PRACTICAL ELECTRONICS
JANUARY 1984

Lighting Effects Desk

Plus... COMPACT DISC...
THE TECHNOLOGY
THE NEW
MPF1 PLUS...

...THE LOWEST COST
Z80 SINGLE BOARD COMPUTER
AVAILABLE WITH ALL THESE FEATURES!

The MPF1 PLUS incorporates the Z80—the most widely used 8-bit microprocessor in the world, to form a Single Board Computer (SBC). Packed in a plastic bookcase together with three comprehensive manuals and power supply (to BS3651 standard), the MPF1 PLUS is a microprocessor learning tool for every application.

FLIGHT Electronics Ltd.

Teaching you in a step-by-step method the MPF1 PLUS helps the user fully understand the Software and Hardware of a microprocessor easily and conveniently—as opposed to micro-computers that aim to teach high-level languages instead of microprocessor systems fundamentals.

Not only is the MPF1 PLUS a teaching tool but with the available accessories it can also be used as a low-cost development tool or simply for OEMs.

£140
+VAT & carriage

THE MPF1 PLUS
Just look at the specification -

Technical Specification

CPU: Z80A – 158 instructions
Software:
  - Z80/8080/8085 machine code
  - Z80 Assembler, line and 2 pass.
  - 8K BASIC interpreter (Extra)
  - 8K FORTH (Extra)
ROM: 8K Monitor (full listing and comments)
RAM: 4K CMOS (2 x 6116)
Input Output: 48 system I/O lines
Speaker: 2.25" coned linear
Display: 20 character 14 segment green phosphorescent
Expansion:
  - Socket for 8K ROM
  - Cassette interface
  - Connectors 40 way, complete CPU bus
Keyboard: 49 key. Full "QWERTY" real movement good tactile feedback
Batteries: 4 x U-11 for memory back-up (batteries not included)
Serial Interface: 165 baud for read/write via audio cassette

Manuals

   1. Overview and Installation.
   2. Specification (hardware and software).
   3. Description of Operation.
   4. Operating the MPF-1 Plus. 44 Useful Sub-Routines.
   5. The Text Editor.
   6. Assamler and Disassembler.
   7. System Hardware Configuration.
2. Experiment Manual. 16 experiments.
3. Monitor Program Source Listing with full commenting.
4. Also available the MPF-1 Plus Student Work Book (self-learning text).

Accessories

- EPB-MPF-1P: Copy/list/verify 1K/2K/4K/8K ROMs. Ready to plug in.
- SSB-MPF-1P: Speech Synthesizer. Inc. 20 words and clock program. 1200 words available.
- SGB-MPF-1P: Sound Synthesizer Board.
- IO - MPU-1P: Input/output board

Yes! I now realise that I need an MPF1 PLUS and that it is the lowest cost Z80 SBC available with all these features. I enclose £165.00 (£140.00 + £21 VAT plus £4 carriage). Overseas P.O.A. Please allow 28 days delivery.

Cheques payable to FLIGHT ELECTRONICS LTD.
Please debit my
Barclays/Access
Account No

An invoice will automatically be sent.

Name
Address
Signature
Date

Quayside Rd, Southampton, Hants SO2 4AD. Telex 477793. Tel. (0703) 34003/27721.
Micro-Professor is a trade mark of Multitech Industrial Corporation. Z80 is a trade mark of Zilog Inc.
CONSTRUCTIONAL PROJECTS

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<td>ULTRASONIC CAMERA TRIGGER by R. A. Penfold</td>
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<td>Ideal for capturing wildlife on film</td>
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<td>High voltage output board and isolated input board</td>
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<td>Experimental speech system</td>
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SPECIAL SUPPLEMENT

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<td>MICRO-FILE by R. W. Coles</td>
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OUR FEBRUARY ISSUE WILL BE ON SALE FRIDAY, JANUARY 6th, 1984
(for details of contents see page 13/6 Micro-file)
**OPTO**

LEDS 100W includes Clun
RL08 100w 10 4 A @ 25°C
TR021 Yellow 10
TR022 Green 10
TR023 Blue 10

**VOLTAGE REGULATORS**

5V 700 795 795
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**ZIP DIL SOCKET**

28 way
28 way
28 way
28 way
28 way
28 way
28 way
28 way
28 way
28 way
28 way
28 way
28 way

**SPECTRUM FORTH I/O UNIT**

12x off Fig. – FORTH in ROM

**FULL RS232 and 24 bits of I/O for Centronics and control units can be used from BASIC or FORTH. Will work on 16K or 48K Spectrum. Many more features.**

**ZPL**

(See SAE for full details)

**IDC CONNECTORS**

(Special black type)

PCB Male
Female
with Header
with Socket

<table>
<thead>
<tr>
<th>2 rows</th>
<th>5 rows</th>
<th>10 rows</th>
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<tbody>
<tr>
<td>10 pin</td>
<td>20 pin</td>
<td>30 pin</td>
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<table>
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<tr>
<th>Female</th>
<th>Male</th>
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<td>10 pin</td>
<td>20 pin</td>
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**IDC PLUGS**

(Full RS232)

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<tr>
<th>2 way</th>
<th>4 way</th>
<th>6 way</th>
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<tbody>
<tr>
<td>15 pin</td>
<td>30 pin</td>
<td>40 pin</td>
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**EURO CONNECTORS**

(Male)

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<tr>
<th>10 pin</th>
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<th>30 pin</th>
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<tbody>
<tr>
<td>200 nF</td>
<td>400 nF</td>
<td>600 nF</td>
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**GROUNDING PLUGS**

(Pitch 0.635)

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<tr>
<th>2 pin</th>
<th>3 pin</th>
<th>4 pin</th>
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<tbody>
<tr>
<td>600 nF</td>
<td>1200 nF</td>
<td>1800 nF</td>
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**SPEAKER CARBON SPEAKER CARBON**

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<tr>
<th>44W</th>
<th>88W</th>
<th>132W</th>
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<tbody>
<tr>
<td>100W</td>
<td>200W</td>
<td>300W</td>
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**TRANSMITTERS**

(Price Prime 220-260)

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<tr>
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<th>3.3V-6.6V</th>
<th>-12V-18V</th>
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<tr>
<td>240VA</td>
<td>6V-1.54A</td>
<td>95-1.2A</td>
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**EDGE CONNECTORS**

(Designed to match)

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<tr>
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**MACHINES**

(Time Per Track)

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<th>2011</th>
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<tr>
<td>2009</td>
<td>2010</td>
<td>2011</td>
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**COMPUTER CORNER**

- **SEIKOSHA GP100A** – Unimaker Printer, normal dual width character printer, dot resolution graphics 10" Tractor feed, parallel interface standard. FREE 500 Sheets

- **SEIKOSHA GP 250X** Printer


- **EPSON RX80 100CPS**, 9x9 matrix Epson printer, Didirectional logic sensing, etc.
The ideal Christmas Gift!

A topical selection from the current ambit parts and equipment catalogue — 148 pages — £3.51

discount vouchers! Send 80p for your copy now!

★ mix quantity prices apply for callers to our sales counters

NiCad battery bonanza time

<table>
<thead>
<tr>
<th>0.5Ah</th>
<th>2.2Ah</th>
<th>4.0Ah</th>
<th>0.11Ah</th>
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<tr>
<td>40p</td>
<td>74p</td>
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<td></td>
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<tr>
<td>8.25</td>
<td>8.99</td>
<td>12.05</td>
<td>13.70</td>
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<tr>
<td>2.25</td>
<td>2.65</td>
<td></td>
<td>3.50</td>
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Stockcode 01-12004 01-12026 01-12064 01-84056

200 North Service Road, Brentwood, Essex CM14 4SG
Tel: (0277) 230909 In stock items despatched within 48 hours.

REMENBER to add 15% VAT & 60p postage to all orders — THANKS!

BATTERY ADAPTORS 01-12001

A unique battery sleeve adaptor set that allows AA or C size to D size. Together, C and D size, for 16 hrs.

Power: 240V 50Hz, Output Voltage: 2.9V, for AA, C and D size, 11.0V for PP3 size. Weight: 0.475kg. Size: 100x109 55mm.

CHARGERS

CH4/RX4 £7.49 01-02204

ambit INTERNATIONAL

Product List

THE P.E. ENTHUSIAST’S A-Z BUYING GUIDE

It’s amazing what you’ll find in the pages of our current autumn price list, be you beginner, expert or professional. The list below gives some idea of the enormous stocks we carry, and our service is just as good as our reputation! And nearly twenty years of specialised experience can make it for you.

Phone or CALL FOR OUR AUTUMN PRICE LIST NOW!

IT’S FREE!

Good Bargains

Good Service

Good Choice

Please mention this journal when applying

Access accessories

Aerosols

Connectors

Discounts

Lamps

D国际机场

Electrolytics

Discontinued

Eurosensors

Electrolytics

Batteries

Electrolytics

Boxes

Electrolytics

Breadboards

Electrolytics

Computers

Electrolytics

Speakers

Electrolytics

Capacitors

Electrolytics

Knobs

Electrolytics

ElectroVALUE LTD., 28 St Jude’s Road, Englefield Green, Egham, Surrey TW20 9HU, (0784) 336003, Telex 264475: Northern Shop (Callers only) 680

Burnage Lane M/C 1591 TNA. (061-432 4948) EV Computing Shop, 700

Burnage Lane, Manchester (061-431 4966).

Power. 240V 50Hz, Output Voltage, 2.9V.

CHARGERS

CH4/RX4 £7.49 01-02204

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SUPERKITS! FOR BETTER MUSIC & EFFECTS

Sets include ICs, Electrologic Parts, Instructions, Boxes, Wire, Solder. Batteries not Included, but most will run from 9V to 15V DC supplies. Fuller details in list.

CHORUS UNIT: A solo voice or instrument sounds like more! KIT162 £31.40

COMPRESSOR: Lanes & levels maximum signal strength! KIT133 £10.86

COMPUTER HYPOTHY GEN: 9 drums for digital control KIT185 £30.84

COMPUTER-SYNTH INTERFACE: Sequencing & comparsion aid KIT154 £17.44

ECO UNIT: With double tracking KIT108 £44.30

FREQUENCY DOUBLER: Raises guitar frequency by 1 octave KIT168 £9.80

FREQUENCY CHANGER & WAVEFORM MODIFIER: Tunable KIT172 £34.46

FLANGER: Fasinating effects plus phasing KIT153 £22.74

GUITAR SWITCH: Electronic effects for guitar KIT146 £21.02

GUITAR EFFECTS: Multi-variation of level & filter modulation KIT42 £15.40

GUITAR OVERDRIVE: Fuzz plus variable filter quality KIT176 £18.92

GUITAR SUSTAIN: Extends effective note duration KIT175 £16.04

GUITAR TO SYNTH INTERFACE: With voltage & trigger KIT173 £32.87

JABBERVOX: Voice disguiser with reverb & tremolo KIT150 £23.84

MANDO-P: Variable siren, incl. police, galaxy, machine guns KIT146 £9.96

METRONOME: With audible & visual beat & down-beat multi-beat KIT143 £13.81

MICROPHONE PRE-AMP: with base & treble switching KIT144 £9.21

NOISE LIMITER: reduces tape & system hiss KIT146 £9.87

PHASER: with automatic & manual depth & rate controls KIT164 £18.40

REVERB: with variable delay & depth controls KIT122 £21.82

RING MODULATOR: 15 switchable rhythms KIT190 £35.64

ROBOWOX: Variable robot type voice modifier KIT165 £21.02

ROGER 2 GONG: 2 gongs sounded at end of transmission KIT126 £11.38

SCRAMBLER: Codes & deodes authorized clients KIT117 £22.09

SPEECH PROCESSOR: for cleaner transmission KIT110 £8.68

STORM EFFECTS: Automatic & manual, wind, rain, surf KIT154 £15.86

TREMOLO: deep tremelo with depth & rate control KIT136 £8.71

VOICEDOBOX: modular vocoder KIT152 £64.31

VODALEX: Robot type voice modulator KIT155 £12.44

VOICE-OP-SWITCH: with variable sensitivity & delay KIT123 £13.41

WAH-WAH: with auto-trigger, manual & oscillator control KIT140 £17.26

MANY OTHER GREAT KITS IN CATALOGUE such as Autowah, bass boost, call sign, comparator, frequency generator, Funky-wobulator, harmonia, hum-cut, mixers, sequencers, synthesizer interface, tremolo-knob, tone control, vibrato, voice filter, voice operated fader, Whoopee-pot, wobble-wah. Plus digital synthesizer, juxted synthesizer, envelopeshapers, D-A converter, multifrequency VCO, Keyboards, contacts, etc. — Send S.A.E. for comprehensive catalogue (overseas send CI).

YES — WE ALSO HAVE A KIT MAINTENANCE & REPAIR SERVICE!

Add 1P & 15% VAT to all orders. (Overseas post details stated in cat). Payment methods: CWO, Chq, PO, Access, Barclay, or pre-arranged collection. Despatch usually 10-14 days. Details correct at press, E&OE.

PHONOSONICS, DEPT. PE3D, 8 Finucane Drive, Orpington, Kent, BR5 4ED.

Tel: Orpington (STD 0689) 37821. Mon - Fri 10-7 Callers by appointment.

Weight. 0.475kg. Size. 100x109 55mm.

Power. 240V 50Hz, Output Voltage, 2.9V.

CHARGERS

CH4/RX4 £7.49 01-02204

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**HOME LIGHTING KITS**

These kits contain all necessary components and full instructions designed to create a standard wall or ceiling installed light fitting for most uses.

**TEN50** Remote Control £16.36

**MSE** Touchplate £4.20

**T500** Touchplate £7.00

**T125** Touchplate £12.50

**TD12** External kit for 2-way switching £10.95

---

**CHRISTMAS PRESENTS GALORE**

3-NOTE DOOR CHIME

- Check will do the rest
- Electric lock mechanism for use with latch
- Supplied
- Will drive most relays direct
- Full instructions

10-way keyboard, PCBs and all components

**BEGINNERS STARTER PACKS**

Containing selection of electronic components including transistors, LEDs, diodes, capacitors, ICs etc. together with a descriptive booklet. 10 easy to use, plus a solderless circuit board enabling the components to be re-used. Requires 9V Battery. Integrated circuit probe pack £2.00

**STOCKING FILLERS**

- All full spec. branded devices.
- PACK (1) 650 Resistors 47 ohm to 10M ohm 5% tolerance - £4.00
- PACK (2) 40 x 16V Electrolytic Capacitors 1uF to 1000uF - 5% tolerance £3.25
- PACK (3) 60 Polyester Capacitors 0.01 to 5000pF 5% tolerance - £5.45
- PACK (4) 25 miniature Presets 100 ohm to 1 Mohm - 5% tolerance - £2.90
- PACK (5) 20 Low Profile IC Sockets 8, 14 and 16 pin - £4.60
- PACK (6) 25 Red LEDs (5mm dia.) - £1.25

NEW PRODUCT

- LCD 3-1/2 DIGIT MULTIMETER 10 digit decimal display including DC voltage (000 to 200V), AC voltage (750V), current (30A), ohms, diode test, transistor test, capacitance and temperature. Ideal for beginners £9.00

**DISCO LIGHTING KITS**

- DL 1000K
  - A lower cost version of the above, featuring essential channel selection with ease enabled by means of potentiometer switches only and colour changing panel switches. Includes probe and transmitters. Full instructions £14.60

- DL 2000K
  - A lower cost version of the above, featuring 2 channel selection with ease enabled by means of potentiometer switches only and colour changing panel switches. Includes probe and transmitters. Full instructions £11.95

**HOME CONTROL CENTRE**

- A 24 channel version of the above, featuring 4 channel selection with ease enabled by means of potentiometer switches only and colour changing panel switches. Includes probe and transmitters. Full instructions £19.95

**FREE GREEN CATALOGUE**

- TECHNICAL BOOKLETS ON REMOTE CONTROL
- DISCO LIGHTING KITS
- LIGHT DIMMER KIT
- 40 LED matrix lighting kit
- 45 Subminiature Presets 100 ohm to 1 Mohm
- 60 Polyester Capacitors 0.01 to 1 pF/250V
- 30 Low Profile IC Sockets 8, 14, and 16 pin
- 40 x 16V Electrolytic Capacitors 100F to 1000,ff

**BEGINNERS CHRISTMAS PRESENTS GALORE**

- Kit includes all components, PCB, box assembly and programming instructions.
- Order as C1100K

<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
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- PACK (6) 25 Red LEDs (5mm dia.) - £1.25

**FREE GREEN CATALOGUE**

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- DISCO LIGHTING KITS
- LIGHT DIMMER KIT
- 40 LED matrix lighting kit
- 45 Subminiature Presets 100 ohm to 1 Mohm
- 60 Polyester Capacitors 0.01 to 1 pF/250V
- 30 Low Profile IC Sockets 8, 14, and 16 pin
- 40 x 16V Electrolytic Capacitors 100F to 1000,ff

**BEGINNERS CHRISTMAS PRESENTS GALORE**

- Kit includes all components, PCB, box assembly and programming instructions.
- Order as C1100K

<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1100K</td>
<td>£15.50</td>
</tr>
</tbody>
</table>
DIGITAL MULTIMETERS

- All-case probe (not switchable)
- 4 digit button - cost £2.95
- 4 digit button - cost £1.95
- 2 meg ohm £2.30
- 10 meg ohm £3.80
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Maxwell 3000 Range 10A AC 1M OHM £85.00
G2008-10A 28 Range 10A AC 200 ME OHM £80.00
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G2108-16A 18 Range 10A AC 20 me ohm £30.00

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001 867 £70 150 51 50 00 00
2000 £60 32 £69 35 20 00
4000 £35 33 25 00 25 00
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27163 £21.14
2732 £41.16
2764 £61.15
2761 £81.18
2732 £101.20
2761 £121.23

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71442 £13.50
71443 £20.00
71445 £25.50

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2342F £4.50
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2346D £4.50
2346X £4.50
2346W £4.50
2347 £7.46
2348 £7.46
2349 £7.46
2350 £7.46

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Full specification any model

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S/N75452BP

SPICY Accessories

<catalogue>

S/N75189

SPICY Accessories

<catalogue>

S/N75300

SPICY Accessories

<catalogue>

S/N7545I

SPICY Accessories

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S/N75150P

SPICY Accessories

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Practical Electronics January 1984
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J. L. Potts - Chairman

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With over 10 years experience in audio amplifier technology ILP are recognised as world leaders.

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Output Power</th>
<th>Impedance</th>
<th>I.D.D.</th>
<th>M.O.D.</th>
<th>Supply Voltage</th>
<th>Size</th>
<th>W.T</th>
<th>Price inc. VAT</th>
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<tbody>
<tr>
<td>HY67</td>
<td>15</td>
<td>4.8</td>
<td>0.015%</td>
<td>0.006%</td>
<td>1.48</td>
<td>120 x 78 x 40</td>
<td>240</td>
<td>£6.40</td>
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<td>HY68</td>
<td>30</td>
<td>4.8</td>
<td>0.015%</td>
<td>0.006%</td>
<td>1.25</td>
<td>76 x 68 x 40</td>
<td>240</td>
<td>£9.55</td>
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<td>HY69090</td>
<td>30</td>
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<td>HY124</td>
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<td>430</td>
<td>£30.75</td>
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<td>HY129</td>
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<td>0.015%</td>
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<tr>
<td>HY364</td>
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<td>4.8</td>
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<td>HY386</td>
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<td>1.25</td>
<td>76 x 68 x 40</td>
<td>240</td>
<td>£20.75</td>
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PRE-AMP SYSTEMS

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<thead>
<tr>
<th>Module Number</th>
<th>Module</th>
<th>Functions</th>
<th>Current Required</th>
<th>Price inc. VAT</th>
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<tbody>
<tr>
<td>HY6</td>
<td>Mono pre amp</td>
<td>Mic, Mag, Cartridge/Tuner/ Face</td>
<td>10mA</td>
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<td>HY66</td>
<td>Stereo pre amp</td>
<td>Mic, Mag, Cartridge/Tuner/Face</td>
<td>20mA</td>
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<td>HY73</td>
<td>Guitar pre amp</td>
<td>2Guitar (Bass 400L and 3K1), Dual, 100K Ohms</td>
<td>20mA</td>
<td>£15.36</td>
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<tr>
<td>HY78</td>
<td>Stereo pre amp</td>
<td>2Guitar (Bass 400L and 3K1), Dual, 100K Ohms</td>
<td>20mA</td>
<td>£14.30</td>
</tr>
</tbody>
</table>

Most pre-amp modules can be driven by the PSU driving the main power amp.

A separate PSU 30 is available purely for pre-amp modules if required for £2.63 inc. VAT. Pre-amp and mixing modules in 16 different variations. Please send for details.

Mounting Boards

For ease of construction we recommend the BS for modules HY6-HY12 £1.05 inc. VAT and the B66 for modules HY66-HY78 £1.70 inc. VAT.

POWER SUPPLY UNITS

<table>
<thead>
<tr>
<th>Model Number</th>
<th>For Use With</th>
<th>Price inc. VAT</th>
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<tr>
<td>PSU 200</td>
<td>HY66/HY78</td>
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<td>PSU 220</td>
<td>HY66/HY78</td>
<td>£320</td>
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<td>PSU 230</td>
<td>HY66/HY78</td>
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<td>PSU 250</td>
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<td>PSU 260</td>
<td>HY66/HY78</td>
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MOSFET MODULES

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<th>Impedance</th>
<th>I.D.D.</th>
<th>M.O.D.</th>
<th>Supply Voltage</th>
<th>Size</th>
<th>W.T</th>
<th>Price inc. VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOS 129</td>
<td>15</td>
<td>4.8</td>
<td>0.015%</td>
<td>0.006%</td>
<td>1.48</td>
<td>120 x 78 x 40</td>
<td>240</td>
<td>£6.40</td>
</tr>
<tr>
<td>MOS 248</td>
<td>30</td>
<td>4.8</td>
<td>0.015%</td>
<td>0.006%</td>
<td>1.25</td>
<td>76 x 68 x 40</td>
<td>240</td>
<td>£9.55</td>
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<td>MOS 364</td>
<td>30</td>
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<td>0.015%</td>
<td>0.006%</td>
<td>1.25</td>
<td>100 x 78 x 40</td>
<td>430</td>
<td>£14.69</td>
</tr>
</tbody>
</table>


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Mono Power Booster Amplifier - increase the output of your existing car radio or cassette player to a nominal 15 watts rms.

Write now to use.

Example:

Mounting anywhere in car.
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<table>
<thead>
<tr>
<th>VA</th>
<th>62 x 34mm</th>
<th>0.35Kg</th>
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<td>15</td>
<td>66 x 66</td>
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<td>50</td>
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<td>2.05</td>
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<td>75</td>
<td>186 x 125</td>
<td>3.21</td>
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<tr>
<td>100</td>
<td>240 x 157</td>
<td>4.64</td>
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<tr>
<td>150</td>
<td>314 x 210</td>
<td>7.50</td>
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<tr>
<td>225</td>
<td>417 x 283</td>
<td>11.78</td>
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</tbody>
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Prices including P&P and VAT

VA Size £ VA Size £
15 10 7.43 150 12.90
30 15 8.09 220 16.20
50 20 10.10 300 18.55
100 30 16.80 500 25.75
150 40 21.83 1000 51.55

For 110V primary Insert "O" in place of "K" in type number.
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*January 1984*
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Practical Electronics
January 1984

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THE MALTINGS, HIGH STREET, WEM, SHROPSHIRE. SY4 5BN.

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A.C. Voltage 3.6, 15, 50, 100, 300, 600, 1000.
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A.C. Intensity Max 0/3, 3, 30, 300, 3000.
D.C. Resistance 0.2, 5, 50, 500, 3000, 30000.
F. g. e. (levlld) -10 to 10.

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ARRAY PROCESSING

ARRAY processing, the next step in technology, will be a reality by the end of 1984—perhaps a fitting year—if INMOS keep to their proposed production plans with the Transputer. The single chip processor, which was announced recently in the UK, USA, Paris and, by the time you read this, Japan, is set to revolutionise the face of processing.

A 32 bit processor (T424) with 4K of memory, plus communications on a single chip covering just 45mm² is convincing enough, but the Transputer also has the ability to cope with 10MIPS (10 million instructions per second) and memory expansion of up to 4G bytes. Add its ability to communicate directly with up to four other Transputers, in an array set up, with almost total multiplication of performance and INMOS plans for 16 bit versions, graphics and disc controllers and processors, and you have a formidable computing ability. (It is claimed that the device will be almost as universal as TTL).

Such set-ups might be capable of real time instant language translation with speech input and output, of driving a car including planning the route, arrival times and consumption etc. or of any similar complex task.

PROBLEMS

What are the problems? According to the "father of the Transputer" Iann Barron, INMOS have built and tested the individual elements of the chip and now have to put them together on one piece of silicon to be mounted in a 48 pin leadless chip carrier. How big a task is that? Well the density of the device will work out at 250,000 components in a \( \frac{1}{4} \) inch square. About the same as a street map of London which also shows gas, sewerage, electricity and telephone networks condensed to \( \frac{1}{4} \) inch square. Or, alternatively the power of 100 home computers on a single chip.

Provided INMOS can build it in production quantities in their planned time scale, the Transputer will undoubtedly put them ahead of the world and guarantee the long term success of the company. Incidentally the Transputer was designed in the UK headquarters of INMOS although initially chips will be produced in the US.

TO COME

Over the coming months Ray Coles—author of MicroFile—will be looking closely at this new device from the technical side for us and we will also carry a feature on "INMOS The Company" taking an in-depth look at the past, present and future of the UK's own chip maker. These articles will give an insight into the possible future of the electronics industry, and the direction of our hobby in years to come!

Some would say that we are now passing through a technological revolution and the Transputer may be a vital part of it. What will 1984 bring?

We hope it is prosperous for all our readers and pass on our seasonal greetings.

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EDUCATIONAL COMPUTER LATHE

1982 was Information Technology year. A year when the Government began in earnest encouraging us to put aside our micrometers and pick up the microcomputer in an effort to update our technological awareness. Many schemes were initiated offering great financial help for those in both industry and education who were willing to adopt an innovative approach to education and manufacturing techniques.

As Minister of State for Information Technology, Kenneth Baker used 1982 to launch schemes including the 'micro's in schools' programme. In this scheme packages of equipment have been specified for schools and colleges and financial help offered. However a new and more flexible approach to education and manufacturing techniques who wish to explore computer based numerical control systems (CNC).

This new approach will allow colleges etc. who are interested in the furtherance of CNC to choose the equipment they need and have the financial backing from the Government at the rate of 50 per cent. This 'pound-for-pound' aid will enable colleges to combine new micro-electronics skills with the wealth of machine-tool expertise already available in this country, and ultimately of course apply them to industry.

One piece of equipment which hopes to find its way into the scheme is the Colne 5 CNC educational lathe—a machine tool designed for use with 8 bit p/p micros. The user will provide the micro, the memory arrangements and the VDU. The lathe is supplied with software on the memory medium of the customer's choice and for the micro of their choice. At present software is available for the BBC micro, the Apple, Commodore, Research Machines 3802 and the Spectrum. Eventually the manufacturers (Colne Robotics Co Ltd) will write software for all the micros.

Once the lathe, the computer and its peripherals are set up the power of the software becomes apparent. Tooling instructions are entered and converted into numerical 'G' codes. This information is then fed to the lathe where the sequential turning functions are carried out. An important feature is the ability of the operator to see what the completed workpiece will look like before it is actually made. In this way miscalculations or programming errors can be rectified before the program is run.

The control electronics are basically the computer/software. The lathe itself has only three p.c.b's—power supply, stepper motors and chuck speed.

The lathe has a centre height of 70mm and is compact and portable. Overall dimensions are 680mm length, 445mm depth and 240mm height, the total weight being 40kg. The bed is mounted in a shallow tray and supports the head and tail stocks the saddle and the cross slide. The d.c. motor is bracket mounted to the rear of the headstock: it drives the chuck via a pulley with tachometer feedback to provide speed stabilisation under load. The X stepper motor is mounted to the rear of the saddle and the Z stepper motor to the bed. The stepper motors drive leadscrews which give X and Z movements accurate to 0-025mm. Maximum workpiece diameter is 80mm with a distance between centres of 325mm.

Being an educationally based system the lathe incorporates several safety features which include limit switches on the X and Z movements and isolation switches on the perspex cover and the drive mechanism cover. A lockable cut-out button to disable the d.c. motor is also incorporated.

An optional extra to the system will be a capstan type rotatable tool post with its own stepper motor, allowing tool changes to be carried out during the program.

The Government will pay half the purchase price of £1,889 to teaching establishments who can satisfy the grant requirements. Further details from Colne Robotics Co Ltd, Beaufort Road, Twickenham, TW1 2PQ. (01 892 8197/8241).

PROGRAMMER

According to Enterprise Technology Ltd, their EPROM programmer, the ZP 4000, is the most sophisticated and cost effective available. It is designed for use with the Z81 in conjunction with a 16K RAM pack.

This module will enable the user to program 2516 or 2532 type EPROMS and create prototype software or even produce EPROMS in production quantities. The p.c.b. houses a 25V d.c. generator, parallel I/O, address decode logic, ZIF socket and 2K machine code operating software.

There is no operating manual for this system as user interaction is claimed to be very comprehensive.

The ZP 4000 is supplied built and tested with a 12 month guarantee and costs £63-25 inc VAT and p&p. From, Enterprise Technology Ltd, PO Box 140, Wigan, WN3 6LF.

ALARM CONTROL

A matching control unit has been developed for use with the PE Ultralight intruder alarm (July 83).

The 2020 control unit from GJD Electronics has six buttons for time code entry and 24hr tamper selection. L.e.d. indication is provided for Alarm Off, Trip and Mains so that the system can be checked at a glance.

The four digit entry code gives 360 possible combinations. Alarm inputs are BS compatible with a 24hr panic loop and button selectable tamper loop. The controller offers auto-shut off with alarm loop faults and variable entry and exit delays, 40 seconds on leaving and up to 20 seconds on entry. Connections to the unit are made via a 12 way terminal block including those to the internal mains power supply; trickle charge internal ni-cad batteries are an optional extra in case of mains failure.

The unit will retail at around £30. Details from, GJD Electronics, 105 Harper Fold Road, Radcliffe, Manchester, M26 0RQ (061-724 8547).
ZX RELAY BOARD

A low-cost relay board is now available for ZX Spectrum users. The NMS Relay Controller has four channels each of which has a double pole 5 amp relay rated at 1kW at 240V a.c. or 100W at 25V d.c. Unlike other relay boards it plugs into the Spectrum's MIC socket leaving the expansion port free and is powered from the Spectrum supply. The controller is easy to use as any of the four relays may be turned on or off by means of a simple 'beep' command, either from within a program or direct from the keyboard. Each relay has an on/off LED.

The board is supplied built into a black plastic case measuring 180 x 110 x 55mm together with 1m leads. The controllers may be daisy-chained so that more than one may be used under the control of one Spectrum.

The unit is available from Ness Micro Systems, 100 Drakies Avenue, Inverness IV2 3SD, and costs £24.95 plus £1.50 p&p.

Silicon News Corner

New SOT-39 Darlington (BU826) has VCEO 375V & IC 6A. Fall time 0.2μs.

Power transistor (BUB89) has VCEO 800V & IC 8A. Turn-off = 0.5μs resistive load.

Standard Schottky (74SS) family completed by introduction of four new devices—three buffers (N745S240, N745S244 & N745S244) and one octal latch (N745S73). Clock calendar i.e. (type PCB8573) for 1IC bus μP systems.

Low cost solid-state image sensor for monochrome TV cameras. Type RGS-4. Mullard Ltd., Mullard House, Torrington Place, London WC1E 7HD.

POINTS ARISING...

LOGIC ANALYSER August '83

The MK4801AN-55 RAM (IC16) is a Mostek device (Mostek UK Ltd, Masons House, 1-3 Valley Drive, Kingsbury Rd., London NW9. 01-204 9322) and should not be confused with the Sprague octal latch/driver sharing the same generic code. It should be available from any Mostek outlet, for example: Lock Distribution, Neville St., Oldham OL9 6LF. 061-652 0431. Exact price (around £24) and availability should be checked before ordering. A hex dump of the contents of IC10 and IC11 of the Analyser's display board may be obtained from PE (Poole office) by sending a 9 x 6 inch SAE.

INGENUITY UNLIMITED

Versatile Timer, November '83

As an added precaution an extra earth wire should be connected from T1 earth tag to the output earth pin.

Countdown...

Please check dates before setting out, as we cannot guarantee the accuracy of the information presented below. Note: some exhibitions may be trade only. If you are organising an exhibition, radio or scientific event, big or small, we shall be glad to include it here. Address details to Mike Abbott.


Which? Computer Show 84 Jan. 17—20. NEC. T1


Electro-Optics/Laser International 84 March 20-22. Metropole, Brighton. T1

Scottish Computing Show March '84. Holiday Inn, Glasgow. T1


Cable 84 July 10—12. Wembley Conf. Cntr. O


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MAREE'S PLACE
OVER the last few years groups and bands have come to realise that a proper lighting system is a desirable, if not absolutely necessary, adjunct to a decent PA set-up. Where once upon a time a couple of strategically placed spotlamps might have been considered a cut above the average, the process of mood enhancement by the use of controlled lighting is now considered so important to presentation that in more well known bands the lighting engineer is perhaps equally as important as the sound engineer. Certainly, whoever is in charge of the lighting must have, even if he or she is not a musician, a good grasp of the relationships between tempos, musical phrases etc., effective lighting changes being required to be timed exactly, to coincide with a drum beat for instance.

In the field of amateur dramatics there is an equal potential for a decent and comprehensive lighting mixing desk. Stage lighting equipment in any small auditorium is often antiquated, if functional at all.

The lighting control desk which is the subject of this article was designed to meet the requirements of the two above types of end user. However, its uses are not confined to those two alone. It will provide an efficient means of secondary lighting control for clubs, discos, and even for the mobile disco, due to its compact one piece design. If for no other reason than the moderate cost of construction, it will enable many groups, musical or theatrical, and also a host of others, to enjoy the facilities of a purpose designed controller.

FACILITIES

The mixer may be divided into two sections which are situated on the left and right halves of the facia. The left hand section comprises an eight channel twin preset mixer. By this is meant that for each channel there are two preset sliders. Governing the two sets is a master A/B slider, the sets being denoted A and B respectively. With the master at A, the 'A' group of sliders are operational and the levels set are fed to the power stage, allowing the 'B' sliders to be set up in advance. When the 'B' setting is required, the master slider is then moved to the 'B' position. The transition is dipless; that is to say that the change in levels, if indeed both levels are above zero, is a smooth change from one level to the other without a null point somewhere in the middle.

Some of the more expensive mixers feature a timed crossfade between the two preset levels, discharging the operator of the responsibility of making a smooth transfer. The Stardesk has this facility and in fact it will be seen, as the article progresses, that the timer section is a lot less complicated than some of its contemporaries. Also included on the left hand side of the mixer are eight 'flash' buttons, one for each channel. This allows manual operation of the channel outputs, and this is where we see the first of the novel features. Most light mixers feature flash buttons. However, these merely bring the channel in question to full output, regardless of the slider, or fader, settings. In some instances, particularly where groups are concerned, the desire will not be to flash to full brilliance from zero or some lower level, but to interrupt a high level of illumination. As an example, a group may have several spotlights trained to illuminate them, but still wish to affect the lights in some way with the rhythm of the music. One way is to allow the flash buttons to momentarily reduce the output level, not necessarily by a large amount, but sufficiently to be in accord with the tempo and character of the music. Another somewhat startling effect is to use the flash button to momentarily black the stage out entirely. To this end the flash buttons on the Stardesk are fed from a master control that allows the flash buttons to provide any level of output required. Needless to say, since the button is not then just used to raise the channel output to maximum, operation of the flash button also disables the slider outputs for the channel or channels in question.

So much for the left hand section which, incidentally, may be termed the static section. Onto the right hand side of the
channels are selected for the sequence effects automatically. There are eight each of four and eight channel effects. Whatever practical electronics will assume the blackout mode with all outputs, including the blackout mode. When the mixer is initially turned on it continued indication also takes place when the mixer is in brightness, allowing switch settings to be changed. This channel indicator I.e.d.s continue to function at reduced simplify matters for the four independent channels, the ned since the physical position of the sliders can be seen. To come back with a change of lighting on cessation of the switching of the independent outputs, so as to be able to use a four channel effect to be routed to channels 1-4, and independent outputs alike. When in this mode, it strobes. This is easy enough where the presets are concerned since the physical position of the sliders can be seen. To simplify matters for the four independent channels, the channel indicator I.e.d.s continue to function at reduced brightness, allowing switch settings to be changed. This continued indication also takes place when the mixer is in the blackout mode. When the mixer is initially turned on it will assume the blackout mode with all outputs, including strobe outputs, disabled. Independent channels may be switched and the presets set up prior to operation of the mixer ‘on’ button, when the mixer will be fully operational.

The strobe outputs are intended to feed four strobes with a four channel sequence. This arrangement could however be modified to feed one strobe only with an authorisation signal. Few lighting control units, let alone mixing desks, offer a strobe facility.

Regardless of how the sequence programmes are routed, the programmes themselves may be selected manually or automatically. In the automatic mode, each programme, 32 stages in length, is played once before the next is proceeded to. On some of the more expensive units available, there exists automatic crossfade on the sequence section. Rather than the sequence stages changing abruptly, the lamps dim up and down gradually. This result is only effective at low speeds and is normally, if featured at all, accompanied by a fair number of switches. The Stardesk incorporates a single ‘attack’ control, which in its highest setting allows a normal on/off sequence and in the lowest setting gives the slowest rate of response to the changes in sequence. This setting can be particularly useful when used in conjunction with the first of the audio functions.

**AUDIO FUNCTIONS**

There are two audio functions, as mentioned earlier. The first is audio chase. When this is selected, the beat of the music, derived from a signal fed into the rear of the mixer, causes the sequence to be advanced in jumps. It is this function which produces some interesting variable brilliance sequential effects. The reason for this will be discussed further in the article when we proceed to a technical description of the mixer. The second audio effect, not commonly found, is used with a fairly high chase speed and arrests the sequence in time with the beat of the music. As far as the author is concerned, this is the better of the two effects. Apart from the halting of the sequence giving a more clearly defined mark point than would jumping a stage or two, this...
function allows the sequence speed to be set at a normal rate. Therefore, this effect has something in common with the flash button, when that button is being used in the flash off mode. The audio input sensitivity is quite high, being a few hundred millivolts, as is the input impedance, which is 1M or 10M depending on the input range setting, which may be altered by a link wire on the board. In fact the sensitivity may be further increased, but since the more sensitive range was intended to match the output of an audio mixer, such increase in sensitivity is unlikely to be required. Having the audio sensitivity to match OdBm precludes the necessity of running loudspeaker leads to the Stardesk, since it is highly likely that the unit will be set up adjacent to an audio mixer.

Finally the output from the right hand, or kinetic section, is patched into the static side through a master dimmer. This allows a smooth transition from purely static operation to kinetic plus static or kinetic only operation. Obviously, there is a need to ensure that controls are operated in the right order. Early in the process of design, the inclusion of a preselection facility for the kinetic section was considered, but it was felt that this could be one complication that could be done without. With the minimum of practice, a completely inexperienced operator will soon get the hang of things: for one used to operating a professional size group mixer or some such similar audio system, operation should be child's play. All the switches used are light action keyboard types.

**INSTALLATION AND MAINTENANCE**

Depending on the intended use, whether club, group etc., there will be differing requirements for installation. A club will almost certainly require the unit to be permanently installed.

A group will need the desk to be housed in a rugged flightcase type package, possibly with incorporate lead stowage. Given that the unit is basically portable, a theatre group may well find that for rehearsals and the initial setting up of lighting plots and cues, that the mixer would be best placed out in the auditorium, whereas once the presentation is under way, it would be situated backstage. To meet the primary requirements of all three circumstances, the mixer is safe to use freestanding, all power connections being through glands at the top or rear edge of the unit, depending on whether the mixer is upright or flat. To allow for accidental damage due to shorted leads or faulty lamps, the output stage is both accessible and repairable through a panel above the sliders. This avoids the need to demount the mixer if it is installed in a rack. Needless to say, it is vital to remove the power supply from the mixer before making any internal examination.

**CIRCUITRY**

The whole mixer is built on one printed circuit board, except for the interference suppression chokes used on the eight dimmed outputs. The independent channels are switched at the mains zero crossing point and therefore require no chokes. In Fig. 1 C1 and C2 are to quench any residual interference resulting from triacs being switched. They are limited to such a low value by the legally allowed maximum earth leakage current. There is no actual power on/off switch. Incoming power is fed directly to the mains transformer and the 12-0-12V output is biphasic rectified and fed to the mains reservoir capacitor C3 through a further 1N4000. This blocks off the 100Hz d.c. pulses from the rectifiers, providing an input for the zero voltage pulse derivative. The raw smoothed d.c. supplies part of the ramp generator which is used to operate the dimmer, the output stages, the bilateral switches used for routing, and all such places where the control signal may reach the design maximum of 10V. A simple resistor/Zener combination provides a regulated and smoothed supply for the master dimmer section.

The chain of pulses at the output of the two rectifier diodes are fed to TR1 which acts as a limiter, producing a narrow positive pulse whilst the voltage on its base is less than 0.5V. This pulse takes two paths, first to the independent switching circuit for zero voltage control of those four outputs, and secondly to the ramp generator. The pulse from TR1 is buffered by TR2 and each positive pulse resets the voltage on C7 to that of the Zener diode, namely 10V. Once the pulse has ended, the voltage on C7 is at the mercy of the constant current generator comprising TR3, D4/5, and R5 and R6. This stage charges C7 at such a rate so that immediately before the next pulse, the collector voltage of TR3 has reached a minimum. The next pulse restores the voltage on the collector of TR3 and so on. A feed is taken from this point to the static dimmer section which is described further on.

When power is first applied to the mixer, a flip flop comprising 74LS00 IC2 a/b is set, by virtue of the capacitor C8 connected across the blackout switch (Fig. 2). The output of IC2a is thus low, and the blackout I.e.d. illuminated. The output of IC2a is termed the blackout line and is taken to various points around the board. Firstly, to the strobe output buffer stage comprising IC23, a 74C08; secondly, to TR4/5 which provide a ground return for the drive I.e.d.s in the opto triacs controlling the four independent channels, IC6–9 and thirdly to the eight 4016 bilateral switches that control the signal feed to the individual channels, IC26–33. When the 'Mixer On' button is depressed, this line goes high allowing the outputs of the mixer to function. A common resistor, R8, is used to take the I.e.d. anodes to the positive rail since only one I.e.d. is on at a time.

**INDEPENDENT SWITCHING**

Two 4027, dual J–K flip flops are used, giving touch-on, touch-off control. These are positive edge triggered. R9–12 and C9–12 serve to prevent faulty operation due to contact bounce. The Q outputs of these are fed to the data inputs of...
a 4042 quad clock D latch. Information presented at the data inputs is only transferred to the corresponding outputs when the clock input receives the appropriate pulse, which in this case derives from the zero voltage stage TR1, as mentioned previously. At the zero crossing point the latest switching arrangement appears on the Q outputs of the 4042.

The zero crossing reference may not be thought to be perfect for two reasons.

The first is that the ratio between the knee voltage required at the base of TR1 and the peak voltage output from the diodes, say 15V, is only 30:1 giving a corresponding switching point of just under 12V of mains potential. The second point is that the phase delay in the mains transformer could produce an inaccuracy in the point of switching. In practice, the switching of 12V causes negligible interference and the phase delay caused by the transformer being under load actually reduces this voltage to a much lower value by moving the switching point back a few degrees.

The outputs of the 4042 are buffered by four BC172s, TR6/9, and fed to the four indicator LEDs and to the opto triacs ICs 6/9. The cathodes of the opto triacs are returned to OV through TR4/5 which are only on when the blackout line is high. To obtain the correct specified I.e.d. current for the MOC3020, which is 30mA, the return resistors are 270 ohms. All this current flows through the indicator I.e.d.s. However, in the blackout mode, this path is blocked and, in order to obtain an indication the cathodes of the indicator I.e.d.s are grounded also by R18-R21 which, being 2k2, give a reduced level of illumination, and thus a further warning that the mixer is in the blackout mode.

The MOC3020 has many advantages over conventional opto-isolators, since no power supply is required on the output side. The device is coupled to the gate and MT2 terminals of the output stage triac by a 150 ohm limiting resistor. All else that is required is a snubber network, comprising a 47 ohm resistor and 0.11.1 capacitor in series across the MT1 and MT2 terminals of the triac. On the other eight stages a choke/capacitor combination is also used to combat r.f. interference resulting from the steep leading edge of the switched a.c. waveform. All capacitors used in the output stages are 'X' rated: that is to say, they are especially designed to cope with being connected directly across the mains.
SEQUENTIAL CIRCUITRY

There are several ways of including a fade in/fade out effect on a sequencer. The common requirement of all successful circuits is that the fading up and down must be proportional to the period of each stage of sequence. This can be accomplished using up/down counters, which are enabled by each individual output. Apart from requiring an individual counter for each output, reasonably complicated circuitry is required to vary the count rate in order to change the rate of attack. The author decided to take the simplest approach here, working on the basis that out of all the effects on the unit, the fade up/down effect would probably be the least used (do not confuse this kinetic effect with the effects on the unit, the fade up/down effect would probably approach here, working on the basis that out of all the rate of attack. The author decided to take the simplest circuitry is required to vary the count rate in order to change individual counter for each output, reasonably complicated.

The 555 timer, IC10 is arranged to run 128 times faster than required for the fastest sequence speed (Fig. 4). To obtain the correct sequence speed the 555 is used to clock a 4520 dual 4 bit cascaded counter, IC11, which then is cascaded to the second 4520, IC12, which actually addresses the sequence memory. The attack control, VR2, forms part of the resistance between pins 6 and 7 on the 555. Pin 7 is the discharge pin, which goes to ground when the threshold voltage is reached, discharging the timing capacitor, and taking the output pin 3 negative. The width of the negative edge of the output waveform of the 555 is directly controlled by the total resistance between these two pins. Unless the maximum width of the bottom or negative edge of the waveform is a substantial fraction of that of the top edge, the effective rate of oscillation will not be changed. This variable mark-space ratio signal is then fed, via a blocking diode D17, to the output enable OE, pin 20 of the sequence memory IC13. The OE terminal is blocked off by a diode because it is necessary to force this pin down to ground continuously when the strobe mode is selected and thus a second diode, D18, provides a feed from the strobe control IC which is a 74C08 (IC23). This is a CMOS device and is necessary because its inputs are connected to the memory 2716 outputs. Part of the function of the crossfade circuitry relies on the fact that when the output enable pin is high, the outputs are high impedance, as will soon be seen.

The second D output, i.e. that output giving a final division of 256 of the input from the 555, is fed both to the first counter, namely pins 14 down to 11, address the next four inputs of the 2716, giving a total of five inputs and thus a 32 stage programme capability. The fourth, or D output of the counter, pin 14, is also taken to the automatic section, which is a 74LS02 (IC14). This is a quad NOR gate. The first two gates, a and b, are connected as a flip-flop, with C19 being used to set it to the manual mode when initial switch-on takes place. When the manual l.e.d.,
D19, is lit, b output (pin 1) is high and this holds the d output (pin 13) low since a '1' on any input will cause the output of a NOR gate to go low. This in turn means that the output of gate c, which is high, both inputs being low, will go low if the manual button is depressed. This output is taken back to the 4520, IC12, to the enable input. Each depression of the manual button will advance the counter.

The A, B and C outputs of the counter are connected to the A5, A6 and A7 inputs of the 2716, providing a choice of eight programmes. When the auto button is operated, IC14d is now free to work on information from the first half of the counter IC12, and each time the D output of the counter goes low, i.e. at the end of each count of 32, pin 13 will go high, forcing output c low and clocking the second half of the counter onto another programme. The three programme addresses A5–A7 are also taken to IC15, a 74LS138. This 1 of 8 decoder provides indication of the selected programme through I.e.d.s D30–D37. As for the blackout flip-flop, the manual/auto flip-flop and the 744LS138 indicator I.e.d.s are fed through common 270 ohm resistors, since only one is on at a time.

Having established how the sequence memory outputs come to be, with the exception of the routing circuitry and how it relates to the remaining three address pins of the sequence 2716, we can now return to the description of how the crossfade effect is obtained. For simplicity, only one stage of the crossfade section is shown, and, having established the variable mark–space pulse to pin 20 of the memory, the rest is simple.

When any output should be high, according to the stage of the programme, a series of pulses will appear at that output and will charge the 2µ2 capacitor (C20–27) through the 1k resistor (R39–46). Because the output of the memory is at very high impedance when the output is disabled, the charge will stay on the capacitor, the only other load being that of the emitter follower (TR11–18) and its load (R47–54). This load is the series input resistor to the comparator i.c. for the channel in question. The time taken for the capacitor to charge is dependent on the width of the pulse on pin 20 of the 2716. Once charged the voltage will remain constant, any leakage being topped up by each successive pulse, until that output returns to the low state, when the series of pulses will cause the capacitor to discharge at the same rate as at which it charged. The waveform of the charge is not identical to that of the discharge owing to the exponential nature. However, the disparity is reduced by the fact that, on the rising waveform, the source voltage is somewhat higher than the required maximum on the capacitor; similarly, taking into account the knee voltage of the buffer stage transistor, and also that of the input to the op-amp (LM3900 type), the 2716 low voltage is lower than the lowest required voltage on the capacitor. In practice, if one is looking for it, there is a small difference between the rise and fall of illumination, but small enough to be ignored.

Fig. 5 shows the waveform on the capacitor (ignoring the exponential effect) for differing settings of the attack control. One of the advantages of this circuit is that consecutive stages of the sequence overlap, thus avoiding 'holes' in the display.

There is a need for a master effects slider, if only to provide, when required, a smooth transition to kinetic effects, although there will also be occasions when a sudden switch to a sequential effect may be desired.

**SEQUENCE ROUTING**

As already mentioned, there are a total of eight buttons giving easy routing of sequential effects to five groups of four channels, all eight channels, the four strobe control outputs, or no sequential effect at all (Fig. 6). To simplify selection, each switch operates a flip-flop whilst taking an input of an eight input NAND gate (IC20) low, producing, via a second gate (IC22b) used as an inverter, a reset pulse. This reset pulse is applied to the other input of each and every flip-flop, resetting that which was previously selected. The currently selected flip-flop will not be reset because the switch is still operated, the actual reset pulse being short in duration. It may be noticed that pull-up resistors are used in this group of flip-flops, whereas only one was for the blackout/mixer 'on' flip-flop. This is because with the route selection set of flip-flops there are two inputs in parallel for each flip-flop, namely the flip-flop switched input and the corresponding input to the eight input NAND gate. Given the usual tolerances, the internal pull-up resistor for one of the gates may well beat the other input to the tape, as it were, resulting in faulty operation. For the blackout flip-flop, this is not the case and reliable operation is obtained without the need for an external pull-up resistor for the mixer 'on' switch.

The blackout switch does need a pull-up because of the capacitor CB. IC21 a/b and IC22a are three four input NAND gates which produce, from the outputs of the flip-flops, a three bit code which is used to address the three remaining inputs of IC13, the sequence memory i.c. The same address lines are fed to IC24, a second 2716, which is programmed with the necessary information to ensure that the slider presets on any channel chosen as part of a sequence group, are disabled.

IC16, 17, 18 and 19 comprise the flip-flops and IC20 and IC22b perform the reset function. The 'sequence off' flip-flop indicator is not returned to +5V via the common 270 ohm resistor, R77, as are the other seven indicators but instead monitors the 'C' output of the second half of the first 4520, IC11. This is the output immediately before that feeding the A0 input on the sequence memory and therefore when the 'Sequence Off' switch is depressed that i.e.d. will pulse showing the clock speed and allowing the sequence speed to be set in advance. The anode of the i.e.d. is thus taken via R34 and TR10 to the 4520.

There may be those that think there are purer ways of effecting this switching. For instance, one could use one or two shift registers plus a 8:3 priority encoder. However, the reset circuitry would still be required and the net saving would only be one or two chips.
IC19 c/d, which is the strobe selection flip-flop, controls the strobe outputs, independent switching circuit and sequential/static section in the following manner: Pin 8, which goes low on strobe selection, disables the independent switching stage via D14, and ensures that the memory output is no longer pulsed by pulling the OE pin down to logic low, pin 11, having gone high, no longer holds the four commoned inputs of IC23 low (see Fig. 7) and thus the strobe outputs are enabled. The static and sequence functions are disabled via the second 2716, IC24, as a result of the three bit code presented to its inputs A0, A1, A2.

Having generated the three bit code, the sequence memory uses it to select the correct group of programmes, i.e. four or eight channel, and deliver that selection to the correct group of inputs i.e. 1–4, or 5–8 etc. The routing memory looks at the group selected and via the eight quad bilateral switches in the dimmer side of the unit, disables the presets for the channels in question. Conveniently, there are eight inputs left on this memory. One input is taken to each flash button. Whenever a flash button, or for that matter, buttons are depressed, the memory disables both the static circuitry and the sequential feed for that channel/s.

**STROBE OUTPUTS**

The strobe output stage is gated by IC23, a 74C08 (Fig. 7). Four of the inputs, i.e. one from each gate, are commoned, and held at +5V, unless pulled down to logic low via D46, and/or the blackout line. When not constrained by either, the four gates are free to respond to inputs from outputs 1–4 of IC13, the sequence memory. Each time a gate output goes positive, the RC combination on the base of the buffer transistors TR19–22 produces a short pulse which is fed via limiting resistors to the output socket. Four I.e.d.s give indication of the type of sequence selected.

**Next Month:** more circuitry, construction and testing.
COMPONENTS . . .

Resistors
R1, R5, R7, R9–13, R55–67, 10k (37 off)
R76, R83, R84, R165, R175
R2, R3, R36, R37, R39–46, 1k (17 off)
R76, R83, R84, R165, R175
R4
R6, R8, R14–17, R34, R35, 270 (19 off)
R38, R77, R129–136, R169
R18–21, R30, R167
R22–25, R137–144
R26–29, R68–75, R145–174
R22–25, R137–144
R26–29, R68–75, R145–174
R31
R32
R33, R105–112, R157
R47–54
R80
R81, R82, R156, R158, R162
R85–87, R89–194
R90–120, R159, R160, R168
R88
R92
All 1W 5% unless otherwise stated

Semiconductors
IC1 7805
IC2, IC16–19, IC44, 74LS00 (7 off)
IC7, IC22, 74LS20 (2 off)
IC10 555
IC11, IC12 4520 (2 off)
IC14 74LS02
IC15 74LS138
IC20 74LS30
IC21, IC22 74LS20 (2 off)
IC23 74C08
IC24 2716 (5V) programmed 'sequence'
IC25, IC34, IC35 LM39300 (3 off)
IC26–33 4016 (8 off)
IC46 74LS10
TR1–23, TR25, TR26
TR24 BC184
TR27–34 2N4403 (8 off)
TR35 2N3819
D1–3 1N4000 (3 off)
D6, D7, D14–18, D21–29, D46, 47,
D54–69, D66–89
D8–13, D19, D20, 3mm red l.e.d. (27 off)
D28–45, D78–85,
(3mm l.e.d.s must have wide spaced legs, not parallel)
D48–53, D30–37 5mm red l.e.d. (long leads) (14 off)
D4, D5 10V 400mW Zener (2 off)
D70–D77 4V7 400mW Zener (8 off)
CSR1–12 TXAL 2215B triac (12 off)

Capacitors
C1, C2 4n7 'Y' rated ceramic disc
suppression type (2 off)
C3 2200μf 16V radial electrolytic
C4 100μf 10V axial electrolytic
C5, C63 50μf 10V ceramic disc (2 off)
C6 100μf 16V radial electrolytic
C7, C8, C18–34, C52–54, C60, C61
C13–16, C35–50 100μf 'X' axial lead suppression type (20 off)
C17 1-47p 10V tantalum bead
C19, C21, C25, C31, C62 2n2 ceramic disc (6 off)
C55 6.8p ceramic disc
C56 0.33p 10V tantalum bead
C57 39p ceramic disc
C58, C59 47μ 16V radial electrolytic (2 off)

Miscellaneous
VR1, VR4, VR5 470k linear radiohm
VR2, VR3 2k2 linear radiohm
VR6, VR7, VR10–25 100k linear 60mm slider
VR8, VR9 220k vertical miniature preset
(JD2in. x 0.1in. fixing centres)
FS1 2A 20 x 5mm fast fail fuse
FS2–13 5A 20 x 5mm H.R.C. type fuse
13 fuseholders for above, 20mm p.c. mounting types
T1 12–0–12V 0.5A p.c. mounting
RS207–669 or see below for supplier see end of parts list
S1–27 TRS keyboard set—for supplier see end of parts list (comprises switch, l.e.d. holder and finger pad)
L1–8 Suppression chokes (8 off)
JK1 Mono printed circuit jack socket
SK1 5 pin 180° printed circuit mounting DIN socket
P.c.b. 425 x 250mm doublesided and solder resisted
Also required:
18 knobs to suit slider pots, 5 knobs to suit rotary pots, internal heatsink bracket, case, front panel, back panel and various screws etc.

A full kit of parts for this project is available from:
Bensham Recording Ltd.,
327–333 Whitehorse Road,
Croydon, Surrey CR0 2HS
Tel: (01) 684 8007

Items such as the ready painted and printed panel, plated case assembly, printed circuit board, chokes and other groups of components may be purchased individually, and a list is available on request.
The price of the complete kit is £195 including VAT and carriage.
INDUSTRY
NOTEBOOK

By Nexus

Born Again

What will a born-again Labour administration do for industry? At the party's Brighton conference the 'dream-ticket' became reality. By the end of the week the delegates were infected with a crusading belief in victory. But although the leadership had changed and was now in younger, supposedly more vigorous, hands the old policies rejected by the electorate last June remain intact. Conference insisted that the Manifesto is sacrosanct. For industry this means more nationalisation, withdrawal from the European Common Market, import controls, exchange controls and re-inflation.

I listened patiently throughout the week. Many delegates were strong in denouncing Britain's economic collapse. But others, making a case for more overseas aid and other spending programmes, constantly referred to the nation as being among the richest countries in the world. A few managed to introduce the notion of national bankruptcy and national riches in the same speech. And then, when party leaders openly admitted that the party's own finances were in tatters, one wondered if they could do any better for the nation.

Much depends on the new leaders. Neil Kinnock, if he can retain the confidence he inspired at Brighton, could transform the party but will clearly need to moderate the principles and application of nuclear magnetic resonance. Whether this assisted the sale of shares is problematical but it certainly did no harm and the issue was successful.

I coupled Oxford last month with Telemetrix, also going public. The value of shares once lower than £3 million. Applications totalled some £350 million, an oversubscription of 35 times. What an overwhelming success for the ex-Racal engineers who decided to go it alone only five years ago. All Telemetrix employees got full allocation of shares asked for. Outsiders got as little as three percent so the employees were rewarded and have a stake in the company.

The New Rich

Telemetrix and Oxford are just two of a lengthening list of new-technology companies making fortunes for their founders and prosperly for their investors and employees. I was tempted to generically call them high-tech companies but Alan Sugar's Amstrad is a notable exception in the low-price audio and video market. Amstrad has clocked up a 69 percent gain in pre-tax profits and is now making over £8 million a year. On second thoughts perhaps I am doing Amstrad an injustice equating low cost with low technology. One recalls the old adage that the engineer is the man who can build for five bob what the fool builds for a pound. Designing down to a price takes genuine, even superior, engineering skill.

A recent list of 24 new-rich millionaires in electronics shows a spread of 31 to 51 as the age at which they hit the jackpot, with an average of 40. All but two started their companies in the 1970s and the great majority gained experience with established large companies before taking the plunge. Perhaps surprisingly you don't need to be a large employer to make big money. As few as 50 employees in one instance, not more than 500 and an average of 200 appears sufficient. And you don't need to be in hardware manufacture. Computer leasing, component distribution and software services have also been money spinners.

The companies in which these entrepreneurs once worked and gained experience include IBM, GEC, Plessey, Racal, Rolls-Royce, British Aerospace, BL, Texas Instruments and Sinclair. Opportunity, it seems, still knocks. At least for the bright and the bold. But there is no guarantee of success. High-flyer Alan Osborne, the Britisher who made the big time in the USA with Osborne Computers, has ended up with company, if not personal, insolvency. Microcomputers is now the most treacherous high-risk area and in view of recent crashes almost any company involved could be vulnerable.

Jobs

Our 24 new millionaires mentioned above are in 13 different companies generating millions of pounds worth of business. Yet between them they employ directly fewer than 2,500 people; indirectly about 500 and an average of 200 appears sufficient. And you don't need to be a large company in the electronic and electrical industries. A few extra jobs through equipment, components and services bought in from outside. On the other hand their products are mostly designed to improve the efficiency of their customers thereby eliminating jobs elsewhere.

It is arguable that high-tech companies, while creating jobs, are destroying old jobs at a faster rate. Nobody yet knows whether this is so and whether high-tech is doing more harm than good in employment prospects. One argument is that without high-tech modernisation many firms would go out of business altogether so high-tech at least helps to stabilise employment. In our own industry of electronics it is well proven that more product is produced yearly with fewer workers per unit of product, meaning little expansion of the workforce and in many cases a reduction.

No wonder trade unions express alarm. An international conference of union leaders from 32 countries was recently held in Tokyo to discuss employment prospects in the electronic and electrical industries. One hundred and thirty delegates were attempting to co-ordinate a strategy to protect workers against loss of earnings or redundancy through introduction of new technology.

The problem is not new. We had it with machine tools years ago when skilled fitter operators became mere machine-minders with consequent overmanning. Resistance to change in the name of job preservation is a natural reaction but not necessarily in the interests of those seeking protection. Nobody profits if a company fails, all are then equally workless.

As a member of a union for over twenty years I find it difficult to take sides. A. J. P. Taylor, historian, one-time member of the Communist Party and a life-long socialist, sadly comments in his autobiography 'A Personal History' that the organised trade unionists have not only outstripped the well-to-do middle class, they have become the principal exploiters of the poor and humble. Like all aristocrats they cling to their privileges at the expense of everyone else.

An extreme view, perhaps, but with a grain of truth. At least it makes us all think again on what our roles are or should be. Perhaps we should also be reminded that we are on the threshold of that ominous year of 1984.

Teletext

A substantial order from Zenith Radio Corporation for teletext decoder assemblies to be supplied by Mullard marks the entry of British designed teletext into the potentially huge market in the USA. The Japanese, too, have ordered the Mullard product for incorporation into their export models for the US market.

Austria, Australia, Finland, Germany, Holland and Sweden are all now broadcasting British system teletext and a further seven countries have adopted it for their trials. So great is the interest that henceforth it is dubbed as World System Teletext. One big appeal to the Americans who are still transmitting on the original NTSC 525-line standard is that the system offered can be extended to higher display levels without obsolescence of existing equipment.
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AUTOMATIC camera and flashgun triggers are useful for certain specialised types of photography, and the most popular of these is probably wildlife photography. An automatic trigger can be used where human reactions would be too slow to catch a momentary event, or where there is likely to be a long wait before an animal appears and a photograph can be taken. In this second case where the equipment is set up so that the animal, in effect, takes its own photograph and the photographer does not have to maintain a constant vigil.

TRIGGER SYSTEMS
Most photographic trigger circuits use either some form of broken light beam system to detect the event or object to be photographed, or use sound triggering. However, there are alternative systems, one of which is to use reflected light or sound. An advantage of this system is that the transmitter and receiver can be built as a single unit, and this is rather more convenient when setting up and using the equipment.

Both infra-red and ultrasonic reflection circuits were tried, and both methods seem to be perfectly feasible in practice. The infra-red circuits that were tried proved to be quite sensitive even to small objects, but the maximum range was not very large. Ultrasonic circuits were less sensitive to small objects, but an adequate range of around one to two metres was achieved with objects such as large insects and small to medium sized birds. Practical tests with an ultrasonic system gave good results, and the ultrasonic trigger finally devised forms the subject of this article. A few examples of shots taken using the unit are shown in the accompanying photographs.

Although problems with a lack of directivity were anticipated these did not materialise, and only objects within a small area straight in front of the transducers will trigger the unit. This is presumably due to the highly directional nature of ultrasonic soundwaves, and the use of new narrow beam transducers also aids good performance in this respect.

As sound travels much more slowly than light an ultrasonic system has a slower response time than an equivalent infra-red one, but as it only takes the reflected sound waves a maximum of about 6 milliseconds to be reflected back to the receiver, the response time is perfectly adequate for most purposes.

ULTRASONIC SYSTEM
The block diagram of Fig. 1 helps to explain the overall operation of the unit. The transmitter is basically just a 40kHz oscillator which drives the transmitting transducer. A frequency of 40kHz is used as it is at this frequency that the transducers have peak efficiency. The transducer is driven from the two-phase output of the oscillator so that a strong output signal is obtained.

Signals reflected from a detected object and back to the receiver are not likely to produce a very strong signal from the receiving transducer, and a high gain amplifier has to be used in order to obtain a useful signal level. A gain control is
The output from the amplifier is used to trigger a monostable circuit, and this in turn triggers a second monostable, but not until the end of the output pulse from the first one. The second monostable is used to trigger the camera via a switching transistor. The effect of the first monostable is to provide a delay between an object being detected and the camera being fired, and this delay is adjustable. Obviously in some situations the trigger will be required to operate as rapidly as possible, and in such applications the delay can be switched out.

A useful feature of the circuit is its ability to operate in a sort of single shot mode where it effectively switches off once the camera has been operated. This mode can be used in situations where there would otherwise be a danger of numerous almost identical shots being taken, and a lot of film being wasted. Here, the output of the monostable is used to trigger a flip/flop which switches off the transmitter until a reset button is operated.

In Fig. 2 the amplifier at the input of the receiver is a two stage common emitter circuit which gives a high maximum voltage gain of about 80dB. The two stages are capacitively coupled via gain control VR1. C5 rolls off the gain of TR2 at radio frequencies, and this reduces the risk of instability due to stray high frequency feedback.
The two monostables are both based on 555 timer i.c.s. IC1 provides the delay which can be adjusted by means of VR2 from about 25 milliseconds with VR2 at minimum resistance to about 2.5 seconds with this control at maximum value. This gives a useful delay range, but obviously the value of timing capacitor C7 can be altered to give a longer or shorter delay range if desired. Any change in the value of C7 has a proportional effect on the timing range. When S1 is open C7 is switched out of circuit so that the output pulse from IC1 (and the delay) are of insignificant length. R5 and VR3 bias the trigger input of IC1 above the trigger threshold of 1/3 V+ so that the circuit is triggered by a negative output half cycle from TR2, when a suitably strong input signal is present. If necessary, VR3 can be adjusted to optimise the sensitivity of the circuit.

R8 and R7 bias the trigger input of IC2, and C8 capacitively couples the output of IC1 to the input of IC2 so that the latter is triggered at the end of the output pulse from IC1 as its output reverts to the low state. The output pulse length of IC2 is fixed at about 1.1 seconds, and this is long enough to ensure that the camera is operated reliably. Indicator D1 is switched on during the output pulse from IC2, and this is helpful when setting up the equipment ready for use. TR3 is used to trigger the camera, and as this might have to handle quite high currents a power transistor is used. If a flashgun trigger rather than a camera trigger is required it is necessary to replace TR3 with a triac (a 400V 1A type is suitable).

The transmitter is based on IC4 which is a CMOS 4047BE astable/monostable multivibrator. In this circuit it is used in the true gating mode, and the control signal at pin 5 must be high in order to produce oscillation. C11, R14, and VR4 are the timing components, and VR4 is used to trim the output frequency for optimum results. The 4047BE has both Q and not Q outputs, and the transmitting transducer is driven direct with the antiphase signals provided by these.

The latch is a simple CMOS type formed from two 2 input NOR gates wired as inverters, and having positive feedback provided by R12. The other two gates of IC3 are unused and their inputs are tied to the positive supply rail. At switch-on C10 sets the latch with the input of IC3a low and its output high so that the transmitter is switched on. When the output
of IC2 goes positive the latch is triggered to the opposite state and the transmitter is switched off, but only if S2 is closed. D2 prevents IC2 from resetting the latch at the end of its output pulse, but the latch can be reset using S3.

As the circuit has a current consumption of about 20 milliamps or so and is likely to be used for long periods of time it is advisable to power it from a high capacity battery such as six HP7 cells or six AA NiCad batteries fitted in a plastic battery holder.

CONSTRUCTION

Details of the printed circuit board and wiring are provided in Fig. 3. As IC3 and IC4 are MOS devices it is advisable to fit them in i.c. sockets and to take the other normal MOS handling precautions. Note that IC1 and IC2 have the same orientation as IC3 and IC4. TR3 is mounted horizontally on the board and is bolted in place.

A plastic box having an aluminium lid and approximate outside dimensions of 150 by 90 by 50mm is suitable as the case for this project. The two transducers are mounted at one end of the case, as far apart as possible. The easiest way of mounting them is to drill small holes in the case to take the two terminal pins of each one, and to then glue them in place using a good quality general purpose adhesive. The controls, D1, and output socket are mounted on the lid of the case, and the printed circuit board is bolted to the base panel. The hard wiring is then added. The pin which connects to the casing of X1 is wired to the negative supply rail and the other pin connects to C2. It does not matter which way round X2 is connected. Incidentally, the two transducers are identical.

IN USE

The connection from the camera to the trigger unit is made using an electric cable release with the push button switch removed and a 2.5mm jack plug (which plugs into SK1 on the trigger unit) connected in its place. The plug must be connected with the right polarity, and a multimeter is used to determine the polarity of the voltage on the cable when it is connected to the camera. The tip of the plug is connected to the positive lead and the barrel connects to the negative lead. Few cameras have an electronic shutter which can be triggered by an external switch, but many SLRs these days can be electrically triggered via an autowinder or motordrive. The prototype has been tested with a Minolta XD7 which is directly triggered, and a Pentax LX triggered via the autowinder, and it should work properly with any camera that can be controlled electrically.

If the unit is used with a flashgun (and this should only be attempted if TR3 has been replaced with a suitable thyristor or triac), the connection to the flashgun can be made using a flash extension lead. The plug which would normally connect to the camera is removed and replaced with a 2.5mm jack. VR4 can simply be adjusted by trial and error to find a setting that gives good results. If an a.c. millivoltmeter is available this can be used to monitor the signal level at the collector of TR1, and VR4 is then adjusted to peak this signal level.

Results will probably be satisfactory with VR3 set at about half maximum resistance. If the unit does not trigger with the transducers aimed into empty space and VR1 set for maximum sensitivity it should be possible to obtain a small increase in the maximum sensitivity by adjusting VR3 for slightly lower resistance (turning it in a clockwise direction). If it is adjusted too far though, IC1 will be continuously triggered and the circuit will fail to operate at all.

A trigger of this type works most effectively when the object to be photographed will be well clear of anything that would provide reflected signals. VR1 can then be well advanced without any unwanted reflections triggering the unit. A little experimentation with the unit should soon determine what can and cannot be achieved, and how it can best be used.
The Technology

Chris Kelly

Most of us listen to records at some time, whether as casual background music or to be entertained by virtuosos. We like to think that the sound we hear is as 'true to life' as possible and recent years have seen remarkable advances in sound reproduction. But we are about to witness a revolution in the machines we use to play back the music: we are entering the age of computerised consumer electronics and hi-fi is no exception.

The digital audio disc (DAD) has been launched carrying the commercial name of compact disc or CD.

Our perception of reproduced sound quality is becoming more and more critical. Because of the poor sound quality of the first commercial records of the early twentieth century, certain musical instruments did not record well. Musicians had to play the bassoon for the part of the cello and the tuba for the part of the double-bass. Few people seemed to mind in those days. The early Edison machines were regarded as 'true to life' sound, indistinguishable from the real thing.

Today we have progressed to sophisticated replay systems where the sounds can be classed as high fidelity or hi-fi. But the conventional vinyl long playing record still depends on a stylus vibrating in a bumpy groove. The stylus recreates electrical waveforms which represent the frequency and amplitude variations of the original sound: analogue from source to loudspeaker.

GOING DIGITAL

Now a new type of 'record' and 'record player' are being marketed by the top manufacturers. The compact disc is only 120mm (5 inches) diameter yet has a playing time of up to 60 minutes with the sound information on one side.

The CD rotates like a record, it is not touched by a stylus but scanned by a small low-powered laser built into the CD player. The disc provides information about the sound in the same way that computers handle information: using binary pulses of 1s and 0s, in digital terms. The bit stream obtained by detecting microscopic pits on the disc is constant at over 4 million bits per second (Fig. 1.). The disc rotates at 500 r.p.m. when the laser starts at the centre, and slows to 200 r.p.m. as it follows the spiral of pits to the outside.

Having been detected by the laser and converted to electrical pulses by a photo-diode, the digital codes are separated into two channels for stereophonic reproduction and eventually conver-
tied to analogue sound using digital to analogue converters (DACs). See Fig. 2.

The analogue audio output from a CD player can be connected into any line-level input of existing amplifiers or music centres. Connection is possible to tape or auxiliary inputs but never to the phono input because the signal level is too high. This means that conventional record decks can still be used alongside the CD player and you don’t have to abandon your treasured collection of l.ps.

The digital information on the disc is protected by a layer of clear plastic, so the discs are more robust than normal vinyl lps; we all know how easily they are scratched! The CD can suffer a number of scratches and finger marks without degrading the sound quality of the music because the laser focuses right through them.

Also, even if a certain number of bits are lost (generally called drop-outs), sophisticated error-correcting codes are used to restore the information. This does not mean that CDs can be used as beer-mats as suggested by one writer. Surface scratches, finger marks and beer stains eventually cause too many drop-outs for the information to be restored and an interruption is heard in the music. So contrary to popular belief, CDs do require careful handling and the occasional clean with a soft cloth.

Some CD players have a hard-mute, meaning that the audio signal drops to zero when drop-outs occur and this is far more noticeable than the soft-mute as provided on the Philips and Marantz machines which are programmed to make an educated guess at what sound should be provided.

Apart from robustness, the CD offers listeners better quality sound with less distortion (typically 0.005% THD) and no audible background noise. You may be surprised how accustomed we have become to hearing scratching and hissing noises behind the music provided by conventional lps. This is caused by the stylus detecting surface roughness in the vinyl. The silence behind music from CD is uncanny! Only the occasional but quiet tape-hiss from the original master-tape can be heard if it is an analogue recording. Digitally recorded music is ‘clean’.

The background silence of CD provides no audible cue as the surface noise of lps does. New users of CD may be tempted to turn the volume up far too high so that the opening bars of music could well be an un-neighbourly crescendo lifting speakers from the floor, or even worse, blasting ear drums if the listener is wearing headphones.

The stereo image, that is the apparent position of instruments and singers as presented to the listener, is rock steady from CD because of a 90dB channel separation and negligible phase shift over the whole audible sound range. Conventional pick-ups provide slightly over 30dB channel separation at best and this is subject to phase changes over the frequency range giving an unstable stereo image.

**DAD DEVELOPMENT**

The Dutch company of Philips began investigating the possibility of a compact disc in the late 1960s. They worked out a standard format, inviting Sony in the later stages to design the fast error-detecting codes which were very important to the feasibility of the idea. This standard was eventually adopted by almost all of the major hi-fi equipment manufacturers. Philips were anxious to avoid the proliferation of incompatible systems that resulted in the failure of quadraphonics in the early seventies and the confusion which exists today over video tape systems.

Compact disc prototype players were demonstrated in 1981 and were not enthusiastically reviewed by the hi-fi press. Poor musical material and heterodyne whistles were heard and all this produced by equipment packed into many suitcases as the very large scale integrated circuits were still being designed. Some journalists predicted its death before it was launched and they seemed particularly derisive when launch delays were announced and the disc and player prices were found to be higher than anticipated.

The actual launch in Japan in late 1982 and in Europe early in 1983 proved the critics wrong. In the first few weeks players and discs were sold out and production was stepped up to meet a healthy demand. And, as if to clinch its acceptance, recording artists such as Paul McCartney were demanding that their work be released on the new medium.

**TECHNICAL DETAILS**

In practice, a CD player is an extremely complex piece of equipment. Far more than just audio information is encoded on the disc such as index details which give the number of tracks and location of tracks on the disc. The more sophisticated players will display the title of the disc.

All this digital information is encoded onto the disc in a very complex format in order to reduce the possibility of errors when
being read. The information is divided into frames; Fig. 3 gives one frame of the successive bit streams. There are six sampling periods for one frame, each sampling period giving 32 bits (16 for each of the two audio channels). These 32 bits are divided to make four symbols in the 'audio bit stream' B\textsubscript{2}. In the 'data bit stream' B\textsubscript{1} eight parity and one C&D (Control and Display) symbols have been added to the 24 audio symbols. To scatter possible errors, the symbols of different frames in B\textsubscript{1} are interleaved, so that the audio signals in one frame of B\textsubscript{1} originate from different frames in B\textsubscript{2}. The modulation translates the eight data bits of a symbol of B\textsubscript{1} into fourteen channel bits, to which three 'merging bits' are added (B\textsubscript{3}). The frames are marked with a synchronisation signal and the final result is the 'channel bit stream' (B\textsubscript{4}) used for writing on the master disc, in such a way that each '1' indicates a pit-edge (D). This technique is called eight to fourteen modulation or EFM.

Although the disc spins with the normal slight fluctuations of speed, a first-in first-out (FIFO) buffer store is employed to absorb the irregularities (Fig. 4). The data is clocked out of the store under the control of a crystal oscillator. However, the bit stream from the disc must be reasonably constant so a servo system spins the disc initially at 500 r.p.m. When the laser is nearest the centre and progressively slows it to 200 r.p.m. as the laser moves to the outer edge during play.

The C1M ( Concealment, Interpolation and Muting) circuit deals with errors that are only detected since they cannot be corrected; these are 'masked' or concealed.

The standard sampling frequency was chosen at 44.1kHz, conveniently satisfying Nyquist's sampling theorem which states that in order to fully reconstruct a waveform it must be sampled at a rate of at least twice the highest frequency in the waveform.

Most CD player manufacturers have designed their systems around 16-bit DACs followed by analogue low-pass filters in each channel which are expensive and introduce small phase errors. Philips and Marantz, however, have opted for fast 14-bit converters which read the digital information at a rate equal to four times the normal 44.1kHz sample frequency. This is achieved by processing the 44.1kHz information from the disc using a digital transverse filter TDF in each channel.

The apparently faster sampling rate of 176.4kHz, called oversampling, spreads most of the quantisation noise out of the audio frequency range and this is filtered using sophisticated digital filters which are really mathematical processors working on the digital information prior to analogue conversion. The overall result is 16-bit performance with no phase error from circuitry which is cheaper and simpler to manufacture in the long term.

**THE DISCS**

Software is the name often given to the musical content of the discs and the initial batch of releases received mixed reviews. Of the 200 early titles only 20 or so were considered first rate both artistically and technically. The remainder were so exposed by the faithfulness of the CD system that poor recording techniques such as bad microphone positioning, audible edits in the master-tape and unusual balance of the musical components were scrupulously revealed.

However, considering the vast amount of mediocre to poor material published on vinyl since the advent of the microgroove l.p., we can conclude that the CD is doing somewhat better. Some reviewers tend to compare the worst of compact discs with the best of vinyl l.p.s. When compared best for best the compact disc is superior in every way.

One reason for a so-called 'bright' reproduction on some CD's is that the original master recordings were engineered for the vinyl l.p. which is known to depress the high frequencies in the pressing process. Recording engineers sometimes deliberately boosted the high frequency in recording to compensate for this loss, yet CD reproduces this faithfully. It is generally realised in the recording industry that recording techniques will be modified...
to take full advantage of the new medium.

A few ‘golden-eared’ hi-fi reviewers have claimed that they can hear the odd harmonics caused by quantisation, particularly at lower frequencies (Fig. 5) where the transitions between levels may be much lower than 44.1kHz because of the slowly changing waveform. Some have claimed that the low frequency steps give harmonics which are not filtered from the audio range giving a ‘graininess’ to the music. Most of us mortals with normal audio faculties hear, as near as possible, the sound that is heard in the recording studio. To put this to the test recently an assembled group of top reviewers listened to the CD replay compared directly with the most sophisticated studio tape machine. They all conceded that they could not tell the difference.

**Fig. 5. A low-level low-frequency signal digitised. The transitions between levels can be at a much lower frequency than the 44.1kHz sampling rate**

The conclusion is that the CD medium is almost totally transparent, permitting the listener to hear clearly what was recorded on the master-tape. But we are all subjective beings and as such hear and assess sound quality according to our own preferences. The hi-fi press have consistently hailed the Philips/Marantz machines as having a more subtle, ambient sound than the Japanese machines. Yet I know of someone with a very expensive hi-fi system who has auditioned most of the CD players at home on his own system and produced a list of preferences in reverse order to what the experts told him.

It all boils down to personal taste. If you like the sound of a particular CD player on your system, ignore the experts: they have a vested interest in controversy.

**THE FUTURE**

Second generation CD players are already being designed and when they are launched they will be claimed as being easier to use, providing more information (such as track titles, playing duration, etc) and probably hailed as producing better quality sound.

Present CD player prices will hold steady until the original research and development costs are recovered. This may be some time because the launch prices of £500 to £650 can only leave a lean profit margin on this highly sophisticated technology. Ultimately the prices should fall to the £200 to £400 level.

The disc prices should fall in real terms, eventually leaving little difference between the price of a CD and the conventional l.p. It is not expected that vinyl l.p. sales will rapidly decline. CD is offered as supplementary, not as a replacement. Some have predicted that the vinyl l.p. will be dead within ten years, but it is my guess that there will still be a market for the analogue enthusiast.

There is news of a possible alternative system from the USA. A company called Soundstream have developed a digital ‘card’ player where a postcard sized plastic card is slowly moved past a rotating lens system and a laser beam detects the information (See PE July 83, Patents Review). This is potentially cheaper in terms of the player and ‘care manufacture, but as yet there is no commitment by any manufacturer. As advertisements for CD claim ‘Pure, perfect sound forever—and it’s available now.’ The first in the market-place has a distinct advantage in setting standards.
Vernon al Large!

V.F.'s views and opinions are entirely his own and not necessarily those of PE

The rest of the kids in our street were normal enough. They all wanted to be engine drivers. Not so your humble servant. I went through an impressive list of aspirations: brain surgeon, Master of the Rolls, Chief of the Imperial General Staff, even Prime Minister until I read somewhere that Chequers can be a bit chilly in the winter.

But probably my most burning ambition was to be a farmer. That yen lasted a long time. It was sparked off by an idyllic week spent on a farm in the Home Counties under the auspices of the Children's Country Holiday Fund which in those days catered at rock-bottom cost for the offspring of parents in strained circumstances. Mine were that alright.

Reared in the concrete jungle of Central London, it was my first real taste of the pastoral existence. Acres of green earth, an old thatched farmhouse, great lumbering horses pulling ploughs, friendly old cows, agile chickens, weatherbeaten men with bits of string tied below their knees (to stop the agile chickens, weatherbeaten men with bits of string tied below their knees (to stop the rats running up their trousers, they told me), large quantities of wholesome food and air that tasted like new wine. It all gave me a sense of heritage.

But apart from the personal pleasure, that glorious week engendered for me an abiding respect and admiration for people who get their living from the land. They worked long hours in all weathers for low pay. There was always some chore to perform. They were never off duty. And they found their reward in doing a vital job superbly well and in a life, it seemed to me at the time, untouched by the stresses of other callings and one that appealed practically immune to change.

Just how rose-tinted were my spectacles was brought home to me recently when I went along to the Ministry of Agriculture, Fisheries & Food (I wonder who looks after Drink?) to learn how far modern electronic technology has invaded the farmer's world. The indications are that in many cases it has taken over almost completely.

The man from the Ministry—who, because Civil Servants are quite properly a self-effacing breed, must remain nameless—told me that computers have been playing a part in farm management for more than 20 years. And now that they are coming down in price and becoming more and more versatile, so their application to farming services is growing.

"The use of electronics in farming is an evolutionary process," said the M from the M. "As devices and systems become more sophisticated, so the farmer is provided with more opportunities for greater efficiency and more streamlined management.

"Take animal husbandry, for example. Many producers have become virtually automatic." Milk can be weighed, yields can be monitored, cows can be fed, changes in temperature and deviations from the normal can be detected and recorded. Even getting a cow into a byre is becoming an automatic operation.

"The larger farms, of course, are the biggest users." But, as a result of this process of evolution I mentioned, smaller farms, too, are gradually following suit.

"So much in agriculture depends on the weather. A cow, for instance, ovulates every 21 days." If you can't get her in calf then, you haven't a hope of doing it the day after and every month you miss costs money. She still has to be fed. The same goes for crops. A whole year can be lost in that sector if you miss out on the cycle. That's why the more information you can call, the greater the control you can exercise, the more profitable and efficient farming—which is big business today—becomes. This is where modern technology is proving so helpful. "You can now, for example, control a tractor to plough a field."

"A cow for instance ovulates every 21 days"

The Ministry's Agricultural Development & Advisory Service goes all out to aid and encourage farmers and growers in the application of computers and electronics. Exhibitions are staged annually by ADAS at which the newest advances are shown by equipment manufacturers. The most recent of these was held at Stoneleigh, Warwickshire, last Autumn. More than 120 firms participated.

Every aspect of computers and electronics in farm management was covered, from financial forecasting and analysis to the electronic control and operation of intensive feed systems.

In a special supplement, published to coincide with the Stoneleigh show, Farmers Weekly reported a number of case histories to illustrate that the use of computers and electronics pays off. For example, is using a computer to give him a constantly updated picture of every aspect of his activity. So is a Buckinghamshire turkey breeder. Likewise other farmers in Abingdon, Exeter and Salop.

North Yorkshire a spraying contractor has invested £2000 in a radar control unit to take a lot of the hard work out of accurate crop-spraying. A farmer near Basingstoke reckons to have cut electricity consumption by around 30 per cent by adding automatic humidity controllers to his grain and grass drying and storage system.

"Romanticists—and at heart I'm one of them, I'm afraid—may mourn the passing of the old rustic scene of yesteryear when 'Dick the shepherd blew his horn and milk came frozen home in pail' (Shakespeare, I think, but correct me if it wasn't). But one has to be realistic. Electronics is here to stay. Even down on the farm.

The fruits of fame, though always welcome, do not always seem logical.

Take the case of our newest electronics knight, Sir Clive Sinclair. Only a churl would deny admiration of this man of talent and energy who has helped to show the supposedly invincible Japanese the side, if not the back, door. History throws up such a person only rarely and we should be thankful.

Nevertheless, it is hard to accept that because a man has achieved distinction as an innovative entrepreneur in the technical and industrial field, he should automatically be regarded as an instant pundit on everything else that affects human life.

I have just been listening on Radio 4 to a broadcast of the programme Any Questions in which Sir Clive, along with others whose authority might also be brought into question, was asked to pontificate on such matters as the role of IRP terrorists to a number of prisons instead of being lumped together (for as long as it could hold them) in the Belfast Maze: the kind of advice one should give to a daughter about to start her first term at university (the scope here was enormous); whether children should be corporally punished at school; how to solve the labour problems at Vauxhall (how, indeed); and whether your average Civil Servant knows what day it is.

I must say that, because he's a man who thrives on challenge, Sir Clive performed well on all counts. Where he really shone, of course, was when he was asked to comment on the effect of home computers on family life. His answers were constructive, if predictable, but I did detect a wince—even though the programme was in sound—when co-panelist Gerald Kaufman MP went so far as to describe computer techniques as an advanced form of Scrabble.

But I still pose the question: is it sensible that because a man hits the jackpot in one area he should be rated as an oracle in every other? Does a mastery of one discipline spell all-embracing erudition?

Rejoice with the canary. For many years, certainly as long as I can remember, they have been carried by face-workers into mines to detect the presence of noxious gases. Now all that is to be changed. Our feathered friends are, according to a newspaper report, to be sent to good homes when their essential service is taken over by electronic devices. Giving the bird to canaries only can be a good thing. But what about other forms of animal life? Do they still have pit ponies staggering about below ground? If so, is technology looking for new ways for their liberation? I only asked.

It was encouraging to hear that ITV will be launched into space by 1987. We already know that the BBC has the go-ahead for 1986. If we are to be bombarded by a plethora of programmes irrespective of their quality and purpose, it is as well that the blame is evenly distributed.
STILL on the theme of single chip microprocessors, and following
the cheap but primitive Intel 8748 and the elegant, new, Motorola 68701, we now come to the powerful but rather ugly
Zilog entry, the Z8.

The main problem I faced in writing about the Z8 family was in
deciding which particular member I should feature, since in fact
there are several devices which could be used in hobby applications
although none of them has the desirable feature of on-chip
EPROM. The Z8 part number is really a generic title, and no one
device in the family is actually coded Z8, although most people do
refer to whichever chip they are using as “A Z8” anyway, which is
why I have used this number as the file-sheet heading.

All the family devices share the same basic architecture, with dif-
fferences only in the type and quantity of memory provided, so in
the end I decided to do the Z8603 because it is the easiest to com-
pare with the 8748 and 68701 by virtue of its use of EPROM. Not
to true on-chip EPROM, in this case however, but a “piggy-back”
EPROM, utilising a 2716 which plugs into a 24 pin socket on the
upper surface of the 40 pin microprocessor package.

At first sight this “piggy-back” scheme seems very attractive
since it allows the use of low-cost EPROMs which can be program-
med in a standard PROM programmer, but unfortunately the com-
plexities of connecting 24 address, data, and power lines to a 24
pin socket within the confines of the 40 pin microprocessor package
actually makes this technique more expensive than true
on-chip EPROM in which all the interconnections are made at the
chip level.

The Z8603 is one of three devices in a sort of Z8 sub-family led
by the Z8601 which uses masked ROM and is intended for mass
production. Both the Z8601 and the Z8603 have a 2K byte
ROM/EPROM space and 144 bytes of on-chip RAM organised as a
large register file. Each device has 32 programmable I/O lines, a full
duplex UART for serial communications and two 8 bit timer/count-
ters. The third device in this sub-family is the Z8602 which is inten-
ded only for development tasks since it has no on-board ROM or
EPROM but has 24 additional lines brought out for the connection
of external memory instead. As a result, the Z8602 uses a large and
expensive 64 pin package, and is unlikely to be useful for hobby ap-
lications.

Also available is the more recent Z8611, Z8612, Z8613 sub-
family which has provision for 4K bytes of ROM or EPROM but is
otherwise identical to the 01, 02, 03 series.

At the risk of confusing you further, there are two more family
members which have special relevance, the Z8681 and the Z8671.
The Z8681 is useful since it is (like the Intel 8035 and the Motorola
6803) intended for use with external EPROM but it achieves this by
using a multiplexed address/data scheme so that it can take advan-
tage of a cheaper 40 pin package.

The Z8671 is interesting (and useful) because it is a pre-
programmed Z8601 featuring a 2K “Tiny BASIC” interpreter in the
masked ROM. When used with an external RAM the Z8671 can
accept BASIC programs entered via a VDU or similar terminal, and
then run directly without the user needing to be involved with
assemblers or machine code.

The advantages of high level language programming are offset to
some extent by the much slower execution speed, but nevertheless
the Z8671 is very useful for non-time critical applications such as
burglar alarms or central heating controllers. There is more infor-
mation on the BASIC used in the software section below, and in
the next Microfile I will be featuring another single-chip BASIC
machine, the National 8073.

The Z8 family came along after the Intel 8048 of course, but it
has caught on well with users, despite higher prices, thanks to its
powerful high speed architecture. One particular area where Zilog
reigns supreme is in the disc drive controller market where, to-date,
no other single chip processor has been able to operate fast enough
to deliver the required data throughput rates.

Despite its acknowledged power however, the Z8 is a real chip
off the Zilog block and suffers from all the ugly-duckling problems
of its bigger Z80 and Z80000 brothers. True to form, Zilog have
traded elegance and simplicity for raw power, and have shoe-
horned in every possible hardware and instruction set extra in the
interests of performance, even when this adds considerable com-
plexity for the user. Also in the Zilog tradition is the lack of comp-
atability with any of the other Zilog microprocessor families, al-
though Z80 fans will probably feel at home with most features of
the Z8 family.

REGISTERS

All Z8 devices, including the Z8603, have 144 bytes of RAM
available on the chip and every single RAM byte either is, or can be,
used as a register. The only register not mapped into the RAM area
is the program counter which is a full 16 bits long allowing up to
64K bytes of program memory in an expanded system.

There is no special accumulator register, since all 124 general
registers in the RAM register file can be used as accumulators, ad-
dress pointers, or even index registers, in addition to their use for
temporary data storage. As well as the 124 general registers, there
are 20 “specials” which include a register pointer which can be
used to address any one of the nine groups of sixteen registers
available to provide a working register area. Use of the register
pointer allows rapid access to the working register group since only
four bit addresses are needed and these can fit into fast one or two
byte instructions. Although the register pointer is nominally an
eight bit register, only the most significant four bits are used to
specify the working area.

Also in the group of twenty “specials” is the 16 bit stack pointer
which uses two locations. Like the 68701 the Z8 family can have a
stack anywhere in memory and of any depth, allowing unlimited
subroutine nesting and the use of PUSH and POP instructions for
register saver/restore operations.

Although a 16 bit stack pointer is useful in some extended ap-
plications it cannot be used to the full in a basic single chip system,
because of course the stack will have to be in the register array,
leading to a dangerous “dual-function” conflict which the pro-
grammer has to beware of. In small systems the best ploy for saving
registers is simply to swap to a new working group by altering the
register pointer value. Subroutine CALL and RETURN operations
and interrupts, however, will always invoke use of the stack, and so
some of the internal RAM will have to be set aside for that purpose,
even in small systems.

Also in the “specials” is an 8 bit flag register which contains the
usual Carry, Zero, Sign, Overflow and half carry flags, plus a
“Decimal adjust” flag for BCD operations and two “User flags”
which can be set, reset and tested as required by the programmer.

All the other special registers are associated in some way with
the extensive I/O capabilities of the Z8 processor. There are four
registers corresponding to the four 8 bit I/O ports available, and
three more for defining the modes of these ports. Only three mode
registers are needed because ports 0 and 1 share a register due to
their interrelated secondary function as memory/address buses.
**GENERAL**

The Zilog Z8 single chip NMOS processor family is ideal for fast real-time applications where its dual operand instructions and high speed architecture can be used to advantage. Although there is no Z8 family member with on-chip EPROM, the Z8603 version (featured here) does have a piggy-back socket for an external EPROM such as the 2716. A rather complex chip, the Z8 features 2K bytes of ROM/EPROM, 144 bytes of RAM, a UART, two timer/counters and 32 I/O lines and has the raw power to handle most single-chip applications with ease.

**REGISTERS, PORTS & MEMORY**

The Z8 family all have a large on-chip register file (or RAM) memory area into which all the special registers and I/O ports are mapped together with no less than 124 general purpose registers. Only the program counter is not memory mapped. In total there are 240 144 bytes of on-chip register/RAM.

**FLAGS**

<table>
<thead>
<tr>
<th>CY</th>
<th>ZERO</th>
<th>SIGN</th>
<th>OVF</th>
<th>OUT</th>
<th>AUX</th>
<th>LC</th>
<th>D</th>
<th>I</th>
<th>Unused</th>
</tr>
</thead>
</table>

**PERFORMANCE DATA**

- **Z8603**

  - **MEMORY ADDRESS RANGE**: 64K DATA PLUS 64K PROG.
  - **I/O ADDRESS RANGE**: MEMORY MAPPED
  - **CLOCK FREQUENCY**: 8.25 MHz
  - **POWER SUPPLIES**: 5V
  - **INTERFACES**: IRQ0-IRQ3
  - *** 12.5 MHz ALSO AVAILABLE**

**BENCHMARKS**

- **ADD REGISTER TO ACCUM**
  - **074**
- **Q/R ACCUM TO PORT**
  - **034**
- **MOVE MEMORY TO MEMORY**
  - **124**

**MANUFACTURERS**

- **ORIGINATOR**: ZILOG
- **2ND SOURCES**: SYNERTEK, SOS

**INSTRUCTION SET & SOFTWARE**

Like the Intel 8048, the Z8 has an instruction set tailored specifically for high speed controller applications where compact and efficient code is more important than ease of programming. Although the Z8 is optimised for assembly language programming, one version, the Z8671 has a Tiny BASIC interpreter in the on-chip ROM area. There are no readily available standard software packages and no DOS.

**OTHER family MEMBERS**

- **Z8601** Founder Member using masked ROM. Otherwise same as Z8603.
- **Z8602** ROMless Z8 in 64 pin package with all I/O ports & memory bus.
- **Z8681** ROMless Z8 in 40 pin package and with multiplexed memory bus.
- **Z8671** Z8612, Z8613 as Z8601, 02, 03 but with 4K ROM/EPROM.
- **Z8671** Pre-programmed Z8601 containing tiny BASIC interpreter.

**SUPPORT CHIPS**

Although the Z8603 is a complete functional unit with RAM/EPROM, parallel ports, serial port and 2 timers, it can also be expanded with external memory mapped peripherals from the 8080 or 80 family.
INSTRUCTION SET SUMMARY

The port 2 mode register simply determines the I/O function of each line individually, but Port 3 is a catch-all port which, in addition to providing a simple parallel I/O function, can be programmed to provide handshakes for the other three ports, serial I/O lines, timer I/O lines, four interrupt lines and a data memory select output. The port 3 mode register determines which functions are to be implemented and even has a bit to decide whether outputs should be push-pull or should have open drain connections. Some of these functions are mutually exclusive, which means, for example, that if all port 3 lines are required for simple parallel I/O then no external access will be possible to the serial UART or the two timers.

A single read/write register is provided for UART data, although I assume that this must be buffered internally by additional TX/RX registers because the UART is capable of full duplex operation with simultaneous transmission and reception. There is no special UART mode register, and so the programmer has limited control over data formats, but there is a parity ON/OFF flag tucked away in that busy old port 3 mode register.

The two Timer/Counter sections are well endowed with registers, having a total of five in fact. Each Timer has a read/write 8-bit counter register and a write-only prescaler register which can divide the incoming clock frequency by from 1 to 64 using 6 bits. The other two bits in the prescalers are used to select between single pass or continuous operation, and to select between internal or external clock sources.

The fifth Timer register is a mode selector which provides great flexibility in loading, starting and disabling the two sections and in deciding the functions of the Tin and T Out pins available on port 3.

Finally, there are three special registers provided to allow full control over the extensive interrupt facilities offered by the Z8. There are six fully vectored interrupts available, each with a 16-bit vector point which has to be stored in low ROM between 000H and 01H.
and 00BH. The interrupt sources are IRQO to IRQ3 (available on port 3), Serial IN, Serial OUT, Timer 0, and Timer 1, making eight in all because IRQ3 and Serial IN share a vector, as do Timer 0 and Serial OUT.

Any or all of the interrupt sources may be disabled by setting the appropriate bit(s) in the Interrupt Mask Register, and the priorities of individual interrupts can be shuffled by setting up the Interrupt Priority Register. Also available is an Interrupt Request Register so that the status of individual interrupts can be read under program control. Once again, Zilog have gone to great lengths to make their interrupt scheme the best available, one of the reasons for the success of the Z8 in high speed real-time applications.

INSTRUCTION SET

All the Z8 family share the same instruction set, which includes 47 basic instructions with six addressing modes and four data types. Like the 8048 but unlike the 68701, the Z8 instruction set has been optimised to ensure the production of fast, compact code, but the set available is very much more powerful than that of the simpler Intel device.

The Z8 can handle bits, 4 bit nibbles, bytes, and words, and has a full set of 16 condition codes for use with the JUMP and JUMP RELATIVE instructions.

Instructions can be one, two, or three bytes in length, and even the fast two byte instructions can specify both a destination and a source address thanks to the working register bank concept which allows four bit addresses to be used for inter-bank transfers.

Three byte instructions can have 8 bit source and destination addresses to give full access to the RAM array, but external addressing slows things down somewhat, by requiring a register indirect reference to generate a 16 bit address.

Zilog say there are six addressing modes, but to me it looks like seven because there are two types of register addressing. Using the Zilog nomenclature however, these are the modes available:

Register In which the designated operand is contained in the specified RAM register. The register reference can either be four bits or eight bits long for intra or extra bank addressing respectively. This mode can also be used to specify a 16 bit data location when used with those instructions which operate on words rather than bytes.

Indexed In which an operand address is calculated by adding an offset in a working register to an index value held in a different register. Since neither the offset nor the index value are specified in the instruction (both are indirect references) this mode can also be used to provide based addressing.

Direct In which an absolute 16 bit operand address is specified in bytes 2 and 3 of the instruction. This mode is only available for JUMP and CALL instructions and cannot be used for data memory access.

Relative In which an 8 bit two’s complement value in the instruction is added to the program counter to form a new address. This mode is only usable with relative jump instructions.

There are many useful instructions in the set, some of which you might not expect to find in a single chip processor. The useful Zilog DJNZ (Decrement and Jump if Not Zero) looping instruction is there, and any register in the current working bank can be used as the counter. Also available are instructions useful for moving blocks of data including an autoincrement load instruction which can transfer a byte from external data memory, addressed by a register pair, to an internal working register with both pointers being incremented following the transfer. Using this instruction a very simple code loop can transfer blocks of data quickly.

The Z8 supports BCD arithmetic, and has 16 bit increment and decrement instructions. It does not, however, provide 16 bit arithmetic or a multiply instruction like the 68701.

SOFTWARE

Like most single chip processors, the Z8 does not enjoy a freely available software base, but the Z8671 Tiny BASIC is interesting and deserves a mention.

Squeezed into the 2K byte ROM array on the Z8671 is an integer BASIC and a monitor which allows programs and data to be downloaded from a terminal into an external RAM.

There are 16 keywords as follows:

GOTO, GO@, USR, GOSUB, IF . . . THEN, INPUT, IN, LET, LIST, NEW, REM, RUN, RETURN, STOP, PRINT, PRINT HEX.

Up to 26 variables (A to Z) are available, and numbers can be specified in either decimal or hexadecimal format. The Z8671 BASIC can directly address registers and ports which makes it easy to use in control applications, and once a BASIC program has been debugged it can be stored in an external EPROM to run automatically when power is applied.

The number crunching capability of this integer BASIC is not of course adequate for scientific or financial calculations, but in the control applications for which it has been designed, it is quite sufficient.

A number of manufacturers now produce low cost single board computers using the Z8671, and there was a useful applications article published in the July/August 1981 issue of BYTE magazine. If you have a simple process to control or monitor, and are worried about the terrors of machine code programming, then the Z8671 could be for you!

INTERFACING

As you would expect in a single chip processor, the Z8 has an on-chip clock oscillator which only requires an external crystal.

A number of control lines are available to simplify system expansion, and these are worthy of note. An address strobe (AS) is provided to permit the multiplexed low address information on port 1 (ADO to AD7) to be latched, and a data strobe (DS) is activated for each external data transfer to simplify memory design. Also available are the conventional read/write (R/W) and RESET functions.

The Z8603 can address up to 62K bytes of external program memory and 62K bytes of external data memory. The two memory spaces can either be mapped into a common 64K byte range, or they can be kept separate by using another port 3 option, the DM control output, to select between the two areas.

The port 1 and 2 multiplexed data/address bus scheme is similar to that used by the Intel 8085 processor, and so it should be possible to use 8155 and 8755 peripherals with the minimum of logic. Other peripherals which require demultiplexed address and data can be interfaced by means of an octal address latch in the usual way.

Peripherals from the 8080/8085 family, or even the 6800 family, are probably quite suitable, and there seems little point in using the expensive Z80 peripherals with their sophisticated, but unavailable, interrupt logic.

One of the most challenging interface design problems for the Z8 family is in deciding what to do with port 3, which has so many mutually exclusive options, but I suppose that’s half the fun, isn’t it!

APPLICATIONS

The Z8 family has many potential uses both for hobby and professional use, and is particularly well suited to those jobs where very high speed operation is required.

The device is very much a “controller” like the 8048, and is unlikely to be useful for data processing tasks where the 68701 would undoubtedly come off best.

The simplest way to employ a Z8 is to build or buy a Z8671 module so that the advantages of the BASIC language can be enjoyed, but for many jobs this will be too slow, and in these cases the Z8603 piggy-back chip or the Z8681 ROMless version will be best.

Yet another application for the Z8 family is as peripheral devices for larger microprocessors like the Z8000, and there is a special device, the 2 bus Z8090, which is intended specifically for this purpose. Yet another version is available for interface to the Z80, the Z8590.
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EXPANDING THE...

PART FOUR  SAM WITHEY

8 CHANNEL MAINS TRIAC DRIVER BOARD . . .

Each of the opto-couplers mentioned are encapsulated in 6 pin d.i.l. packages. In each, the infra-red light emitting diode has its anode at pin 1 and cathode at pin 2. Outputs are at pins 4, 5 and 6 as indicated in Fig. 4.1.

In order to increase the versatility of the interface, provision has been made on the board to enable the use of any of the couplers illustrated.

The opto-coupled triac is capable of driving lamps or motors up to 400V a.c. and 1.2A r.m.s. On the prototype the author used Ex. WD 24V lorry side lamps connected in series (12 per circuit). They had been previously coloured with spirit based, theatre type stains and produced interesting chasing displays. The lamps were bought very cheaply some years ago from a magazine advert and might be still available.

The opto-coupled s.c.r. is capable of a similar application and has current handling capabilities of 400V a.c. and 5A.

The output from the collector of the transistor of the opto-isolator can be used to drive a further transistor stage, enabling greater current handling facilities.

Yet again, the output can be interrupted by an external electrically insulated switch pulling the logic "1" at the port down to ground potential. If triacs are used to drive disco type lighting displays, these could take the form of toggles mounted on the outside of a case.

CONSTRUCTION

As both boards are single-sided, there should be no difficulty in mounting components, all of which are readily available from Practical Electronics advertisers.

Connections to the boards are really an individual choice, according to the application for which they are intended. The author used p.c.b. terminal pins for grounding the outputs from the ports as this facility would not be required on all outputs and where needed, would be permanent. These were also used for connection of inputs to the Input Control Board.

Two types of 0.2in. pitch terminal blocks are available. One type enables the output leads to be screwed down, whilst the other type is suitable for use with 2mm plugs. The author chose the latter simply because the sockets were available as was a good supply of 2mm plugs. Further to this, these connectors were most suitable for experimental work.

Output sockets from the High Voltage Board presented a different problem. First, insulation had to be considered and provided the board is suitably encased, either type of connector is suitable. Another factor is the choice of opto-coupler to be used and protection of the substrate of the opto-triacs. Again, because they were available, p.c.b. test points were used. These were also suitable for use with the
insulated 2mm plugs, which were plentiful. And by using individual sockets, there could be no accidental connections to the triac substrate.

It should be mentioned here that the sockets used were from ex-computer panels, that are advertised regularly in P.E.

The individual reader’s personal experience will determine whether or not sockets are used for mounting components. In the author’s case, sockets are generally used only for the more expensive i.c.s since modern TTL and CMOS devices are quite robust. If sockets are used for the High Power Board, 6 pin, d.i.l. turned pin types should be suitable for handling the current, otherwise wire-wrap sockets can be cut to fit.

**APPLICATIONS**

**INPUT CONTROL BOARD**

Finally this month, is the Input Control Board. For this interface, only 2 Quad Opto-Isolators are required, but for those who have Dual Opto-Isolators at hand, these will fit neatly into place and are fully compatible internally and pin-wise. See Fig. 4.7.

Input resistors to the anodes of the infrared light emitting diodes at pins 1, 4, 5 and 8 vary according to the input supply voltage and could very well vary with each input. Typical values are 470ohm for +5V, 1K0 for +12V and 1K5 for +15V. A formula is given by the manufacturer:

\[
R_i = \frac{V_s - V_f}{I_f}
\]

Where \(R_i\) is input resistor, \(V_s\) is supply voltage.
voltage, \( V_f \) is forward voltage drop across diode and \( I_f \) is forward diode current.

The cathode of each diode, pins 2, 3, 6 and 7 is coupled to its individual ground.

The transistors of the opto-couplers are completely isolated from the input supply voltages and are used in a quasi common emitter mode. RL is typically 12k, but 1M's were used on the prototype to limit current drain at the port.

Inputs to the port are from the collectors of the internal transistors and the emitters are tied to ground.

When there is no input from the I.e.d., (i.e. the I.e.d. is off) the transistor is also off and output from the collector to the port is at logic “1”. When an input signal turns the I.e.d. on, the transistor conducts, bringing the input from the collector to the computer to logic “0”. (Remember that it is a logic “0” that the computer recognises as an input.)

Note: When all lines are set as inputs, the I/O Register at memory location 37136 shows all logic “1”s, (in other words, NOT inputs) therefore decimal 255 will be indicated on the screen. As each data line is brought to logic “0”, when inputs are sensed, the decimal value of the data line is subtracted.

Try this program again, putting signals on the inputs and monitor the changes.

![Printed circuit layout for high voltage board (actual size)](image)

**NOTE:** If this board is intended for high voltage applications it is suggested that it should be suitably encased to avoid accidents.

It should not be difficult to write a screen indicator, to monitor the I/O Register and either draw a graphic display representing the state of the port, or simply output sound and visual messages. (e.g. Digi-Talker).

The board has many useful applications about the home, laboratory and workshop as a sensor for alarms, levels of liquids and distance of travel, to mention but a few.

**APPLICATIONS**

These interface boards are a means of communication between the computer and the outside world, whilst offering complete immunity from destruction by the external devices to which they are connected, provided that the overloading and insulation precautions are observed.

It was found when testing the opto-coupled triacs, that they remained turned on after removing the logic “1” from the gate. It was also found that they were sometimes turned on, merely by switching on the mains and remained on.
despite instructions from the port. (It must be remembered that the triac is bi-directional and can be activated by either a logic "1", or a logic "0" at the gate.) The problem was overcome by inserting a 'snubber' network across the MT1, MT2 terminals. A 'snubber' network comprises a 0.1µ capacitor and 100ohm resistor, connected in series and can be inserted anywhere in the external circuit across the mains wiring, to suppress interference caused when switching inductive loads. This cured the problem. The networks can be purchased in an encapsulated package for approximately £1, or made up from a 100n polyester capacitor and a 1/4 watt 100ohm carbon film resistor, for a few pence.

It is not the intention of the author, to elaborate on the application of these boards, since school, workshop and home situations abound with opportunities for the computer to break away from the games and graphics modes. The computer can be utilised to control precisely timed cyclic operations in external apparatus, whilst monitoring the progression on the screen, or there can be manual control from the keyboard, of motors and lighting. Use can be made of micro-switches and glass reed relays (and magnets) to provide switching of the inputs to logic "0" and grounding of the output lines to disable the outputs.

It should also be noted that the inputs can be activated by external TTL or CMOS circuitry.

Care should be taken with the Low Voltage Output Board that the load does not exceed 500mA since the internal contacts could be damaged or destroyed by excessive overloading.

It cannot be over-emphasised, that insulation of outputs from the High Voltage Board, must be checked and rechecked before connection to the mains, in the interest of safety.

The High Power Board especially, could provide bright and colourful Christmas lighting, whilst the Input Board guards the presents on the tree.

**MIXING THE FACILITIES OF THE CONTROL BOARDS**

Now that the boards have been fully or partially furnished, for low and high voltage output and for input applications, it might be necessary to mix the signals.
To enable this to be carried out with the greatest of ease, a simple terminal block can be used as an intermediary between the computer and interface boards. This not only cuts out the cost of sockets, but makes the mixing of applications much quicker and adds to the versatility of the boards by making lines CA1 and CA2 available from the input control board to enable interrupts to be utilised (see last month).

The terminal uses just one socket connected by ribbon cable to a 12 way in-line terminal block. Unterminated ribbon cable is used on the interface boards, which can be connected at will. This not only saves wear and tear on the port, but makes the board available for use on several computers by making up suitable terminals.

A quicker method of mixing applications can be achieved by connecting, shall we say, an input control board and low voltage output control board to the terminal block by way of 8 s.p.d.t. switches, the common going to the terminal and one side of each switch to the corresponding data line on the interface boards.
PRINTED CIRCUIT BOARDS

Those who wish to make their own circuit boards will require copper laminated fibreglass board, double sided for Part 1 of the series and single sided for the other projects. Also required is an etch resist pen or etchant repellent component pads, and ferric chloride crystals. Those who have facilities for using photo resist methods of board production should be familiar with their own process.

Drawing with etch resist pens is not as difficult as it at first seems. First cut a piece of board to the size of the board being produced and include in it the extension bar shown on the double sided board foil patterns. These extensions are provided for those lucky few who have gold plating facilities, but they can also provide a guide for placing the edge connectors in the correct place. A photo copy of the foil patterns would be useful here, otherwise use tracing paper and mark off with dots, where every hole appears on the component side of the board. Also place a dot at the thin line that joins the bar with the edge connectors. Whichever method is used, tape the dot pattern to the p.c.b. and drill the holes.

After drilling the holes, remove the pattern guide and clean both sides of the board of all drill burrs and other marks with very fine sand paper or fine wire wool. This also gives an edge for the resist to grip. Now either lay out the component side of the board with etch resist pads and lines, or, first draw the pads and then the lines with etch resist pen. Remember, to get the ink flowing in the pen, it is necessary to press the point at intervals. Do not do this on the board as it sometimes makes a large blob. Do not worry if the resist sometimes appears thin. It is complete coverage that matters—not the thickness of the resist. Any errors should be gently scraped off with the rounded part of a craft knife—not the point.

The opposite side is generally known as the copper, or track side, even when referring to double sided boards. Great care has to be taken when drawing this side not to scratch the top surface tracks. A holding frame is best, but a slot cut in two lengths of wood should form the basis of a satisfactory holder. This side has the greater number of tracks and also has tracks between the pads. Again, draw your pads on the component side of the board with etch resist pads and lines, giving an edge for the resist to grip. Now either lay out the component side of the board with etch resist pads and lines, or, first draw the pads and then the lines with etch resist pen. Remember, to get the ink flowing in the pen, it is necessary to press the point at intervals. Do not do this on the board as it sometimes makes a large blob. Do not worry if the resist sometimes appears thin. It is complete coverage that matters—not the thickness of the resist. Any errors should be gently scraped off with the rounded part of a craft knife—not the point.

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ETCHANT

Ferric chloride crystals should be dissolves in water a day or two before use. The author usually threads a piece of sleeved wire through a hole in the board and suspended this over the neck of the jar. If the board is etched in a dish, it should be floated on the surface of the etchant. Again, the author ties a loose noose of sleeved wire around the board, allowing the board to be examined. By placing the board on the surface of the etchant
at an angle, air bubbles are forced out, leaving the whole surface exposed to the etchant. As copper is dissolved away, it falls to the bottom of the dish, leaving a fresh surface of copper exposed. After total etching of both surfaces, which takes about 15 to 20 minutes in fresh solution, the etch resist is removed from the board. Again, the author uses wire wool, which provides a clean surface for soldering.

A 1lb pack would last for several years, each jar described processes several square feet and keeps until exhausted.

**SOLDERING**

Multicored solder must be used. For the applications in this project, 22 s.w.g. is suitable. When new, soldering irons are normally fitted with a ¼ inch bit. The best size for i.c. work is 3⁄32 or ⅛ inch. Most irons come fitted with iron coated tips. These keep cleaner and last much longer than plain copper tips.

It is usual to mount the lowest lying components first. This makes soldering much easier, because after mounting, the board is turned over on a flat surface, so components are held in place by that surface. The usual mounting order is, wire links, resistors and diodes, i.e. sockets, horizontal presets, capacitors and transistors, i.e.d.s etc, soldering taking place at each level.

When soldering, each joint should take around 2 to 3 seconds, with the solder and iron being applied simultaneously.

**USE OF THE BOARDS**

The author deliberately left out of the article on the RAM, ROM and motherboards, information that is available in the Vic 20 User Manual. Since the author has a copy of The Vic 20 Programmers Manual and Nick Hampshire’s Vic Revealed, he has not read the one supplied with the Vic 20 as the abovementioned does explain everything much more fully. Not being very conversant with programming, he has found the routines provided in these two references invaluable in compiling small routines for testing the interfaces.

The motherboard permits use of 3 x 8K RAM boards if desired, these being placed in BLKs 1, 2 and 3, at edge connectors 10, 11 and 12 counting from the left-hand side of the board, with the edge connectors towards you and the components facing up. These take positions in memory at 2000Hex, 4000Hex and 6000Hex. On the prototype board copper track, a split disc was provided above each of these edge connector segments and a blob of solder was all that was required to select the memory position. However, in the published article, two sets of parallel pads are provided which require short wire links. These locations can be used for RAM or ROM. Indeed, most games cartridges and Vicmon use BLK3. The Vic system uses BLK4 at 8000Hex and BLK5 at A000Hex is available for ROM only and is normally used by Super Expander. The Commodore 8K package resides at BLK1 and the 16K package resides at BLKs 2 and 3. The author uses BLKs 1 and 2 for his two 8K boards. Having a disc unit, he intends using the Vic 20 for storage of amateur radio call signs, but after several years of using a Nascom with 32K memory (it once had 64K!), recommends that the starter in computing should limit his memory to 8K unless he buys games that require 16K and save his money for more useful equipment. Very few people write programs that take up even 8K. The Vicmon and Super Expander chips are available from some Commodore dealers, but it is not known if these are supplied under licence. Should this be so, details will be supplied in a later section. When fitted to the RAM or ROM boards, they behave exactly the same as on the Commodore boards.

The motherboard will permit the use of any commercial i.c. package and these will have no effect on the RAM residing at the same memory location. ROM takes precedence over RAM and normally replaces any program or random values that were previously stored. Should a program in ROM not be correctly terminated (such as END or RETURN in Basic) the program would then try to continue into the adjacent memory locations, but it is unlikely that this should be the case.

Those readers wanting to make the 3K RAM board, with a 4K ROM (Super Expander), might have difficulty in getting the 4118A RAMs. Should only the 4118N or 4118P type static RAMs be available, these have a latching facility at pin 19. In this case, an additional cut will have to be made in the track at pin 19 of the ROM and on the A10 side of the end RAM. An insulated link is then taken from pin 19 of the ROM, across to A10 and a further link on either side of the board between pins 19 and 24 (+5V) of any one of the RAMs to prevent it floating.

**PIGGY-BACKED ROMS**

The author ‘piggy backs’ his ROMs, but did not mention it in the article because this should only be done by experienced constructors. And these readers probably do it in any case. As the method has been requested, this is how it is done. If it is intended to ‘piggy back’ ROMs, there is no point in using sockets, so the first ROM is soldered into place with pin 20 CE bent out instead of being fitted into the hole. The second ROM is then soldered on to the first, again with pin 20 CE bent out.

There is room for a small SPDT (or DPDT) switch to be mounted on the ROM board between ICs 2 and 3. The switch should be towards the back, track-side, of the board, care being taken not to foul or break any tracks. The common terminal of the switch is taken to the most convenient connection to the ROM pin 20 CE pad. This could be the track to the decoding i.c. The other sides of the switch are taken to pin 20 CE of the individual ROMs. Should 2 x 8K programs be put on the board in this way (2 x (2 x 4K)), care should be taken in connecting the correct pairs to the DPDT switch.

The penalty is extra drain on the Vic 20 power supply, but the 6116 RAMs use so little current that the whole would cause less drain than the Commodore 16K RAM Board, which uses 2114 RAMs.

Once again, for the information of experienced constructors, the 4118 stands up well to soldering direct to the board.

It is hoped that these extra notes are helpful to those who requested them. Should there be further requests for extra information these notes will be updated accordingly and will appear in later parts of this series.

**STEPPER MOTOR CONTROL**

It was hoped that a number of more useful BASIC I/O routines would be included at the end of this article, but due to lack of space, they have been deferred to Part 5. Next month will also follow on from this with some hardware of interest to the robotics fan.

With a great interest being taken in robotics and the availability of cheap ex-equipment or surplus stepper motors, the next part in this series will cover applications of two separate stepper motor controllers, and modes of operating them to suit different stepper motors.
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JOBS IN HAND

Further information in the next issue but the test of close proximity living. There will be a little cramped. This will provide a useful since there are so many people on board it will be his sixth flight and the fulfillment of his fondest hopes. With him will be Owen Garriot who was the civilian who flew in SPACELAB 1. He was the first of the astronauts of the time to talk freely and comfortably about his own thoughts. Service personnel tend to be somewhat reserved when they are alone and talking to a civilian. As he was basically an electrical engineer we quickly found common ground especially on the philosophical aspects of a first experience. The other members of the team are Brewster Shaw who will be co-pilot, Robert Parker, Ulf Merbold of West Germany and Byron Lichtenberg. The latter two members will be known as the payload specialists. They will be in constant touch with the Earthbound specialists who devised and set the scientific experiments. Since there are so many people on board it will be a little cramped. This will provide a useful test of close proximity living. There will be further information in the next issue but the mission will be over before that is available.

The many delays of this mission have arisen because of the joint funding. The first space lab under this scheme will belong to NASA. On balance a reduced enterprise has produced something, but we are in danger of being left behind by Russia. It is true that there is a special concentration of energy on the ferrying of hostile hardware into space as is shown with the Soyuz/Salyut space missions; it is also true that the Shuttle system is now proven. We must therefore catch up with the co-operation for the advancement of a peaceful mankind, a great future lies before us if our endeavours are maintained as they were planned. Unfortunately the control of funds lies with those who are perhaps not able to realise the importance of the future, that first priority is for our preservation, order and well-being.

JUPITER AND OTHERS

Now that Voyager's records are being deciphered it is becoming clear that the giant planets were formed from ice particles. The formation of Jupiter and Saturn was not, it is now suggested, formed by the direct result of gravitational collapse of large gas clouds, but by the accumulation of small bodies made of solid ice. It is suggested that Titan, the largest satellite of Saturn, is a surviving example. Until recently it was thought that the formation of the solar system was such that the Earth was about 4-6 million years old and that the original body is now our Sun, this was the generally understood picture. It follows from this that the Sun and the Planets should be composed of components in direct proportion to what they would be in the same proportion. The fact is that the infra-red findings of Voyager disagree with this. Thus the simple view that the solar system came from one source is in grave doubt. This complicates the matter especially for those who have had doubts that the Sun is the main part of the original mass but rather is a large piece while the rest originally was the main source of material. Without digressing however at this time if the findings of Voyager are confirmed then we are forced to do some considerable rethinking. It would seem indeed that a whole new viewpoint is provided for exploration due entirely to the extending of our knowledge in a very short time, less than a year or so. It will be interesting to hear the reaction of others in this regard. One is tempted to enter the fray at such times.

RUSSIAN LAUNCH EXPLOSION

The mishap at the launching of the Russian mission to put a mixed crew into space was the second of such ventures to be aborted. The most recent was much more hazardous than the previous one. The attempted launch was made from the pad at Tyuratam on September 28th 1983. Fortunately the cosmonauts were not seriously injured.

The sequence of events is thought to be as follows: Sensors detected a malfunction and immediately a command was made to the escape system which then fired, drawing the Soyuz away from the area. The escape tower rocketed out the complete Soyuz with its shroud and the crew well away from the booster. Then the main section carrying the crew was separated after first jettisoning the instrument section. The parachute opened at a height of several hundred feet and the crew descended to safety.

There is another matter yet to be settled and that is the 'make up' of the crew. It was known that the third member of the crew was to be a Russian woman or an Indian scientist. Perhaps we shall never know.

Frank W. Hyde
THE exclusive-OR gate (usually referred to as the XOR gate) completes the set of basic gates commonly encountered in digital circuits. The XOR gate only occurs in a 2-input form, and its behaviour is such that the output is a logic 1 if only one of the inputs is at a logic 1. Thus, if both inputs are at logic 0, or both are at logic 1, then the output of an XOR gate will be a logic 0. The corresponding truth table for the exclusive-OR gate is shown in Table 4.1, and the appropriate logic symbol is shown in Fig. 4.1.

<table>
<thead>
<tr>
<th>INPUTS</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4.1. Truth table for the 2-input XOR gate

As its name suggests, the exclusive-OR is a variety of the OR gate; the 'proper' name for the more frequently encountered type of OR gate, which we have already met in the series, is the inclusive-OR gate. The inclusive-OR name is, however, only normally used when it is necessary to make the distinction between the two types absolutely clear; it is normally assumed that OR refers to inclusive-OR, and that XOR refers to the exclusive-OR function. The XOR gate, however, arguably performs the 'true' OR function because its output is 1 when one input or the other is 1, but not otherwise. The point is of passing interest, however, since the common use of these terms is as described above.

Now that we have seen the function performed by an XOR gate, it is appropriate to look at how such a gate can be built up from the other standard gates, before moving on to look at uses for XOR gates. We can make a first guess at the XOR equivalent circuit by working out the Boolean Expression for the XOR function. As a first step in this process, we will suggest a definition of the behaviour of the XOR gate. The description given above tells us that, if the inputs to the gate are labelled as A and B, and the corresponding output is X, then the gate will function as follows:

- If \( A = 1 \) and \( B = 0 \) then \( X = 1 \)
- or if \( A = 0 \) and \( B = 1 \) then \( X = 1 \)

Using the standard Boolean notation, we see that the operation of the XOR gate can therefore be described by the expression:

\[
X = A \cdot B + \overline{A} \cdot \overline{B}
\]

From this expression we can see that an XOR gate can be built up from other standard logic elements as shown in Fig. 4.2. We shall see later that there are other Boolean Expressions which would equally well describe the behaviour of the XOR gate. These in turn would give rise to equivalent circuits that are outwardly different to that in Fig. 4.2, but the point to remember is that these different expressions and circuits are simply alternative ways of describing the same behaviour. We will need to explore Boolean Algebra a little further, however, before we are able to prove that these alternatives are equivalent, so for the moment we will confine our discussion to the circuit of Fig. 4.2.

We now have a description for the behaviour of the XOR gate in terms of both a truth table and a Boolean Expression. The expression given above, however, is rather cumbersome and, in view of the possibility of alternative forms of the expression, it is not always immediately recognisable. For these reasons, therefore, there is a shorthand notation for XOR in much the same way as we have already seen for AND, OR and NOT. The shorthand for the exclusive-OR function is the \( \oplus \) symbol. Thus, from what we have seen above, we can choose to describe the action of a two-input XOR gate by either of the following (equivalent) expressions:

\[
X = A \cdot B + \overline{A} \cdot \overline{B}
\]

These two expressions are equivalent in every way; the second form, however, makes it easier to recognise where an XOR gate could be
used in a practical circuit. Now let us have a look at some examples of uses for real XOR gates.

**7486 TTL XOR Gate**

The 7486 is a quadruple 2-input XOR gate whose pin configuration and internal layout is shown in Fig. 4.3. The i.c. is in fact pin-compatible with the 7432 inclusive-OR gate, although it is rather unlikely that an exchange of this type will be required very often! The four gates are, as usual, electrically identical, and the power supply connections are quite standard.

**The wanted signal and the scrambling**

The idea is that the data to be protected is mixed with a random-looking (so-called pseudo-random) stream of 0's and 1's from a digital generator. The wanted signal and the scrambling signal are combined by an XOR gate to form a chain of mixed good and bad data. Whenever the random scrambling signal is a 1, the wanted signal is inverted, thereby scrambling the original information. The scrambled signal is then transmitted down a line, or even over a radio link. At the far end, there is another XOR gate driven by a synchronised digital generator providing the same signal as was used to scramble the data originally (it may even be the same one), which allows the scrambled data to be decoded. When the scrambling signal is a 1 at the receiving end, the incoming signal is inverted, thereby undoing the inversion introduced at the sending end; when the scrambling signal is a 0, the incoming signal is unaffected. The point to note is that unscrambling the data in the middle (e.g. by tapping the line) is very difficult since neither the original signal nor the scrambling signal are known. This type of circuitry therefore finds considerable use in cryptography, locks and in all sorts of security systems.

A simple demonstration of the coding technique just described is provided by the circuit shown in Fig. 4.5. The circuit is set up by inserting a 7486 in socket A, with pin 1 aligned with A1, and then adding the following links:

- S3 to A1 (Original data)
- S3 to D1 (Coding signal)
- Clock to A2 (Decoding signal)
- A3 to A4 (Scrambled data)
- A3 to D2
- A6 to D3 (Received data)
- A6 to A11 (RX data)
- S3 to A12 (TX data)
- A10 to D4 (Data error)
- 0V to A7 (Supply)
- +5V to A16 (Supply)

In this circuit, S3 provides the signal to be scrambled, and D1 shows the signal level. The Clock signal from the PE Logic Tutor is used as a coding signal, although more complex coding will usually be employed in practice. The scrambled signal is shown by D2, and the unscrambled signal at the receiving end is shown by D3. The third XOR gate is used to compare the sent and received signals. If there is any disagreement between them, D4 will be illuminated to indicate a transmission error.

Pressing S3 should cause D3 to change to indicate the new output state (also shown by D1). The indicator on the scrambled link (D2), however, will show that it is impossible to work out the true state of the coded signal. Remember that in practice the scrambling signal will usually be faster and more random than the Clock used here, and that the link between A3 and A4 could be a telephone or radio link, making the system much more secure.

**XOR Gates as Adders**

The traditional use for the exclusive-OR is shown in Fig. 4.6. The circuit here is for what is known as a binary half-adder, and is used in building up binary addition circuits. The subject of binary numbers is covered in detail in Part Five, but for the present no such detail is required. The half-adder circuit shown follows the rules of binary addition:

- $0 + 0 = 0$
- $0 + 1 = 1$
- $1 + 0 = 1$
- $1 + 1 = 0$ plus carry 1
The truth table for the half-adder circuit is shown in Table 4.2. In multi-bit arithmetic applications, we must cascade the carry output from one stage to the carry input of the next stage. This type of circuit is known as a full-adder stage, having cascaded carry inputs and outputs. Although this subject is a little beyond the scope of the present series, readers may like to investigate the behaviour of the full-adder circuit shown in Fig. 4.7, the truth table is given in Table 4.3.

The full-adder circuit shown below is constructed on the Logic Tutor as follows. Insert a 7486 XOR gate into socket B, and a 7400 NAND gate into socket C, both i.c.s having pin 1 of the appropriate socket. Then add the following links:

- S1 to B4 (Carry input)
- B4 to C4
- S3 to B1 (A input)
- B1 to C1
- S4 to B2 (B input)
- B2 to C2
- B3 to B5 (A + B)
- B5 to C5
- B6 to D1 (Sum output)
- C3 to C12
- C6 to C11
- C10 to D2 (Carry output)
- B7 to 0V (Supply)
- C7 to 0V (Supply)
- B16 to +5V (Supply)
- C16 to +5V (Supply)

In the circuit as wired above, the two normal inputs (A and B) are provided by S3 and S4, respectively; the carry input is provided by S1 (or fixed logic levels if this is more convenient than a momentary switch). The sum output is displayed by D1, and the carry output by D2. It is then an interesting exercise to verify the truth table given in Table 4.3.

Readers may, as a final exercise, like to try constructing a second full-adder stage, using the other two XOR gates from ICB and a further 7400. The carry output of the first stage is simply connected into the carry input of the second. Is its behaviour as you would expect? If not, try again after Part Five!

**THE FORGOTTEN POWER SUPPLY**

The power supply in any well-designed system is rather taken for granted. It does what is required, with the minimum of fuss, and for the most part can be all but ignored. This can, however, have some amusing effects on the thought processes of designers trying to debug a misbehaving circuit. It is not unknown for the problem to be traced eventually to i.c.s which have been carefully wired up according to the circuit diagram, but with the power supply connections omitted. The problem here is that, if only one i.c. of many (usually one that has been added after the original design was produced) is without power, the symptoms are not always easy to spot. Strange you may think, but true we assure you! The extreme of this syndrome is usually the basis of a favourite tale in every lab—the story of how "X" spent all afternoon trying to debug a circuit which was not even switched on! All too easy to do when surrounded by masses of test equipment which is all switched on and working, but it does show how much logic power supplies are taken for granted.

The cautionary tales above reflect some possible results of a situation that we are in fact striving to achieve; a logic power supply should provide power for the circuit without producing any adverse effects. The use of a logic family such as the 7400 TTL series greatly simplifies the task of designing a suitable power supply since the supply requirements for the whole family are similar. On the whole, the major difference between the i.c.s in a logic family, as far as the power supply is concerned, is in terms of the load placed on the supply. We shall see later that there are other factors which also affect the way in which the supply is used, but this does not affect the supply itself. Once we have designed a suitable TTL supply, therefore, we should be able to use it for any TTL circuit which does not exceed the available load capacity.

**POWER SUPPLIES FOR TTL**

The 7400 family of TTL i.c.s are all designed to operate from a single +5 volt power supply. There are, however, a number of features of this power supply which we must consider carefully if our TTL circuits are to operate reliably and predictably. The following characteristics summarise the basic requirements for power supplies intended for use with TTL.

The output from the power supply unit (p.s.u.) should be regulated so that, at any time, the voltage is within...
250mV of the nominal +5 volts. Ideally the supply should also be stabilised so that any variations in the current drawn by the circuit do not affect the output voltage. The ripple on the supply line (often the result of inadequate smoothing in mains powered circuits) should similarly always be kept to less than 250mV.

Some simple small-scale TTL circuits can be operated from batteries (e.g. three fresh HP2 cells wired in series), or from wider-range unregulated supplies. Many unstabilised supplies are actually suitable for small circuits, provided that the output does not exceed ±5-5 volts, but a regulated supply is always to be preferred. The greater the number of i.c.s in a circuit, the greater becomes the need for a tightly regulated supply. In any event, it should be remembered that the absolute maximum voltage at the supply pin of a TTL i.c. is limited to ±7 volts. Exceeding this voltage may cause damage to the device; the other (guaranteed) method of doing this is to connect the supply to the i.c. the wrong way round!

So far, we have concentrated on the power supply requirements for TTL circuits in terms of its voltage specifications. The other side of the problem, however, is to work out the load current for the circuit to be supplied. The data books usually quote the supply requirements in terms of either the power (in mW) or the current (in mA) required by each gate in an i.c. package. Power supply design is usually concerned with load current, so any mW figures must first be converted to mA by dividing by 5 (the nominal supply voltage). The ripple on the supply line (often adequate with Schottky TTL). This is the reason for attempting to stabilise the output from the

A PRACTICAL PSU CIRCUIT

The simplest way to provide power for a TTL circuit is to use a mains transformer, combined with a rectifier/smoothing circuit. This should provide a raw, unregulated d.c. supply in the range +8 to +12 volts. We then add an i.c. voltage regulator stage to stabilise the output from the

ratings a heatsink may be required to cool the regulator; the heat generated (in watts) is equivalent to the product of the load current (in amps) and the voltage by which the unstabilised supply exceeds 5 volts. A typical mains powered TTL power supply circuit is shown in Fig. 4.8.

Where an unstabilised d.c. supply of around +8 volts is already available, the simplified stabiliser circuit shown in Fig. 4.9 may be used. This circuit is simply placed between the unstabilised supply and the TTL circuit to be powered. No heatsink will be needed unless the supply current exceeds approximately 250mA. The regulator specified is suitable for load currents of up to 1 amp, and others are available for higher/lower load requirements.

SUPPLY DISTRIBUTION

Producing a good power supply is only part of the story when it comes to dealing with real digital circuits. No matter how good the supply, it is still possible to run into problems if it is not properly distributed to the i.c.s in the circuit. This is another case where we never really notice good supply distribution, until we forget! There are a number of simple rules which, if followed, will assist in producing good supply distribution, and hence avoiding trouble.

The most important characteristic of the interconnections between the supply and the circuit (i.e. the i.c.s, etc.), is that they should have a low impedance at all frequencies below 35MHz (or 125MHz with Schottky TTL). This is

<table>
<thead>
<tr>
<th>TABLE 4.5</th>
<th>SUPPLY CURRENT FIGURES FOR SOME STANDARD TTL GATES</th>
</tr>
</thead>
<tbody>
<tr>
<td>GATE TYPE</td>
<td>AVERAGE SUPPLY CURRENT (mA PER I.C)</td>
</tr>
<tr>
<td>7400</td>
<td>8</td>
</tr>
<tr>
<td>7402</td>
<td>11</td>
</tr>
<tr>
<td>7404</td>
<td>8</td>
</tr>
<tr>
<td>7408</td>
<td>15.6</td>
</tr>
<tr>
<td>7414</td>
<td>20.4</td>
</tr>
<tr>
<td>7432</td>
<td>19</td>
</tr>
<tr>
<td>7486</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 4.5. Supply current figures for some standard TTL gates

Families discussed in Part Three, Table 4.6 shows typical supply figures for comparable gates in the various sub-families.

<table>
<thead>
<tr>
<th>TABLE 4.6</th>
<th>TYPICAL SUPPLY FIGURES FOR VARIOUS TTL SUB-FAMILIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>GATE TYPE</td>
<td>AVERAGE SUPPLY CURRENT (mA PER I.C)</td>
</tr>
<tr>
<td>7400</td>
<td>8</td>
</tr>
<tr>
<td>7400</td>
<td>17.6</td>
</tr>
<tr>
<td>741500</td>
<td>1.6</td>
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<tr>
<td>74500</td>
<td>15.2</td>
</tr>
<tr>
<td>74ALS000</td>
<td>1</td>
</tr>
<tr>
<td>74L000</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Table 4.6. Typical supply figures for various TTL sub-families

Fig. 4.8. Mains power supply for TTL

Fig. 4.9. Simple stabiliser circuit

See page 49 for the full text.
essential if a sudden change, or burst of high speed operation in one circuit area is not to affect another area via the supply lines. In this respect it should be remembered that, although the signals being processed by a circuit may be slow, the switching speed of TTL is always high. The impedance of the supply leads is usually most affected by two factors: how the supply is distributed, and how the supply rails are decoupled. We will look first at how to minimise the impedance of the supply by proper distribution of the supply, before going on to look at decoupling.

The power supply wiring runs themselves should have the lowest possible impedance. In practice this means that wide foil tracks are required on printed circuit boards for both +5V and 0V rails. Typically, the main ground (0V) rail on the board should be at least 8mm wide, while the main +5V rail should be at least 6mm wide. It is quite a common practice for the main ground rail to run all or most of the way around the edge of the p.c.b. to minimise the impedance of the ground tracks to the individual i.c.s. The general rule here is that the wider the p.c.b. track, the better.

Connecting the supply to the board itself should be via terminals which can carry a heavy current by comparison with the expected load, or through several connector pins wired in parallel. Power supply connections to the board should use heavy gauge wire of minimum length. Again, the general rule is that the shorter and thicker the power supply distribution leads (on and off the p.c.b.), the better.

**DECOUPLING CAPACITORS**

When the output of a TTL gate changes from 0 to 1, or vice versa, the output transistors conduct heavily. The instantaneous current under these conditions may be as much as ten times the normal supply current. The idea is to speed up the switching performance of the output stage, but a side effect is that a large current 'spike' is drawn from the supply rails. This spike can easily exceed 100mA, and typically lasts around 10 nanoseconds. We must do something, therefore, if this spike is not to cause problems for the other i.c.s in the circuit.

The normal solution is to add small-value capacitors (known as decoupling capacitors) along the supply rails, situated near to the i.c.s. The point is that the current spikes represent very high frequency signals, and we must prevent these from going through the supply system, and upsetting other stages. The decoupling capacitors must therefore be distributed throughout the supply system, and not concentrated at the power supply itself. These local capacitors then supply the energy for the supply during the output transitions, and the spikes are prevented from spreading into the system.

The capacitors used for decoupling should be high frequency types (*not* electrolytics), and they should be connected with short lead lengths as close as possible to the i.c. power pins. Small disc ceramic capacitors of 4-7µF to 100nF, and rated at 10 volts working or higher, are recommended for supply decoupling. This type of capacitor can conveniently be mounted adjacent to the appropriate i.c. package, the closer the better.

In general, a useful rule is to use at least one decoupling capacitor for every four or five i.c.s. Add an extra capacitor wherever an i.c. is further than, say, 100mm from its nearest decoupling capacitor. Finally, if in doubt, add some more decoupling; this will then safeguard against the problem that, when a circuit is extended, extra decoupling is often forgotten. Remember: distributed decoupling is essential for proper TTL operation.

In addition to the high frequency decoupling described above, it is good practice to use some distributed low frequency decoupling. As a general rule, a single 10µF tantalum electrolytic capacitor rated at 10 volts is sufficient for each printed circuit board. For very large circuits, one such capacitor per 10-20 i.c.s is a useful ratio.

The main rule for supply decoupling is to add what seems to be enough, and then add some more. Never be tempted, however, to think that, because the decoupling capacitors appear to be connected in parallel, they can be replaced by a single capacitor of seemingly equivalent value. This will not work. The reason is that the distributed capacitors are not connected in parallel, they are separated by the impedance of the supply leads, and by the transit time of the spikes along the leads. Fig. 4.10 shows a p.c.b. layout which summarises the general principles of supply distribution and decoupling for a medium-sized TTL circuit; all signal leads have been omitted for clarity.

**LAWS OF BOOLEAN ALGEBRA**

When we introduced Boolean Algebra in Part Three, we mentioned that a set of rules were really necessary in order to be able to manipulate Boolean Expressions. These rules are often called identities because they tell us how to recognise Boolean Expressions which are equivalent to each other, but which are expressed in a different form. We will also be looking at the basic laws of Boolean Algebra in this part of the series, before going on to the more advanced ideas of De Morgan and Karnaugh in future parts. As with all types of algebra, a firm grasp of the basic laws will be an

---

**Fig. 4.10. Supply distribution and decoupling rules summarised**
invaluable asset when analysing gate circuits.

In looking at the basic Boolean Identities, one useful approach is to use simple switch logic to simulate the actions of logic gates. This analogy was introduced briefly in Part Two, and we will now use it in discussing some of the laws of Boolean Algebra as they relate to two-input gates. To summarise the conventions of switch logic, a closed switch represents a logic 1, and an open switch a logic 0; Fig. 4.11 shows the corresponding representations of AND and OR gates.

The law in essence means that the order in which we write down the input signals when we analyse a gate circuit is unimportant. The order in which the functions are written down, however, may be significant, depending on whether or not the Associative Law applies.

**Associative Law.** This law states that the order in which identical functions are performed is not significant. Thus, if we use brackets to show how cascaded gates implement the logical expression, the following relationships hold true:

\[
(A + (B + C)) = ((A + B) + C) \\
(A . (B . C)) = ((A . B) . C)
\]

These expressions are each illustrated, using standard logic symbols and switch logic, in Fig. 4.13 and Fig. 4.14, respectively. Although the order in which identical functions appear is not significant, the order in which non-identical functions are written down is important; this difference is highlighted by the Distributive Law.

**Distributive Law.** There are two ways of expressing this law, depending on the type of logical operations involved. The two forms are:

\[
A + (B . C) = (A + B) . (A + C) \\
A . (B + C) = (A . B) + (A . C)
\]

The first form is known as the product of sums expression, while the second form is the sum of products result. The logic arrangements corresponding to these two forms of the law are shown in Fig. 4.15 and 4.16, respectively.

**Useful Identities.** There are a number of other Boolean Identities which are extremely useful in practical logic design. We have already seen many of these in our discussions of the behaviour of the basic logic gate functions, but it is useful to identify the underlying theorems for future use.

\[
\begin{align*}
A + 0 &= A \\
A + 1 &= 1 \\
A . 1 &= A \\
A . 0 &= 0 \\
A + A &= A \\
A . A &= 0 \\
A + A &= 1 \\
A . A &= 1
\end{align*}
\]

Although at first sight rather simple expressions, these are probably the most widely used and useful of the Boolean Identities.

**BOOLEAN MINIMISATION**

The most important uses of the laws and identities described above are essentially practical; they allow us to rearrange and simplify logical expressions. When building TTL circuits, the i.c.s we use often have many gates in a single package, and one of our aims is usually to keep the number of these i.c.s to a minimum. Our objective, therefore, is to rearrange the logical expression which describes our circuit so that we make best use of the smallest number of i.c.s.

An example is the best way of illustrating the type of savings which can be made by even simple rearrangements. If we look at the circuit of Fig.
4.17(a), we can see that it involves both OR and NOR gates, and would require two i.c.s to build it in TTL. However, by applying one of the Boolean Identities above, we can rearrange it to make use of only NOR gates, and hence reduce the circuit to a single i.c., as shown in Fig. 4.17(b).

This is obviously a rather trivial example, but it is a useful illustration of the effectiveness of the identities in practice. The introduction of De Morgan's Theorem in Part Seven will give us further scope for this type of 'gate swapping', but for the present the laws and Boolean Identities provide us with useful design tools. Let us look now at an example of how to minimise the number and complexity of the terms in a logical expression.

When we design a logic circuit, the most natural approach is to consider each of the input signals in turn, and decide how it will be combined with the other inputs to produce the output signal(s). This gives us a design (and an associated logical expression) which is usually easily understood, but which is not necessarily the most efficient way of building the associated circuit. What we are looking for is the simplest way of expressing our initial design; a so-called minimal solution. Before embarking on this exercise, however, it is as well to remember that there are often a number of minimal solutions. The choice of which one to use is usually a compromise based on the number of i.c.s required, the number of connections, the layout, the types of gates required, cost, etc. In most cases, one of the hidden factors is also that minimising the circuit often reduces the ease with which it can be understood or modified. As in all branches of design engineering, however, solutions to problems invariably represent some form of compromise between the various factors. Now for the example.

Let us assume that we are again involved with the design of the electronically controlled shop introduced in Part Two. A section of the shop's security system is to set off a warning if the following logical expression is true.

\[ A \cdot B \cdot C + B \cdot A \cdot C + C \cdot B \cdot A \]

Fig. 4.18 shows how this design could be built directly, but we will try rearranging the expression to see if it can be reduced. Let us first apply the commutative law to rearrange the terms, and then collect them up together:

\[ A \cdot B \cdot C + C \cdot B \cdot A + B \cdot A \cdot C \]

Now we apply the distributive law, and use one of the Boolean Identities to simplify the resulting expression:

\[ (C + C) \cdot (B \cdot A) + B \cdot A \cdot C \]

This can be simplified further by applying another of the Boolean Identities, and then applying the distributive law again:

\[ B \cdot A + B \cdot A \cdot C \]

This seems to be about as far as we can go in this direction. The minimised circuit which results from this manipulation is shown in Fig. 4.19, and represents a considerable reduction when compared with Fig. 4.18. A very similar result can be obtained by eliminating B from the first/third terms, rather than eliminating C from the first/second terms:

\[ A \cdot (C + C) \cdot B \]

As a final exercise we will suggest that there is yet another form of the minimal solution which can be obtained by using the following Boolean Identity:

\[ A \cdot B \cdot C = A \cdot B \cdot C + A \cdot B \cdot C \]

This is actually just another form of the identity \( A = A + A \). If we put this identity into our original Boolean Expression above, and then re-work the minimisation, it is possible to reduce the final expression to:

\[ A \cdot (B + C) \]

If this result seems doubtful, try building the two circuits on the Logic Tutor and comparing their truth tables. The circuit for this solution is shown in Fig. 4.20. The final test, really, is to look at what the original logic expression means in terms of the conditions required to set off the alarm, and see whether the minimised expression does the same; it should!

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Experimental Speech System

TWO approaches have been tried for the systematic acquisition of a vocabulary and for selective replay of a specified word. They have both been considered because they have their respective merits. In the first approach the acquisition count routine halts during silences; this has the great advantage of ignoring redundant silence either side of a word as spoken during the period that the Acquisition Enable button is depressed. However, intra-word silences are elided. One solution to this difficulty might have been to make acquisition conditional on the state of the output of an envelope detector; however, this would still be unsatisfactory, because the first few milliseconds of a word would be missed, owing to the response time of the envelope detector. Furthermore, the acquisition procedure would be fooled, since it would be unable to distinguish between such a brief hiatus and the true end of a word.

Yet other approaches might be tried: obviously the problem could be overcome by using a double-precision counter, which would time for long enough to cover the intra-word silences; but it would be wasteful of memory to store two bytes per inter-transition interval, for much of the time the high-order byte would be redundant; it would also (in the case of the 6502) increase the count loop time, so making for poorer resolution of intervals.

The first approach was tried, and was quite successful, apart from the elision of intra-word silences.

In the second approach, for which programs are here presented, provision is made for the acquisition of silences of a limited duration, whose maximum value may be specified before execution of the acquisition program.

The end address of the speech data is automatically recorded in a table when the press button switch is released. This is achieved by means of a routine to which control is transferred by a negative-going transition on the 6502’s NMI line.

The replay program regenerates any chosen word, the appropriate speech data being accessed simply by a number, this being the position of the word in the sequence that was originally stored.

Note that 16K of RAM is needed, and that BASIC must be restricted to decimal 5567 bytes. The additional hardware needed has already been given in the lower part of Fig. 1.2 last month, but revised, rationalised circuitry is given in Fig. 2.1.

REVISED ACQUISITION CIRCUITRY

The acquisition circuitry has been modified to avoid the need for a dual power supply, and to incorporate some nominal filtering to restrict the speech bandwidth. If you wish to experiment with different bandwidths, then omit this filtering and use the variable low and high-cut filters described earlier. A further refinement is the provision of an I.e.d. driven by the comparator output; this is helpful in

---

**Fig. 2.1. Revised Acquisition Circuitry**
setting the comparator threshold just above the noise level: VR1 should be set so that the I.e.d. just stays off at the ambient 'silence' level. (It is important that background noise be reasonably low within the operating bandwidth). A delay interposed between the comparator and the I.e.d. stretches brief threshold crossings enough to visibly light the I.e.d.

REPLAY CIRCUITY

Quite acceptable speech output can be obtained, without the need for an audio amplifier, by connecting a small loudspeaker to the flip-flop as shown. Placing the loudspeaker cone downwards in a small plastic bowl of suitable tapering diameter was found to provide a beneficial resonance; this is something to experiment with.

Fig. 2.2. Replay circuitry

![Replay circuitry diagram]

Fig. 2.3. Power supply connections for i.c.s

POWER SUPPLY CONNECTIONS

15V

POW

7 4070

14 74L500

14 74L574

PIN 14

PIN 2 4741

PIN 14

PIN 7

OV

STARTING UP OF HARDWARE

Setting up the acquisition circuitry involves only adjustment of VR1 as already described. To verify that the D-type flip-flop can toggle correctly, fill up part or all of the word data storage area with some arbitrary interval value (except 255, which is treated as silence), and execute the routine for continuous replay, i.e. RPPF3 given earlier. This should yield a continuous tone of steady pitch; if it sounds ragged or irregular, then try changing the values of the capacitors marked with an asterisk.

CONSTRUCTION

The circuitry is not complicated or critical in layout, and because it is regarded as experimental and open to improvement, a p.c.b. design has not been provided. It can readily be assembled on Veroboard or fitted into space on an existing board.

USING THE PROGRAMS

Having set up the hardware, the programs may now be tried out.

Enter a value into SILMAX, i.e. page zero location 51 hex. This gives the maximum length of continuous silence that can be acquired; a value of 10 hex seems about right. Now execute the acquisition program from 029B hex. No speech data will be stored in memory until the Acquisition Enable button is pressed. Thus the procedure is as follows: decide on the vocabulary sequence you wish to enter; execute the program from the machine code monitor; press the button and hold down, starting to speak the word as soon as the button is depressed, and releasing the button as soon as the word is finished; continue in this fashion until the program returns you to the monitor, which will happen when the memory storage area for either the word data or the end-of-word address table becomes filled up. Depending upon the bandwidth in use, up to 20 average-length words can be stored. If you have more than 16K of memory, then you can modify the programs to increase the vocabulary storage capacity.

Having entered the vocabulary sequence, verify that page zero location 57 hex contains the number of words which you were able to enter; then have a look at the contents of the table of end addresses of words; the two-byte values in low-high order should be in an ascending order.

The replay routine is conveniently tested from BASIC using the test programs given, one of which replays a single specified word, the other replaying the entire vocabulary out in sequence. Clearly the replay routine can be called from any other program of your choice.

It is actually possible to manage without a microphone and preamplifier, because you can store the vocabulary sequence on cassette tape, and then replay the tape recording into the acquisition circuitry at full volume, pressing and releasing the button switch as described above; a particular vocabulary for use with a particular program can be stored on tape along with the program; clearly the vocabulary data could also be stored in its encoded form, in which case the acquisition procedure would not have to be repeated. If you have a disc-based system, then the speech facility becomes much more useful.

BASIC Test Programs

```
1000 REM TO TEST SPK7, SWD5
1005 POKE 11,55: POKE 12,22
1010 INPUT "ENTER WORD NO.": WN: POKE 88,WN-1
1015 X = USR(X)
1020 GOTO 1010

1500 REM RUNS THROUGH VOCABULARY
1505 POKE 11,55: POKE 12,22
1510 FOR N = 0 TO (PEEK(87)-1)
1515 POKE 88,N
1520 X = USR(X)
1525 FOR T = 1 TO 400: NEXT T
1530 NEXT N
1535 GOTO 1510
```

Lines 1005 or 1505 set up the USR address; once this is set up any program in BASIC can elicit a specified word by putting the word number in page zero location 58 hex by doing a POKE 88, word number−1, and then doing a USR call.

MEMORY ALLOCATION

<table>
<thead>
<tr>
<th>Hex</th>
<th>Decimal Name</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3FF</td>
<td>16383</td>
<td>16K Storage area for speech word data</td>
</tr>
<tr>
<td>$1600</td>
<td>5632</td>
<td>6K Table of addresses of ends of words (up to 32 words, subject to memory space)</td>
</tr>
<tr>
<td>$1FF</td>
<td>6143</td>
<td>16K Machine code routines</td>
</tr>
</tbody>
</table>

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PAGE ZERO

$ 50 80 BGNWD(L) * Address of beginning of word to be replayed.
$ 51 81 BGNWD(H) ** Address of end of word to be replayed.
$ 52 82 ENWD(L) Address of end of word to be replayed.
$ 53 83 ENWD(H) Offset or index for table.
$ 54 84 TINDEX Indirect pointer P1
$ 55 85 P1(L) Number of words in vocabulary.
$ 56 86 P1(H) Specifies which word to play back.
$ 57 87 NWOR Specifies which word to play back.
$ 58 88 WCHWD

* ALSO USED AS SILLENGTH
** ALSO USED AS SILMAX

VOCABULARY ACQUISITION PROGRAM

1 : Vocabulary Acquisition Program.
5 : Before execution enter value of (SILMAX) into ($ 0051), e.g. S 10
10 : Assemble from $ 0250.
15 : Execute from $ 029B
18 : Initialisation routine. Execute from here, i.e. $ 029B
20 : Binary arithmetic mode
25 : Interrupt-driven Count routine
27 : Entry point from NMI routine.
30 : Clear interval counter.
50 : Increment indirect pointer to memory storage area.
60 : Exit if end of memory reached (16 K)
70 : Enable maskable interrupts
80 : and start counting until next interrupt
90 : Or, if count reaches 255,
100 : Then disable interrupts, and increment (SILENGTH)
110 : (silence counter)
120 : and branch back to start of count routine

Note. Above code can be shortened somewhat because some instructions are duplicated. However, for the sake of clarity, this has not been done.
## Single Word Replay Program

<table>
<thead>
<tr>
<th>HEX Address</th>
<th>Instruction</th>
<th>Mnemonic</th>
<th>Operand (Hex)</th>
</tr>
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<tbody>
<tr>
<td>0250</td>
<td>8A</td>
<td>TXA</td>
<td>55</td>
</tr>
<tr>
<td>0251</td>
<td>9155</td>
<td>STAY</td>
<td>55</td>
</tr>
<tr>
<td>0253</td>
<td>A200</td>
<td>LDXIM</td>
<td>0</td>
</tr>
<tr>
<td>0255</td>
<td>18</td>
<td>CLC</td>
<td></td>
</tr>
<tr>
<td>0256</td>
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1. Replays a single word specified by (WCHWD)
2. Assemble from $1600
3.Execute from $1637
4. Set memory pointer to beginning of word.
5. Pointer offset equals zero.
6. Fetch next byte of interval data.
7. Count down for duration corresponding to interval data.
8. Treat an interval of 255 as silence.
10. Increment memory pointer.
11. Return if end of word reached
12. Time path adjustment
13. Use to access low byte of end address of preceding word from table.
14. Increment from start address of specified word, and put in (BGNWDL)
15. Get high byte.
16. Add in Carry bit
17. Put in (BGNWDH)
18. Get end address of specified word and put in (ENDWD)
19. Call routine to replay single word
20. and return.

---

Practical Electronics  January 1984
### Disassembled Listing of RPL2

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<th>Instruction</th>
<th>Mnemonic</th>
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**UK101** Bx, boxed, SEK, Cegmon, extended monitor, BASIC 4 & 5, toolkit II, matched cassette, technical literature £200 o.n.o. Derek J. Davies, 48 Bishop Street, Cherry Orchard, Shrewsbury. Salop SY2 5HD. Tel: 55445.

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DESPITE the widespread use of stereo sound in audio systems, there are still many occasions when only mono signals are available, or the stereo sound is presented so poorly that it gives little or no benefit over mono. Many television sets and portable radios fall into these categories; they are either mono only, or their stereo speakers are very close together, giving an unnaturally narrow mono only, or their stereo speakers are very wide apart. This can considerably enhance the stereo effect when listening on closely spaced loudspeakers, and is also very interesting on headphones! The mono signal, again, can be passed through the i.c. normally, or it can be turned into a pseudo-stereo signal. Circuits which can synthesise stereo sound from a mono source have been known about for a long time, but most of these worked on the principle of 'treble on the left, bass on the right', or similar. The majority of these systems sounded very obvious indeed! The TDA 3810, on the other hand, uses a more sophisticated arrangement which produces a much more convincing effect. Mono recordings are reproduced with a realistic ambience that considerably enhances the sound in many cases, giving it a richer and more spacious feel. Recordings made from a disco console being used for parties really came to life when processed in this way; the system seems to be very good with pop music, crowd noise, and a whole host of other sounds.

PRINCIPLES OF OPERATION

The simplified block diagram of the i.c. with its associated external components is shown in Fig. 2. The stereo mode is the simplest configuration; each signal simply passes through its own set of three amplifiers without modification. In the spatial mode, the left signal is fed to the non-inverting input of a differential amplifier. The inverting input of that amplifier is fed, via R1 and R2, which are equal value, so the left output is simply a unity gain signal from the left output, gives the illusion of...
stereo sound. However, we are left with an unfortunate notch in the frequency response of the right channel. To help alleviate this, the left output (which is inverted with respect to the right input) is fed back to the inverting amplifier of the right channel via a bandpass filter and R8. The full effect of this arrangement is very complex indeed, but basically it helps to fill out the right output signal, making up for the loss in signal energy caused by the notch filter's response. The components used for both filters are provided externally to the i.c. in order that they can be tailored to suit individual tastes or desired characteristics. The quality of the pseudo-stereo effect is very dependent on the performance of these filters.

APPLICATIONS CIRCUIT

Fig. 3 shows the full circuit diagram of the stereo signal processor. A single supply rail is used in this system, with a maximum voltage of +15V, and a typical supply of +12V. To bias the internal amplifiers, a voltage reference \( V_{ref} \) is derived internally; this is decoupled to 0V by C13. As a result, input and output decoupling capacitors must be used: C11, C12, C14 and C15. C3, C4 and C5 decouple different sections of the i.c., and help to reduce offset voltages. The notch filter is a passive twin-T network formed by R9, R10, R11, C6, C7 and C8, in conjunction with R7 and R15, while the bandpass filter is a Wien network comprising of R8, R12, C9 in parallel with C18, and C10. Pin 9 is a 'mute' facility which turns the outputs of the i.c. off when pulled down to 0 volts by a resistor of typically a few kilohms. C19 helps to prevent too many clicks when this happens. The mode of operation of the i.c. is controlled by internal analogue switches. These are controlled by pins 11 and 12 of the i.c. as shown below:

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<th>Pin 12</th>
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<td>Logic 1</td>
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<tr>
<td>&quot;Pseudo-stereo&quot;</td>
<td>Logic 1</td>
<td>Logic 0</td>
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</table>

Logic 1 is a voltage between +2V and the positive supply; if left open circuit, a control input will naturally go to logic 1. Logic 0 is any voltage between 0V and 0.5V. These inputs are compatible with both TTL and CMOS logic. Alternatively, a centre-off 3 position switch, as shown in Fig. 3, can be used. The i.e.d.s show the mode selected; if neither is lit, the mode is "normal", or "stereo". (If a mono signal is used, of course, it will still come out mono).

USING THE CIRCUIT

The circuit is largely self explanatory in use. It should be connected after any pre-amplification, but prior to volume controls, balance controls, etc. if possible. (Using tape output and tape monitor facilities on hi-fi amplifiers is often an easy way to connect it in circuit). The two filters can be experimented with, and values changed. The values shown should be adhered to closely when not experimenting, although making R11 = 10k, and R15, R7 = 15k, and R8 = 22k will not degrade the performance very seriously. They could even be replaced with active filters for more striking effects.
Red Shift

Sir—I was interested to read Frank Hyde's witty comments on Quasar red-shifts in his *Spacewatch* column. It seems from his words that he feels it unlikely that any definite answer will emerge from current research on the subject. May I suggest that there could be an answer staring him in the face from the work to which he referred, and which is readily understandable by all who have some knowledge of radio propagation?

The question is: are Quasar red-shifts derived from their supposed extremely remote distance or are they relatively "local" objects with an unknown reason for their red-shifts? I believe the local/remote question can be answered through an aspect of the milli-arc-second-scale maps to which he referred. Several Quasars have now been mapped to this scale and these maps are precisely aligned with the optical object in the sky. But is it not true that light rays are unaffected by ionised material on the line-of-sight to the Quasars but radio waves will tend to be dispersed and distorted by such intervening matter. I think the above series of articles is very thoughtful of these various facts and perhaps we can be reflected in many other fields.

Chip Chop?

Sir — Regarding your September issue editorial I wish I could have been on a bit of high ground behind you as you wrote it and instigated three hearty cheers, for the situation can be reflected in many other fields.

Back in 1969 I received a lettering-off in your columns for my attempt to curb the spread of the i.c. My unstated fear was that by resorting to special components, one could be in difficulty later if a manufacturer had concluded that any definite answer was included in the p.c.b.? I expect that you already have been informed of the many different views, which at the end of Part 3 of Introduction to Digital Electronics (December 1983).

E. J. Hatch
Sittingbourne Kent.

F. Hyde comments:

In dealing with the red-shift problem we must be careful about the derivation of parameters. It would seem that Mr. Shimmon is one of those who still adhere to the generally discarded views of very distant bodies. The subject is not that simple.

Leaving aside the various schools of thought on these matters the energy levels involved are not compatible with close objects and we must compare like with like. The small number of the sources involved which have caused so much controversy are open to the varied reactions of different observers. As a solution the local radar effects, local because they are tunable only at local distances, must of course lead us to quote from experience. The distances involved are very great and consequently line-of-sight obstruction cannot be extrapolated in such a straightforward manner no matter what its nature.

In the case of observations where the bodies involved are in fact moving at right angles to the line-of-sight, observable links were verified. The very fact that the required power involved in relation to the power received is so great that normal explanations do not seem to be relevant. The most recent findngs of shifts many times the speed of light does not help at all.

The recent work carried out by J. Sulentic does offer proof that some of the observed shift can be attributed to the expanding Universe. This would seem to settle a part of the argument which has occupied several decades. It would appear that Mr. Shimmon holds very definite views of these various facts and perhaps we are missing something right under our noses. Unfortunately Spacewatch does not allow the mention of the many different views, which at the moment occupy several erudite volumes, to be put forward. I would however be glad to pursue this matter privately with Mr. Shimmon.

P. W. Shimmon
Crawley West Sussex.

Illogical

Sir—With reference to "Introduction to Digital Electronics". I think the above series of articles is very well written and I look forward to those which are yet to come, having built the "Logic Tutor". In this connection, I should be grateful if you would tell me which i.c.s will be dealt with over the series of articles so that I may buy them all at one time from one of your advertisers. The reason being, there is not a suitable shop in this area, and it is uneconomic to buy them by post in ones and twos. May I point out that there are two R19s on the p.c.b.? I expect that you already have been told that the one adjacent to L2/LK3 is in fact R15.

E. J. Hatch
Sittingbourne Kent.

Thank you for your comments. A list of the necessary i.c.s is shown below—

*7400, 7402, 7404, 7408, 7414, 7432, 7473, 7474, 7486, 74107, 74121, 745124.*

With regard to the Logic Tutor board you are quite right, the R19 next to link 3 should be R15. There was also a misprint under the "Initial Test" heading which is covered at the end of Part 3 of Introduction to Digital Electronics (December 1983).
T.V. SOUND TUNER

In the cut-throat world of consumer electronics, one of the questions designers apparently ponder over is "Will anyone notice if we save money by choos ing this out?" in the domestic TV set, one of the first casualties seems to be the sound quality. Small speakers and bass/treble controls are commonplace, and all this is really quite sad, as the TV manufacturers do their best to transmit the highest quality sound. Given the right design and compact and independent TV tuner that connects directly to your Hi-Fi is a must for quality reproduction.

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