microcomputer Interfacing
  - £8.95

- Interface Manual Handbook A/D & D/A
  - £12.80

- Troubleshooting
  - £12.80

- How to Design, Build and Program your own
  - £13.90

- Computer System Handbook
  - £14.95

- Microcomputer Builders Bible
  - £14.75

- Digital Circuits and Microprocessors
  - £16.95

- PASCAL for Students
  - £5.55

- The C - Programming Language
  - £24.45

- Theory and Practice of Microprocessors
  - £11.35

- Microprocessors and Microcontrollers
  - £9.90

- Microprocessor Applications
  - £46.45

- Handbook of Microprocessor Design
  - £46.45

- Programming the PET/CBM West
  - £20.25

- The Art of Microdesign
  - £15.45

- Starting FORTH
  - £23.10

- Thinking FORTH
  - £15.95

  - £14.85

- Videodac and Optical Memory Systems
  - £42.55

- A Practical Introduction to New Logic Symbols
  - £13.00

- Computer Techniques
  - £17.70

- Build your own Expert System
  - £8.45

- Interactive Video Periscope
  - £12.45

- Programming with D Base III
  - £17.70

- Artificial Intelligence
  - £12.00

- Superfine Programming
  - £17.70

- The Big Red Book of C
  - £17.70

- VLSI Technology
  - £12.00

- User Guide to the UNIX System
  - £21.45

- Going from BASIC to C
  - £25.15

- Introduction to Pascal
  - £11.45

- Welsh/Elder
  - £10.95

- Beginner's Guide to Basic Programming
  - £6.95

- Electronic Designers' Handbook
  - £26.65

- Electronic Circuit Analysis
  - £35.00

- Digital IC Technology
  - £12.95

- Book of Optoelectronics
  - £13.95

- Electronic Instrumentation
  - £15.50

- Practical Computer Techr.iques
  - £12.95

- International Digital IC
  - £10.95

- Principle and Practice
  - £24.95

- Electronic Circuits
  - £22.95

- Microprocessors
  - £13.95

- Electronic Calculations
  - £42.25

- Modern Circuit Reference Manual
  - £57.45

- Electronic Troubleshooting
  - £19.75

- Beginner's Guide to Video
  - £15.45

- Video Recording
  - £16.40

- Video Handbook Van Welse
  - £24.05

- Video Technique
  - £26.25

- Grob Basic Television and Video Systems
  - £14.95

VIDEO

- Servicing Home Video Cassette Recorders
  - £19.05

- Complete Handbook of Videocassette Recorders
  - £10.50

- Theory and Servicing of Videocassette Recorders
  - £15.45

- Advanced Television and Video Systems
  - £6.95

- Video Recording: Theory and Practice
  - £16.00

- Video Handbook Van Welse
  - £24.05

- Video Technique
  - £26.25

- Grob Basic Television and Video Systems
  - £14.95

ELECTRONIC DATA BOOKS

- THT 63/64 Data dictionary and comparison table
  - £9.50

- TVT A-2 Transistor equivalent book
  - £3.00

- TVT 2N Transistor equivalent book
  - £3.50

- DAT 1 Part 1 of the reference
  - £8.40

- DAT 2 Part 2 of the reference
  - £10.50

- DAT 2 Part 3 of the reference
  - £8.30

- DAT 2 Part 4 of the reference
  - £10.50

- LIN 1 Linear operational amplifiers data and comparison tables
  - £5.50

- LIN 2 Linear voltage stabilizers data and comparison tables
  - £5.50

- TTL 685 digital and equivalent book
  - £7.80

- DDV/1 Part 1 European diode data book
  - £7.80

- DDV/2 Part 2 American and Japanese diode data and
  - £7.80

Please send me the books indicated. I enclose cheque/postal order for £___________. Prices include postage and packing. I wish to pay by Access/Barclaycard/Visa/direct debit or standing order. (Please tick the box)

Name: ________________________________

Address: ______________________________

Signature: ____________________________
More This Month at Maplin

Colour-coded 1DC cables
16-way (XR80B) ONLY 32p per metre
20-way (XR81C) ONLY 40p per metre
26-way (XR82D) ONLY 54p per metre
34-way (XR83E) ONLY 70p per metre
40-way (XR84F) ONLY 90p per metre
50-way (XR85G) ONLY 99p per metre
4-way flat flexible telephone lead (XR86T) ONLY 18p per metre.

Stepper motor 48 steps/rev, 12V 0.13A per phase, 4-phase unipolar, 57g, working torque 8mNm max ONLY £9.95 (FT73Q).
Driver chip for motor: SAA1027 ONLY 13.75 (QY76H).

*SAVE* - Kit containing everything you need: motor: SAA1027, data sheet and possessives ONLY £16.35 (LX76H).

Sounds Terrific

Professional Quality High Power Loudspeakers featuring:
- Virtually indestructible high-temperature voice-coil reinforced with glass-fibre.
- 100% heat overload tolerance.
- Advanced technology magnet system.
- Rigid cast-alloy chassis.
- Linen or Plastiflex elastomer surrounds.
- 5-year guarantee. (In addition to statutory rights.)

Prices from £18.95. Send S.A.E. for our free leaflet XH-625.

Top Ten Kits

- May be used by any computer with RS232 facility.
- Stepper Motor controlled.
- Half millimetre/half degree resolution.
- Uses ordinary felt-tip pens.
- Built-in 2-tone horn, line-follower, LED indicators.

The Zero 2 Robot is the first truly micro robotic system available and remarkably it costs less than £80. Complete kit (only mechanical construction required) £79.95 (LK664W).
Full details of power supply and simple interfacing for BBC, Commodore 64 and Spectrum, in Maplin Magazine 15 price 75p (XA15R).

The Maplin Service

All in-stock goods dispatched same day for all orders received before 2.00 pm.
All our prices include VAT and carriage (first class up to 750g).
A 30p handling charge must be added if your total order is less than £5.00 on mail-order (except catalogue).

Telephone before 2.00 p.m. for same day despatch.

Top Ten Books

1. [ ] Laptop Enclosure Design and Construction
2. [ ] Marketing Electronics
3. [ ] Remote Control Projects
4. [ ] How to Build Your Own Solid State Oscilloscope
5. [ ] International Transistor Equivalents guide
6. [ ] How to Design and Make Your Own PC4
7. [ ] Power Supply Projects
8. [ ] Radio Control for Beginners
9. [ ] How to Use Computer
10. [ ] Electronic Synthesizer Projects

All offers subject to availability. Prices firm until 9th November 1985.

www.americanradiohistory.com