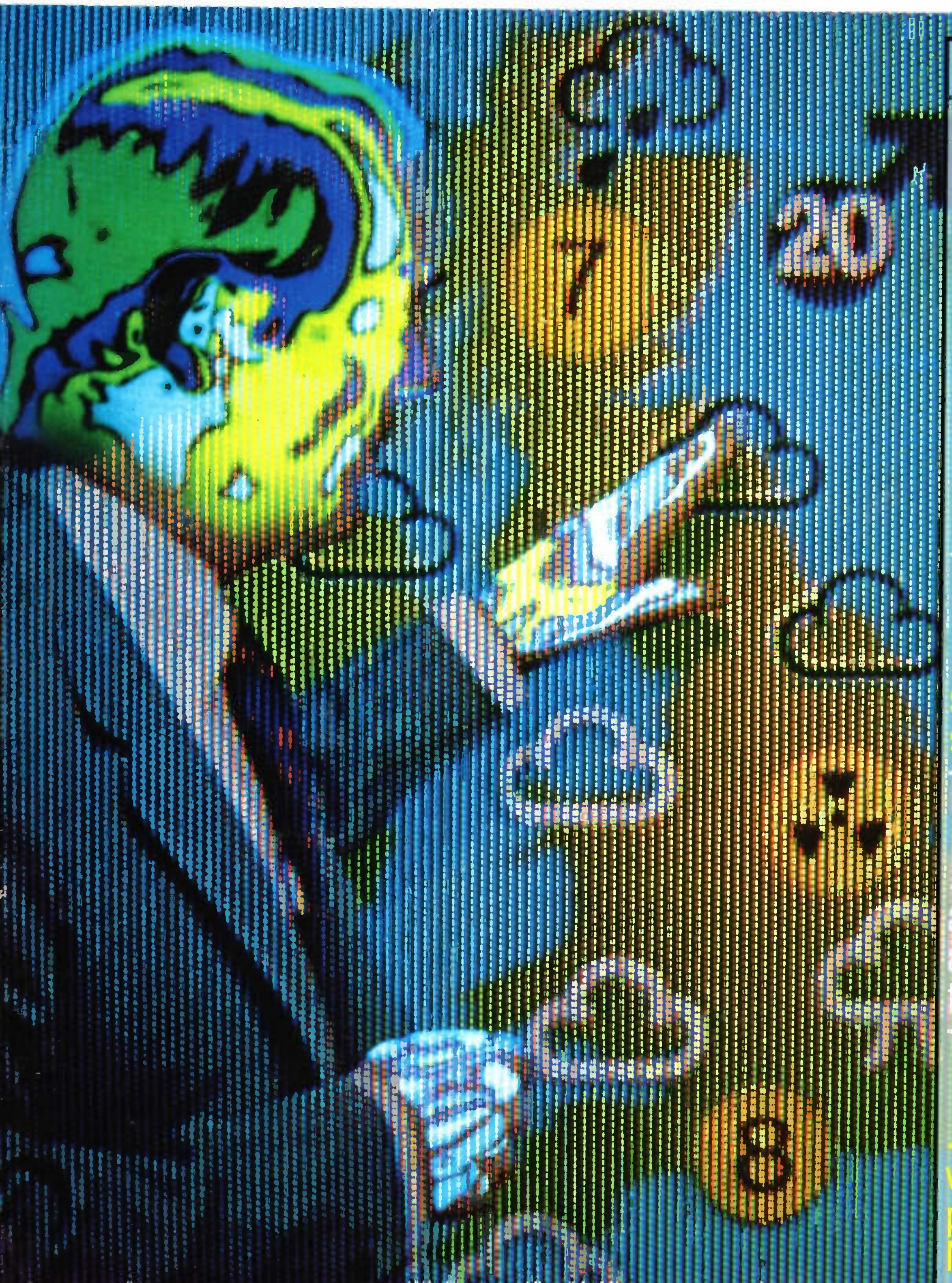
ELECTRONICS

The Maplin Magazine

IR £1.54

AUG-SEP '89 · £1.00



Super weather station project featuring wind speed and direction and temperature monitoring.

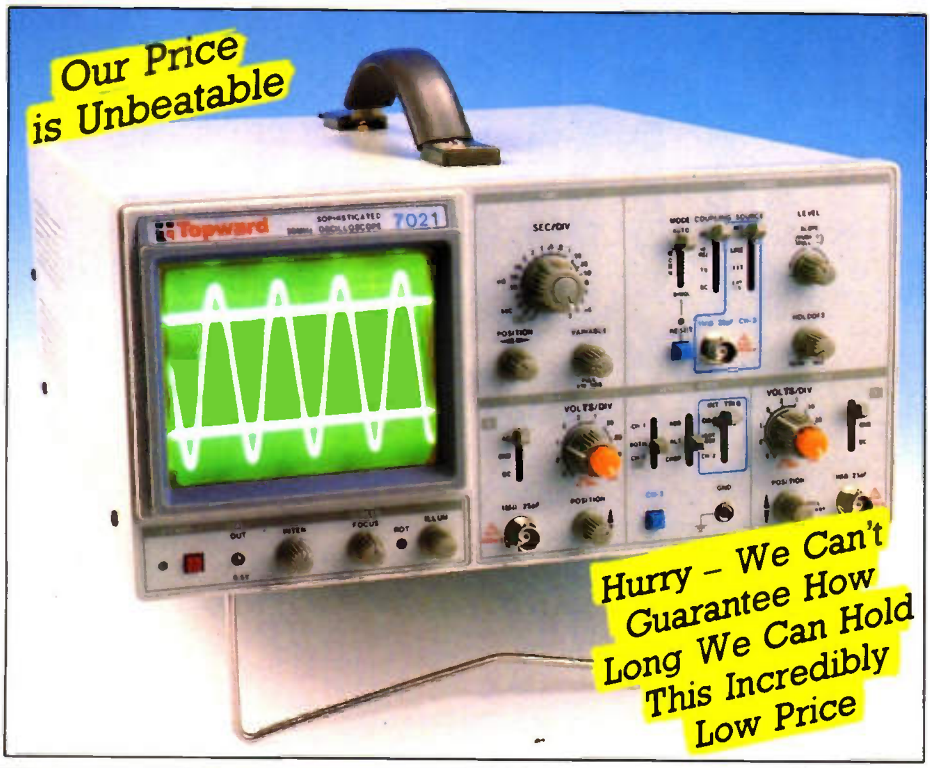
Tips on taking measurements of frequency in the home laboratory.

Full building plans for a superb high power speaker cabinet.

Infra-red remote control switch and a stereo pre-amplifier for you to build.

Features on computer viruses, computer peripherals, & Maplin in Leeds!

Superb Triple-Trace 20MHz Oscilloscope



Precision laboratory oscilloscope.
3 Channels – 3 Trace.
Sensitive vertical amplifier 1mV/div allows very low level signals to be easily observed.
150mm rectangular CRT has internal graticule to eliminate parallax error.
X-Y mode allows Lissajous patterns to be produced and phase shift measured.
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20ns/div sweep rate makes fast signals observable.
Algebraic operation allows sum or difference of Channel 1 and 2 to be displayed.
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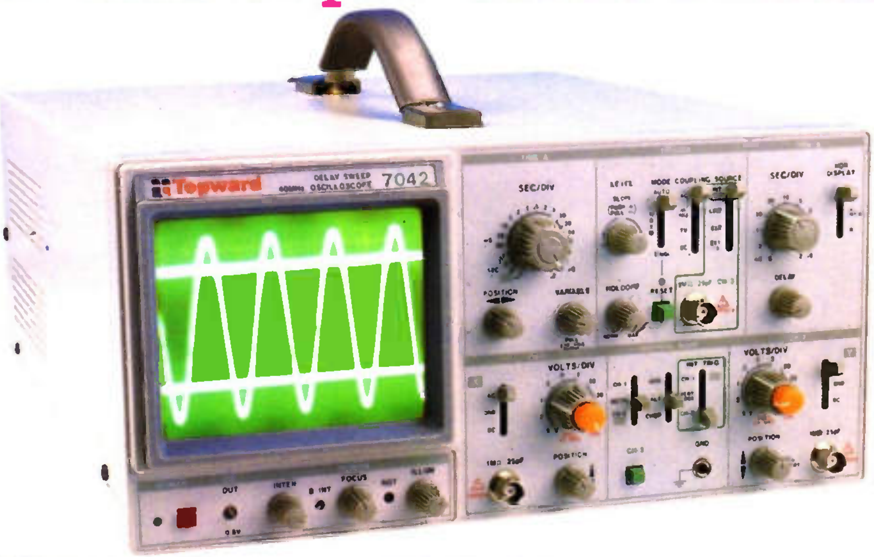
40MHz Triple-Trace Oscilloscope



As above, but with 40MHz bandwidth and super bright 12kV tube even at the highest frequencies. This instrument also has a delayed sweep time base to provide magnified waveforms and accurate time interval measurement. Truly superb precision instrument.

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AUGUST TO SEPTEMBER 1989 VOL.8 No.33

EDITORIAL

This edition of 'Electronics' is crammed full of projects. There's the main display unit for the weather station which decodes the data from the wind speed and direction indicators that appeared in the April-May issue, and also features a temperature readout. The sharp audio filter is the second project in the series aimed at receiving RTTY transmissions. Dave Goodman presents another of his superb speaker cabinet designs, this time he concentrates on the high power requirements of PA and 'Disco' cabinets. Two smaller, but very useful, projects are the stereo pre-amplifier and the infra-red remote control switch. Plus our regular series on experimenting with electronics, electronics related mathematics, etc. Starting this issue is a new series from Graham Dixey on how computers interface with the outside world. In addition, there are two fascinating features, one on measuring frequency in your home workshop and the other is an in-depth look at Casio's new 'personal computer', the FX-850P. As I said, this issue is absolutely crammed! Read on and enjoy!

R.T. Smith

Editor Roy Smith **Technical Editors** Dave Goodman, Chris Barlow, Gavin Cheesman.
Technical Author Robert Ball.
Art Directors Peter Blackmore, Martin King
Art Assistants Eugene Francis, Graham Smith, Dan Shadrake
Technical Artists John Dudley, Lesley Foster, Paul Evans
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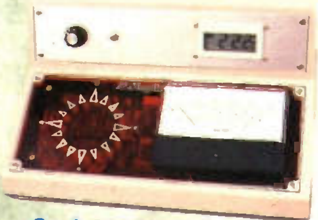
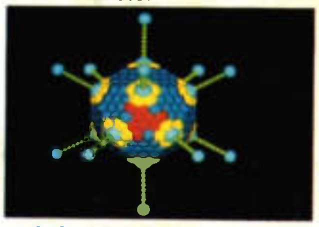
PROJECTS



FEATURES



Due to lack of space, the next part of 'Hello Who's Calling' has been held over until the next issue.

REGULARS

MAPLIN COME TO *Leeds*

Reported by Robert Ball A.M.I.P.R.E.

The City of Leeds is the third largest city in England and is the regional centre of Yorkshire. Located centrally between London and Edinburgh, the City is easy to reach via the A1, M1, M62 and the Inter-City rail services. As with many Cities, Leeds has many connections with past history. In the years long gone, Leeds has seen 12th Century monks, the Industrial Revolution and the technological changes that bring us up to the present. The modern day City of Leeds boasts a fine shopping centre with a delicate balance of big high street names, modern shops, Victorian shopping arcades and side streets, together with ethnic influences and an abundance of restaurants and exciting night-life, providing a cosmopolitan outlook on life for the townsfolk and visitor alike. One of the latest arrivals in Leeds is the new Maplin shop, adding another branch to their country wide chain, the shop brings high technology electronic components and products to the area.


Town Hall

Sights to See!

In 1152, the Aire Valley became home to Abbot Alexander and his order of Cistercian monks. The area having a plentiful supply of water, timber and stone, it was an ideal place to establish a monastery, Kirkstall Abbey still stands as a fine example of Cistercian architecture. The monastery continued to be an active order until the dissolution during the reign of Henry VIII, the Abbey ruins are just two miles from the city centre and easily accessible by road. Leeds owes a great deal to Alexander's early pioneers, leading the way for centuries of development ahead. In the 19th century, Leeds was well established as a major industrial city, producing textiles and the area became a world centre for cloth production. In ensuing years, industry and commerce developed with astounding diversity, Leeds soon became one of the fastest growing Cities in Britain.

The centuries of development have left many reminders of the past and the area proves to be of great interest for tourists. The worlds oldest railway, Middleton Railway can be found nearby, it was established in 1758 under British Parliamentary authority. This old steam railway still operates during the summer, providing trips on weekend afternoons.

For a taste of the industrial past, why not visit the Armley Mills Industrial Museum? This was once the largest woollen mill in the world, now featuring displays on all the main industries of Leeds from the 1800s. The museum was hailed as 'Industrial Museum of the Year' in 1983, and amongst other exhibits, includes water driven industrial machinery and locomotives, the museum also recalls the golden days of the Cinema, an actual cinema gives film shows. There will certainly be no shortage of things providing interest for all the family.

For people interested in stately homes, there are four to choose from in the Leeds area; Bramham Park, which was built between 1698 and 1710, is surrounded by gardens in classic French style. Harewood House is a must for art lovers, the house is noted for its superb collection of paintings, contrasting this in the grounds there is a Bird Garden, and a Paradise Garden with mammals and reptiles. Harewood House was built in 1759 by John Carr and features the furnishings of Chippendale, with the gardens contoured by the famous landscape gardener Lancelot Brown. Lotherton Hall is an elegant Edwardian country house, rebuilt in the 1890s. The collections and displays include modern ceramics, oriental pottery and costumes. There is a large bird garden and additionally the fine gardens have horses and deer. Temple Newsam, was the birthplace of Lord Darnley in 1545, he later became husband to Mary, Queen of Scots. This important English treasure house has a large collection of decorative art. The house is set in 900 acres of ground, landscaped, as

Shop staff: Steve, Bob, Pete, Mike (manager).

Maplin's new Leeds shop.

with Harewood House, by Lancelot Brown.

Further out-of-town is the village of Haworth, once the home of the talented but ill-fated Bronte sisters. West Yorkshire is a county of great contrast from the bright lights of the city to the haunting isolation of the Pennine moors. Surrounding the city centre are some of Britain's best known tourist attractions; the famous Ilkley Moor, which inspired Yorkshire's own 'national anthem', and the Yorkshire Dales, familiar to many as the scene of the BBC TV series about James Herriot, the country vet. From churches and chapels to castles and fortifications, the area unfolds stories of Christian heritage and turbulent years of conflict. The gigantic mills and ornate warehouses stand monumental to the first Industrial Revolution.

The City Centre

The City centre is very distinctive, abundant with Victorian architecture. One of the most promifient buildings is the Town Hall, this building was completed in 1858 by Charles Brodrick. The interior, noted for its Victorian splendour, provides an ideal setting for the Leeds International Concert Season. The magnificence of the Civic Hall contrasts other buildings with its imposing twin towers, on top of which are two eight foot high gold owls surveying the surrounding garden and streets. The Civic Hall is the administrative centre of the City, with rooms for the Lord Mayor of Leeds. Many of the buildings in Leeds are undergoing cleaning operations to remove 'sooty' deposits, the cause of which is the City's industrial past and heavy traffic. The difference after the cleaning process is quite dramatic, one building that certainly does not need this type of face-lift is the modern Carpet World building, the site of the new Maplin shop.

Maplin's Leeds shop opened on Saturday 14th January and is already echoing the success of other regional shops with large numbers of customers coming through the door. The shop is easy to find, situated in the east of the City, it stands prominent in the Carpet World Building, which is in Regent Street. To walk, it is just a few minutes from the City centre, access by road, rail and local transport is good, the shop is just 1½ miles from the M1 and Leeds station is about a mile away. There should be no problems parking if you come by car as customer parking is provided at the rear of the shop.

The spacious self-service layout is an invitation to browse at your leisure. With stock items on display it is easy to find the right component for the job, whether it is an infra-red sensor unit to improve home security or just nuts and bolts for your latest project, you will find all you need at Maplin! The carefully monitored stock control system, ensures the best availability of products (if you are travelling any distance PLEASE phone first to check the items you require are in stock).

At your Service

The Manager of the Leeds shop, Mike, certainly knows how to look after the day to day operations of the shop and co-ordinate the staff in an efficient manner, as his background revealed: After leaving school, he joined the Merchant Navy, serving for 10 years, during that time he 'climbed the ladder' to 2nd Officer level. Whilst at sea he gained experience in electronics, over the years he has worked on ferries, tankers and container vessels, travelling world wide.

After leaving the Navy, Mike spent 7 years involved with a small company dealing in sail design and manufacture, 5 years of which were at company director level. Before managing at Leeds, Mike has worked at the Southend shop in Westcliff-on-Sea and af the Bristol shop. He commented on the reaction of the customers to the opening of the shop, "The feedback from the customers has been very good, they are very pleased that we are open. There aren't any other shops in the area which provide the same sort of service. A couple of shops sell

The Maplin shop has been designed for self-service and easy browsing.

ex-equipment and bankrupt stock electronics, but todays customer demands high quality components and good service, electronic 'junk' stores can't offer that. Quite often people walk by, look in the window and come in to browse round. People like to be able to look round without being pounced upon by some over zealous sales person, but also appreciate help and advice if they need it. At Maplin we can offer the kind of service that people want."

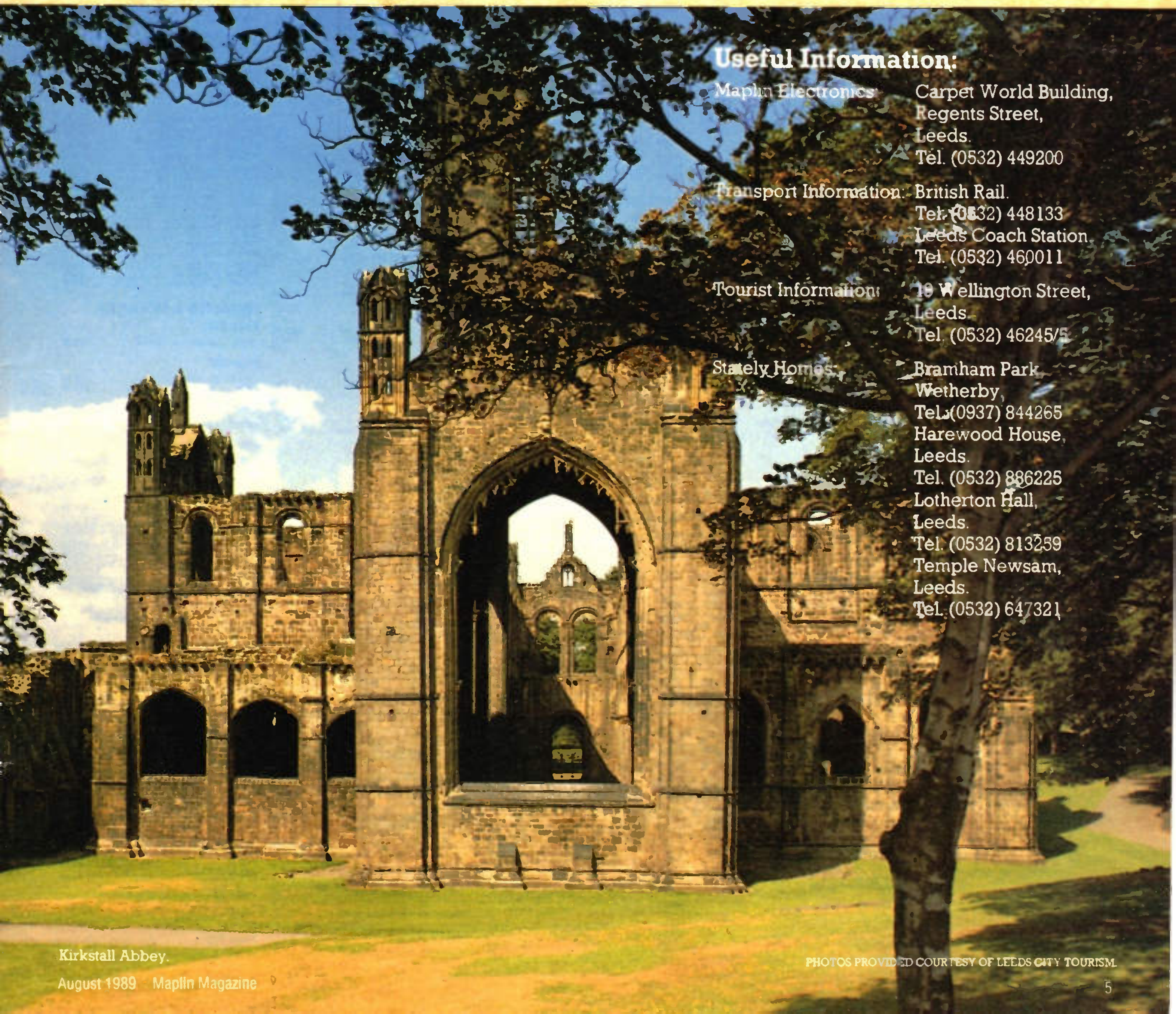
The Assistant Manager is Bob, he joined Maplin in 1984 as a sales assistant at the Manchester shop, he subsequently worked his way up to Assistant Manager level. Prior to joining Maplin he worked for one of the large high street domestic electrical/electronic retail chains, where he was a service engineer. Bob's qualifications include City and Guilds Electronics Servicing, and he possesses a good working knowledge of electronics. His main hobbies are walking the dog, crown green bowling and coarse fishing. At the moment he lives in the Manchester area, but will shortly be moving to Doncaster.

The Sales Assistants are Steve, Pete and Andrew. Steve originally studied medicine at Kings College in London, but he did not feel that this was the career for him, he subsequently worked for two sales companies, after which he joined Maplin in 1988. He is an active electronics hobbyist and is particularly interested in audio, computers and Hi-Fi. He will shortly be starting an Open University degree course studying electronics. Pete went to college after leaving school and studied BTEC computer science and electrical engineering. After qualifying he joined a leisure industry service company working as a field service engineer in Sheffield, Pete joined Maplin in 1988. He is an active electronics hobbyist and other hobbies include cycling and canoeing, he is also considering studying an Open University degree course in computer science.

If you live in the Leeds area and you have not yet visited the new Maplin shop, why not pop in, you will be assured of a warm welcome, excellent service and a comprehensive range of products. If you don't live in the vicinity of Leeds, take a trip out for the day, see the sights and visit the best electronics store around! (Stately Homes are subject to seasonal opening, PLEASE check that they are open before travelling any distance).

Useful Information:

Maplin Electronics:	Carpet World Building, Regents Street, Leeds. Tel. (0532) 449200
Transport Information:	British Rail. Tel. (0532) 448133 Leeds Coach Station. Tel. (0532) 460011
Tourist Information:	19 Wellington Street, Leeds. Tel. (0532) 462455
Stately Homes:	Bramham Park, Wetherby, Tel. (0937) 844265 Harewood House, Leeds. Tel. (0532) 886225 Lotherton Hall, Leeds. Tel. (0532) 813259 Temple Newsam, Leeds. Tel. (0532) 647321



Kirkstall Abbey.

PHOTOS PROVIDED COURTESY OF LEEDS CITY TOURISM.

1989 CATALOGUE PRICE CHANGES

The price changes shown in this list are valid from 17th July 1989 to 31st October 1989. Prices charged will be those ruling on the day of despatch.

For further details please see 'Prices' on catalogue page 20.

Price Changes
All items whose prices have changed since the publication of the 1989 catalogue are shown in the list below.

A complete Price List is also available free of charge – order as XF08J.

Key

DIS	Discontined
TEMP	Temporarily unobtainable.
FEB	Out of stock; new stock expected in month shown.
‡	An additional £5.50 carriage charge must be added.
NV	Indicates that item is zero rated for VAT purposes.
★	See 'Amendments To Catalogue'. Note that not all items that require amendments are shown in this list.
†	Whilst stocks last.

1989 Catalogue Page No.		VAT Inclusive Price

AERIALS

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XQ23A	Mushkiller FM1083	£18.40
XQ25C	Mushkiller FM1085	£28.75
‡XQ27E	Mushkiller FM1087	£37.95
XQ29G	Trucolour TC10 Grp A	£13.80
XQ30H	Trucolour TC10 Grp B	£13.80
XQ31J	TrucolourTC10 GrpC/D	£13.80
XQ32K	Trucolour TC13 Grp A	£16.30
XQ33L	Trucolour TC13 Grp B	£16.30
XQ34M	TrucolourTC13 GrpC/D	£16.30
XQ35Q	Trucolour TC18 Grp A	£19.95
XQ36P	Trucolour TC18 Grp B	£19.95
XQ37S	TrucolourTC18 GrpC/D	£19.95
XG24B	Trucolour TC18 Grp E	£19.95
XQ38R	Extragain XG5	£25.85

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XQ39N	Extragain XG8 GroupA	£33.35
XQ40T	Extragain XG8 GroupB	£33.35
XQ41U	Extragain XG8 GrpC/D	£33.35
XQ42V	Extragain XG8 Wdbnd	£33.35
XQ43W	ExtragainXG14 GroupA	£51.95
XQ44X	ExtragainXG14 GroupB	£51.95
XQ45Y	ExtragainXG14 GrpC/D	£51.95
XQ46A	Extragain XG14 Wdbnd	£51.95
XQ50E	Extragain XG21 Wdbnd	£69.95
YM56L	Hi-Tech TV Aerial	£13.75
XQ51F	Super-Set Top	£10.95
XY30H	Toptenna	£5.75
XJ74R	Loft/Out DIY Aerial	£16.50
XQ52G	Caratenna	£12.95

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XJ75S	Caravan/Boat Aerial	£20.95
BW42V	Univ. Clamp Type 1	£1.95
XQ54J	Mast Bracket Type 8	£14.95
BW44X	Mast Bracket Type 14	£4.25
BW45Y	Loft Bracket	£2.75
XQ55K	Lashing Kit Type 4	£10.95
XQ57M	Lashing Kit Type 7	£20.50
XQ58N	Lashing Kit Type 9	£14.50
XQ60Q	Mast D	£4.80
XQ63T	Mast M	£7.50
‡XQ61R	Mast E	£8.95
‡XQ62S	Mast G	£21.95

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BW46A	Masthead UP1300/W	£16.95
BW49D	Masthead UP1300/V	£16.95
YN41U	3 Outlet Amp Kit	£40.95
YX73Q	Indoor Amp XB1	£27.75

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YP59P	Aerial Amp 22.5dB	£40.95
YP41U	2 Outlet TV Amp	£15.95
YQ22Y	Xtra Set Amp	£26.75
YP42V	2 Outlet TV/FM Amp	£21.50
BK75S	Xtra Set 3 Amp	£31.50
YN42V	Xtra Set 4 Amp	£39.50

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BK76H	TV Amp XB12	£19.95
BW51F	Diplexer UF22	£8.50
BW52G	Splitter CS1000	£8.50
FE28F	Splitter CS3000	£9.75
YP57M	Aerial Combiner A/E	£10.95
YP58N	Aerial Combinr AB/CD	£10.95

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RK49D	6-Section Antenna	£1.70

AUDIO, VIDEO & COMPUTERS

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YW58N	BSR Drive Belt	£1.20

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HR13P	Ctrdg Sono 3549	DIS

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†FR48C	Record Cleaner	£3.95
FV36P	Record Clean Cloth	99p

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†YN97F	CD Cleaner	£7.95
†YN98G	CD Replacement Pads	£3.95
FD28F	CD Library Case	48p

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†YB56L	Tape Editing Kit	£4.95

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FD38R	Drive Belt 35mm	38p

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CT08J	TDK AD-60	DIS

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FE70M	Video Head 3HSS-N	DIS
FE71N	Video Head 3HSS-V	DIS

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YT33L	Printer Stand	£8.95

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YX87U	S/S D/D Disk 5.25	99p
YJ00A	10 S/S D/D Disk 5.25	£7.95
FT80B	D/S D/D Disk 5.25	99p
YJ70M	10 D/S D/D Disk 5.25	£8.95
FT81C	S/S Q/D Disk 5.25	DIS
YJ71N	10 S/S Q/D Disk 5.25	DIS
FT82D	D/S Q/D Disk 5.25	£1.45
YJ72P	10 D/S Q/D Disk 5.25	£12.95
FT83E	S/S D/D Disk 3.5	£1.99
YJ73Q	10 S/S D/D Disk 3.5	£16.95
FT84F	D/S D/D Disk 3.5	£1.99
YJ74R	10 D/S D/D Disk 3.5	£18.95
JC26D	D/S H/D Disk 3.5	£6.95
YP88V	10 D/S H/D Disk 3.5	£47.95
FD27E	D/S H/D Disk 5.25	£1.99
YM82D	10 D/S H/D Disk 5.25	£18.95

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YM84F	3.5in. Library Case	£2.25
YM83E	5.25in. Library Case	£2.45

BATTERIES & POWER SUPPLIES

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FK62S	Zinc Chloride K9VHZ	TEMP

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YJ65V	3Ah Lead Acid Bat 4V	£9.15
YJ66W	1Ah Lead Acid Bat 6V	£6.50
YJ67X	1.2Ah Ld Acid Bat 6V	£8.40
YJ68Y	2.6Ah Ld Acid Bat 6V	£8.80
XG70M	4Ah Lead Acid Bat 6V	£11.45
XG71N	6Ah Lead Acid Bat 6V	£12.60
XG72P	8Ah Lead Acid Bat 6V	£13.00
XG73Q	10Ah Ld Acid Bat 6V	£15.30
YJ69A	1.2Ah L/Acid Bat 12V	£13.40
XG74R	1.9Ah L/Acid Bat 12V	£17.20
XG76H	4Ah Ld Acid Bat 12V	£21.80
XG77J	6Ah Ld Acid Bat 12V	£26.40
XG78K	15Ah L/Acid Bat 12V	£44.80
XG79L	24Ah L/Acid Bat 12V	£51.30
XG80B	38Ah L/Acid Bat 12V	£78.55

BOOKS

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RL27E	Book NB147	£9.95 *NV*
RL31J	Book NB157	£6.95 *NV*
WP76H	Mastr Electrical Eng	£4.50 *NV*

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†XW64U	Book NB449	£6.95 *NV*
WP82D	Electronics	£5.35 *NV*
WK61R	Electrnics for Techs	£8.95 *NV*

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WP05F	Pract Electronics	£8.95 *NV*
WS19V	Intro Elect Circuits	£11.95 *NV*
WP09K	Elec Syst & Tech	£7.95 *NV*
WS12N	Radio Communication	£11.35 *NV*

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WS06G	Tol Design Ccts	£19.95 *NV*

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WP40T	Linear IC Equivlnts	£5.95 *NV*
XW56L	Book FT1037	£14.95 *NV*

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WP55K	PE Microproc Handbk	DIS
RR28F	Book NB2028	£18.50 *NV*
WA29G	Book BP88	£2.95 *NV*

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WK63T	Make And Design PCBs	£2.50 *NV*
WA53H	Book BP110	£2.50 *NV*

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WP50E	Intro Electronics	£3.50 *NV*
WM60Q	Mastering Electronic	£4.50 *NV*
XW63T	Book JM671	£4.75 *NV*
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WG86T	Book BP98	£2.95 *NV*
WA36P	Book BP103	DIS

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WG60Q	Book BP95	£2.95 *NV*
WG72P	Book BP93	DIS
WA49D	Book BP104	£2.95 *NV*
WG54J	Book NB535	DIS
RB10L	Book NB269	£9.95 *NV*

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RQ30H	Book NB353	DIS
WG43W	Book BP87	£1.35 *NV*

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WG46A	Book BP90	£2.50 *NV*
WP51F	Audio Projects	£8.95 *NV*

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WP87U	Radio Ams Exam Manul	£5.00 *NV*
WA37S	Book BP105	£2.50 *NV*

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WG95D	Book FT1305	DIS
XW43W	Book NB467	£9.95 *NV*
WS18U	TVI Manual	DIS

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WG89W	Book NB132	£10.95 *NV*

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WP52G	Service Persnl Comps	£20.00 *NV*
WM32K	Micro Introduction	DIS
RQ02C	Book Sybex C207	£20.95 *NV*

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XW80B	Book C202	£21.95 *NV*
WK30H	Programming 6809	£17.95 *NV*

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WM76H	Programming M68000	£14.95 *NV*
XW72P	Book C280	£23.95 *NV*

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WA40T	Your Atari Computer	£22.95 *NV*
WM75S	Mstr Mem Map CBM64	DIS

BOXES

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FD96E	Potting Box Cube	22p
LH56L	Potting Box Min	18p
LH57M	Potting Box Small	24p
FD97F	Potting Box Medium	28p
FD98G	Potting Box Ex Large	40p

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LL00A	Verobox 103	£5.95
LQ03D	Flip-Top Box 601 Blk	£3.60

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XY19V	Laminate Alum Small	£1.85

CABLES

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XR20W	Lapped Pair	24p
PB18U	100m Lapped Pair	£15.95
PA91Y	100m Fleximic Orange	TEMP
XR90X	HD Fleximic	45p
PB39N	100m HD Fleximic	£29.95

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FP21X	50 Pk Small Base	£3.95
FP22Y	50 Pk Large Base	£4.45
FP23A	50 Pk Screw Base	£1.45

CAPACITORS

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WW44X	Poly Layer 0.18	30p

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FA25C	Memcap 1F 5.5V	£4.98
FP87X	Ceramic Trimmer 5pF	£1.75
FG75S	AM/FM Varitune	DIS
†FT78K	Min AM Tuner Cap	98p

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HX60Q	Crystal Socket 25u	55p
HX61R	Crystal Socket 6u	75p

COMMUNICATIONS

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YG16S	Mag Mount	DIS

CONNECTORS

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YX48C	Comcon Terminal	8p

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QY73Q	Polarising Key IDC	9p

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HH88V	Cassette Skt Paros	DIS

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BK97F	PC Edgconn 2x20 way	£2.40
RK35Q	PC Edgconn 2x23 way	£2.65
FA87U	PC Edgconn 2x25 way	£3.25
FG23A	PC Edgconn 2x28 way	£3.45

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†FL30H	Edge Conn Silver	£1.98

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FE84F	TNC Male/UHF Fem	£2.20

ELECTRICAL ACCESSORIES

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JC27E	Simplicity Plug	DIS

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HL58N	Rubber 13A Plug	£1.20
JG35Q	Triple Skt Unswtched	£7.50
HL71N	Single Sw Socket	£2.70
XJ83E	Single Sw Skt 10pk	£19.95

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JG40T	Metal Single Sw Skt	£5.25
HL72P	Double Sw Socket	£5.50
XJ84F	Double Sw Skt 5pk	£21.95
HL83E	Switched Flex Outlet	£4.80
HL86T	Blanking Plate	85p
HL87U	20A Plateswitch	£3.50
JG30H	20A Neon Plateswitch	£4.95

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HL89W	Light Swch ST Single	£1.40
XJ85G	Light Sw ST 1W 10pk	£10.95
JG39N	Metal Light Sw DT	£3.50
XJ97F	Mtl Light Sw DT 5pk	£14.95
HL91Y	Light Swch Dual	£2.85
HL92A	Light Switch Triple	£3.95
FQ12N	250W Push Dmr Sngl	£8.95
JG31J	Metal Box 16mm	65p
XJ88V	Metal Box 16mm 20pk	£10.50
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XJ89W	Metal Box 25mm 10pk	£5.95
JG33L	Metal Box 2-way 25mm	£1.10
XJ90X	Metal Bx 2w 25mm 5pk	£4.50
JG34M	Metal Box 2-way 47mm	£1.98

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YP99H	Patt 20mm Sngl 10pk	£6.45
YB15R	Sur Patt 29mm Sngl	85p
XJ91Y	Patt 29mm Sngl 10pk	£6.95
XJ92A	Patt 29mm Dble 5pk	£6.50
YB17T	Sur Patt 47mm Dble	£2.85
YB18U	Conversion Pattress	£2.70
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FQ02C	BC Lampholder	95p
FQ05F	Ceiling Rose	£1.20
XJ86T	Ceiling Rose 10pk	£9.50

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YB19V	24 Hour Timeswitch	DIS
YK57M	7 Day Timeswitch	DIS

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YT07H	Spkr/Phones Kit	DIS

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FD10L	6BA Tapped Spacr 1/4	98p
JG20W	6BA Tapped Spacr 7/8	£1.95

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FW60Q	Grommet Large	3p

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HK81C	EE-1001 Passive Crs	DIS
HK82D	EE-1002 Transtr Crs	DIS
HM05F	EE-1003 Anlg Dsn Crs	DIS
MD55K	EE-1004 Dig Circuits	DIS

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HK65V	EE-3403A Synth Cours	DIS

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†HM15R	EC-2001 Cmptr Fndmnt	£44.95

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†MD26D	EC-2002 Cmptr Prphrl	£49.95
†MD31J	EC-2003 Cmptr Mntnce	£39.95
HK86T	ET-100 16-Bit Trainr	DIS

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HK20W	ETS-18 Hero 1 Robot	DIS
HK21X	EE-1800 Robotics Crs	DIS

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HE96E	IM-4180 FM Dev Meter	DIS

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†FE12N	Knob PK0	60p

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YR65V	Knob K8B	85p
†HB35Q	Knob K106L	£1.50
†HB33L	Knob K106	£1.40

MUSICAL & EFFECTS

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†YP49D	Guitar Amp + Pre-amp	£19.95

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YB40T	Cry Guitar Pick-Up	TEMP

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AF98G	DE1400 Digital Delay	DIS

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†YM89W	Hi-Z I/P Springline	£9.95

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XB04E	Earth Bar	TEMP
BH63T	Keyboard Spacer	3p

OPTO-ELECTRICAL

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UF90X	Min Cliplite Amber	15p
UF91Y	Min Cliplite Clear	15p
UF92A	Min Cliplite Green	15p
UF93B	Min Cliplite Red	15p
UF94C	Min Cliplite Yellow	15p
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YH55K	Cliplite Green	15p
YH56L	Cliplite Red	15p
YH57M	Cliplite Yellow	15p
UF95D	Square Cliplite Red	15p

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YH71N	Photodiode TIL100	TEMP

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BL23A	Solar Cell MS4A	DIS
QY82D	Infrared Sensr TIL81	£1.45

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XR56L	1mm Light Guide	95p

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FD87U	15mm LCD DPM	DIS

PCB EQUIPMENT

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FL09K	Vero 10347	£1.95
FL10L	Vero 10348	£1.50
FL53H	Vero 10401	£3.80

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YJ98G	Pos Photores Spray	£2.95
YM62S	Pos Photores 200g	£5.80
YJ38R	Photoresist Developr	£2.70

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YJ45Y	PCB Cleaner Aerosol	£2.10
YP73Q	-70/+125 Conformal	£5.10
YP74R	-70/+300 Conformal	£4.85
YT50E	HPA Conformal Coat	£4.95
YT49D	Peelable Coat 35ml	£1.60
YT48C	Peelable Coat 250ml	£4.15

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HX04E	Polish Block	£1.75
BW21X	Track Tape 31	£1.50
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PROJECTS & MODULES

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LW73Q	RTX3 Doppler Kit	£44.95

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LW97F	Panic Button Kit	£4.45

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GB69A	Gas Detector PCB	£1.95
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LK57M	Musical Announcr Kit	£14.95
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GD13P	Lead Acid Bat Chrger	£1.35

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GA74R	Train Receiver 1 PCB	£1.49
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GA23A	Strobe HT PCB	£1.35
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LK61R	4 Ch Servo Cntrlr Kt	£19.95

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GB67X	RTTY Terminal PCB	£9.45
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FP58N	Screening Can Low	68p

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BW11M Latchsoft 2-pole DIS
FH74R Mains Latchswitch TEMP

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FH37S Mains Push DIS

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JL63T Resistance Box £89.95

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†YM68Y Function Gen MG205 £119.95

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YK38R Low-Cost Counter DIS
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†JG25C Temp Clock White £9.95

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FP64U Min/Max Temp Module £7.50

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XX05F UHF Modulator UM1111 £7.95

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The following list of items have been introduced since publication of our 1989 catalogue, it excludes new items in this issue.

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WS19V Intro Elect Circuits Price £10.95 NV
WS20W Art of Electronics Price £20.00 NV
WS21X Data Book CMOS 4000 Price £5.00 NV
WS22Y Audio Ccts Manual Price £10.95 NV
WS23A Remote Control Handbook Price £3.95 NV
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LM90X Wind Hardware Kit Price £29.95
LM95D RTTY Demod Kit Price £16.95
XM13P 1kW Mosfet Amp Case Price £59.95
XM17T IC Tester Assm Price £129.95
YT63T 4 Way SP Switch Box Price £14.95
YT64U Modulator Box Price £5.95
YT67X Top Housing Price 80p
YT68Y Bottom Housing Price 80p
YT69A Pointer Shaft Price 95p
YT70M Mounting Bar Price £3.45
YT71N Wind Cups Price 50p

WOUND COMPONENTS
UK80B Choke 4.7mH Price 68p
UK81C Sensor OPB706B Price £2.15

Weather

Station

by Dave Goodman

Introduction

This project decodes the variable frequency and four bit binary outputs from the wind speed and direction indicators that were published in the April-May edition of 'Electronics', and displays the result. Wind direction is represented by a ring of 16 LED's, for 22.5 degree resolution, and 'electronic damping' is incorporated to stabilize the display during turbulent weather conditions. Wind speed is represented on an analogue meter which has a special scale calibrated in both MPH and KNOTS. The scale is calibrated to display 0 to 100 MPH (0 to 87 KNOTS) and 0 to 25 MPH (0 to 22 KNOTS) using the divide by four scaling switch.

The kit contains all items necessary to build the module and a smart case is available separately, to house the project. In the optional case panel, provision has been made for fitting of a clock and temperature module so that both inside and outside temperatures (in degrees C or F) and the current time can be logged. The pre-punched and screened base panel is manufactured from dark red, translucent plastic (also an optional item which replaces the larger metal panel normally supplied with the case) which allows the LED's to be seen once they are illuminated.

An eight bit bus output is provided for wind speed and also a four bit bus, for wind direction. This facility allows for the decoder module to be connected to computers having suitable parallel bus inputs and for the data to be entered into your own programs as required.

Circuit Description

Full details covering construction and operation of the speed and direction sensors can be found in issue number 31 (as already mentioned), with the exception of the wind speed verses frequency graph which is shown here in Figure 1. The sensor output frequency is directly proportional to the cup rotation speed and, therefore, linear in performance; that is apparent from the $y = mx+c$ straight line response. Data for the graph came from taking many hundreds of sample readings over many months, in all different weather conditions, comparisons being made against known calibrated systems. Other well known methods entailed fitting the anemometer above a car roof and sample readings taken (not by the driver I hasten to add!) in different conditions and environments. The final results are an average of the data and at extreme ends of the scale, are likely to be inaccurate, e.g. below 5 MPH and above 70 MPH.

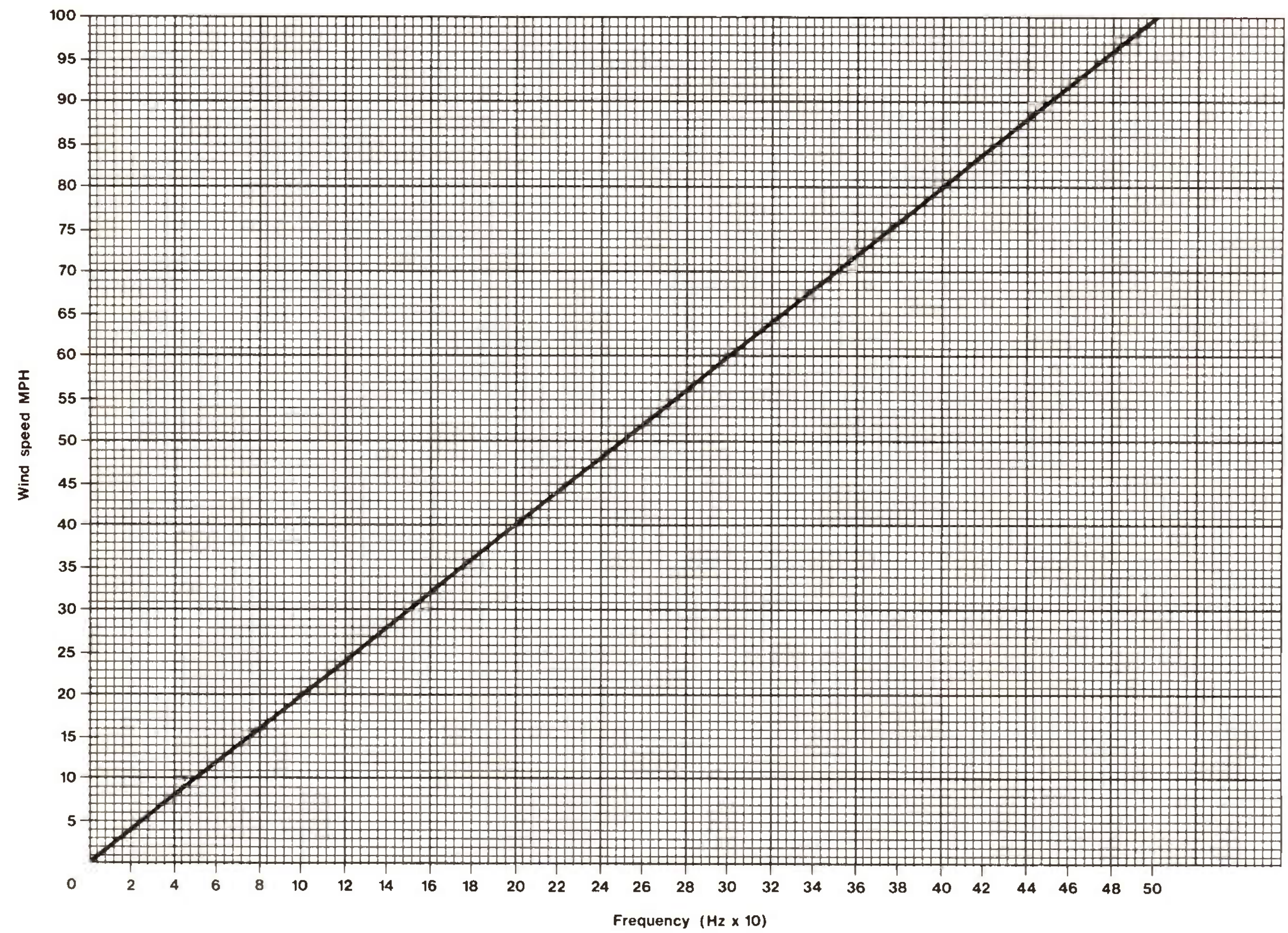
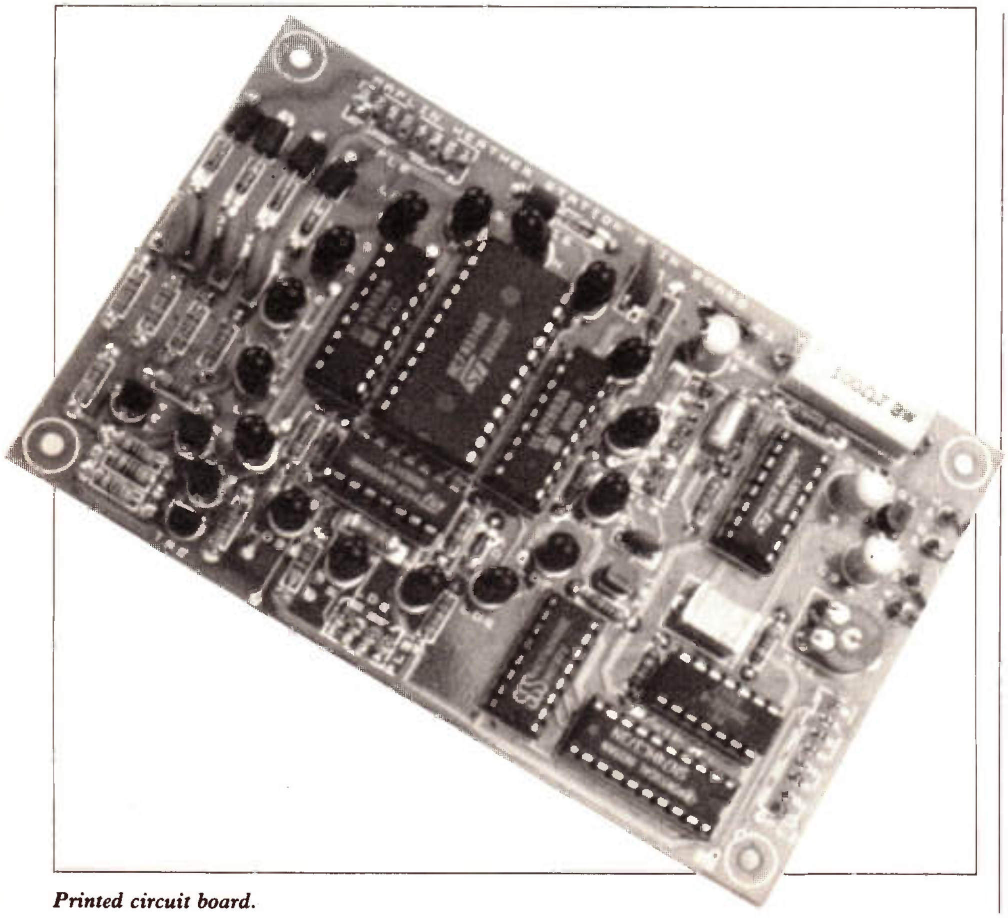


Figure 1. Wind speed verses frequency.



Printed circuit board.

Figure 2 shows the full circuit diagram for the decoder module. The 5V DC power rail is derived from a regulator IC and input voltages from 7.5V to 15V DC can be connected to pins P1 and P2. Power is also supplied to the sensors from pins 1 and 7 on PL2. Latched wind direction data is connected to pins 3 to 6 on PL2 with the least significant bit (1) at TR2 and the most significant bit (8) at TR5. RF filtering in the form of ferrite beads and 1000pF capacitors has been added to reduce RF interference pick-up from using long connecting wires. Transistors TR2-5 buffer the incoming code which is then re-inverted and shaped by the schmitt triggers IC1 A-D and are connected to a 4 to 16 line decoder IC2. The schmitt outputs are also made available for external connection at PL3 pins 1-4. IC2 decodes the 4 bit binary pattern into 1 of sixteen outputs, only one output is active at a time, which is then buffered by drivers IC3-4 and operates one of the common anode direction LED's LD1-16.

The remaining input circuitry on PL2 pin 2 connects to the wind speed sensor, and functions in exactly the same manner as the other four input buffers. TR1 output clocks the input of a 12 stage binary counter, IC5, so that the eight outputs, Q0 to Q7, generate a new binary code after each reset pulse that appears on pin 11.

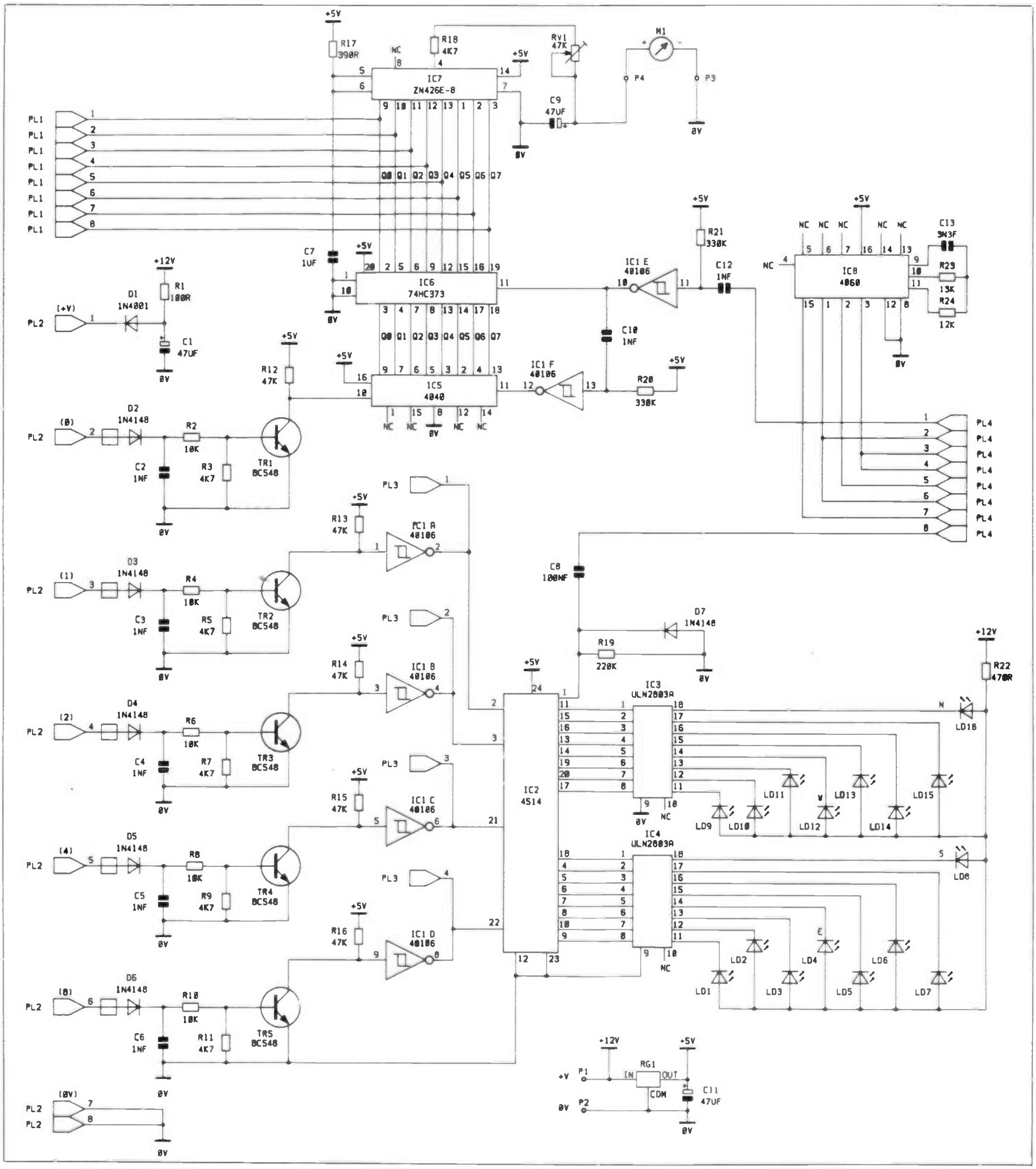


Figure 2. Circuit.

This data is then latched by IC6 before conversion in D/A converter IC7. IC8 is the master clock, running at a frequency of 8.5kHz, with divider timing outputs as follows:

IC8 pin	Frequency (approx.)
15	8.5Hz
1	2.2Hz
2	1.1Hz
3	0.5Hz

Timing outputs are used for resetting and latching the code generator, via IC1

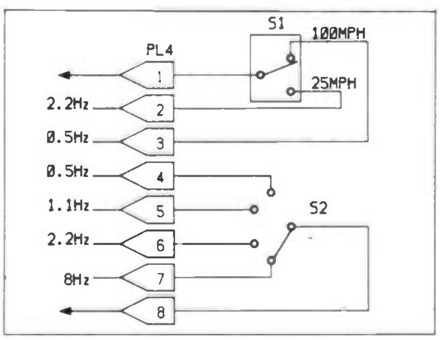


Figure 3. Timing outputs.

E-F, and toggle switch S1, see Figure 3. With S1 set for 0.5Hz sample rate, the meter M1 is scaled for 0 to 100 MPH and with a 2.2Hz sample rate the scale is 0-25 MPH. Bus inputs to IC7 need to be relatively stable between latch (sample) pulses, otherwise the meter pointer will increment up and down in small steps; R18 and C9 form a very-low-pass filter which removes small step pulses and gives M1 a smooth response. Fine calibration is made by adjusting RV1 – more on this later on.

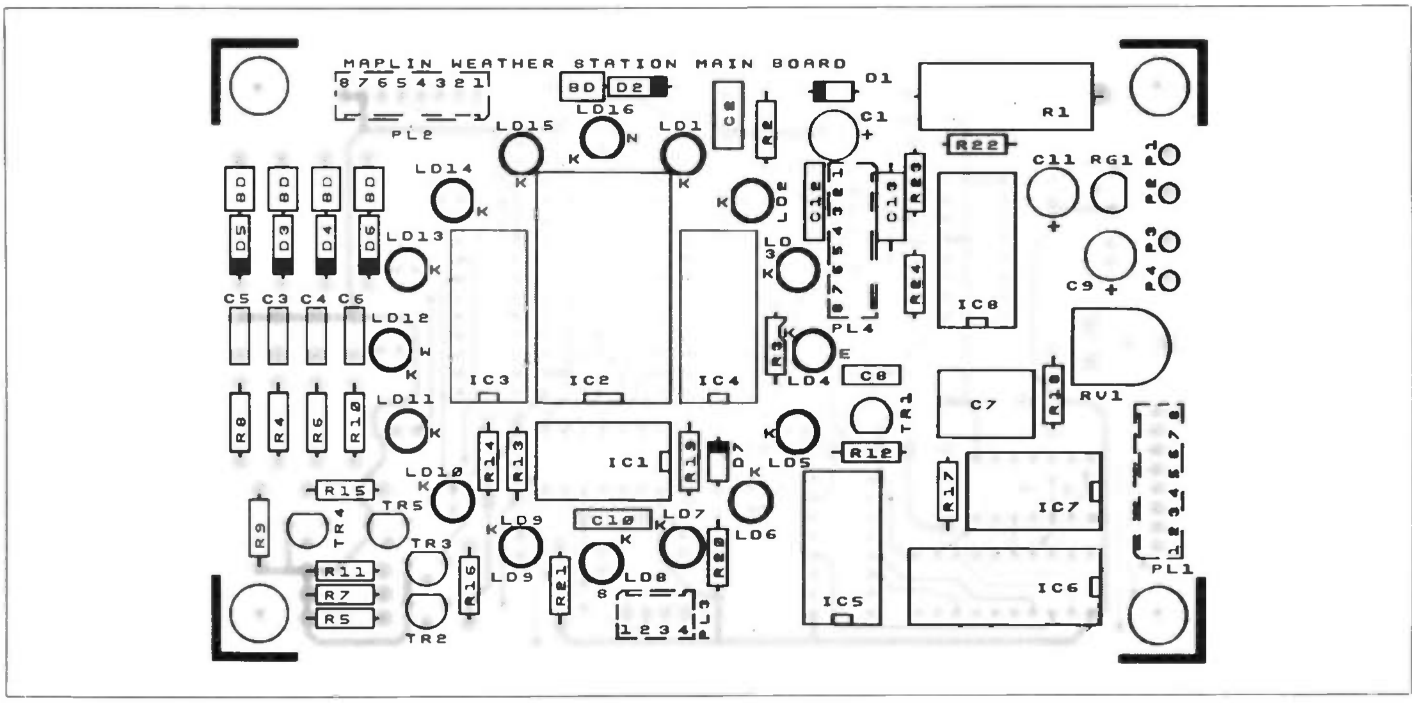


Figure 4. PCB layout.

PCB Construction Notes

Refer to Figure 4 and the Parts List and identify the components to be used. I would suggest that resistors are fitted first, followed by IC sockets, transistors and capacitors. Either solder each component in as you go, or solder components in a group; this helps reduce errors and produces a neater finish.

The five input diodes, D2-6, require a ferrite ring to be placed over each anode lead, as shown in Figure 5; take care not to bend the leads too close against the glass envelope!

Mount the LED's so that they stand vertical and no more than 15mm above the PCB, as shown in Figure 6. Sleeving is supplied to assist in this exercise and sixteen pieces should be cut 6mm long; check the LED body length first as dimensions given allow for 9mm and sizes may vary. With reference to Figure 4 you will note that the cathodes (K) of each LED have been positioned around the inner side of the circle!

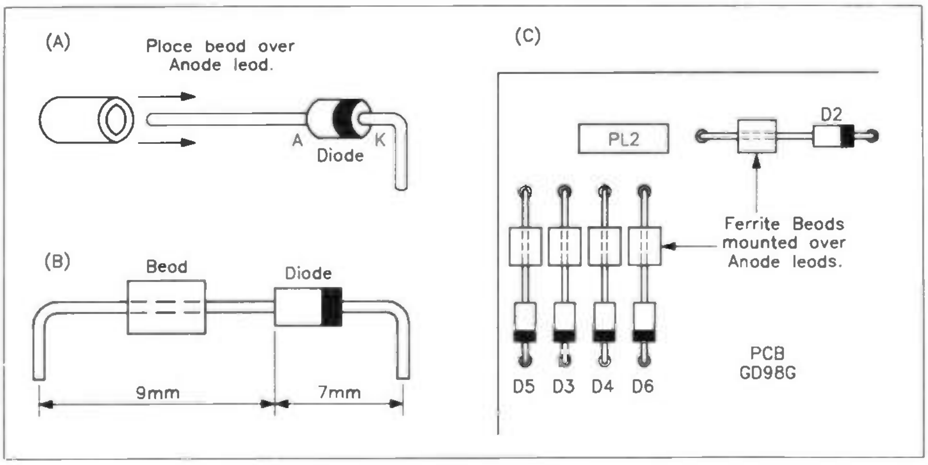


Figure 5. Fitting ferrite beads.

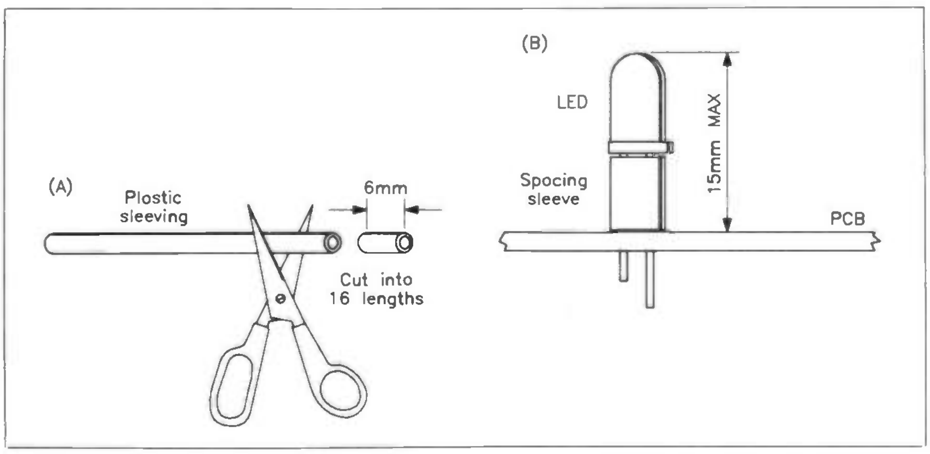


Figure 6. Fitting LEDs.

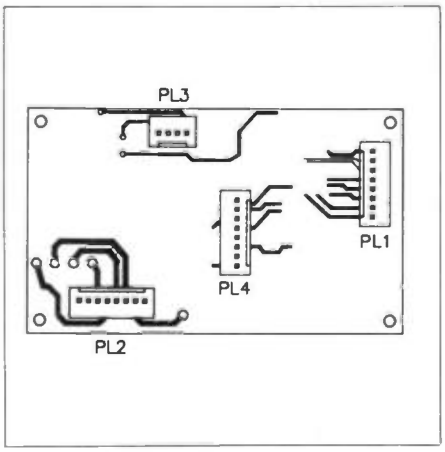


Figure 7. Fitting plugs.

Once all components, sockets and LED's have been mounted and soldered, cut off the excess component wires and inspect the assembly. Insert the IC's into their sockets and finally, fit the connector plugs. Note that the Minicon plugs are mounted onto the PCB from the TRACK side and NOT from the usual component side, see Figure 7, therefore they should be soldered on the component side of the PCB only.

The Terminator

Switches S1 and S2 are connected to the PCB using an 8-way minicon socket and 10 way ribbon cable. Remove two

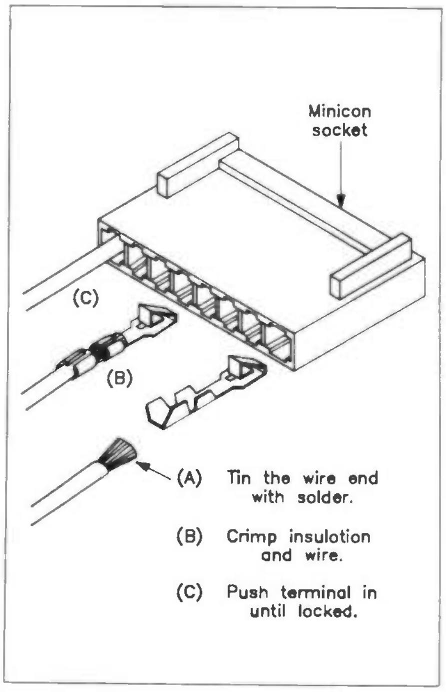


Figure 8. Terminating wires.

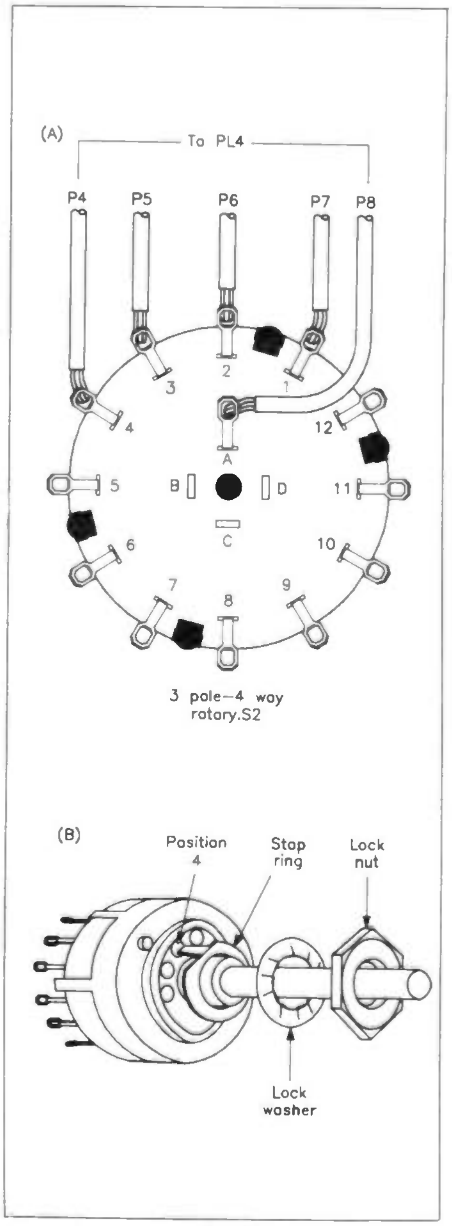


Figure 9. Damping switch S2.

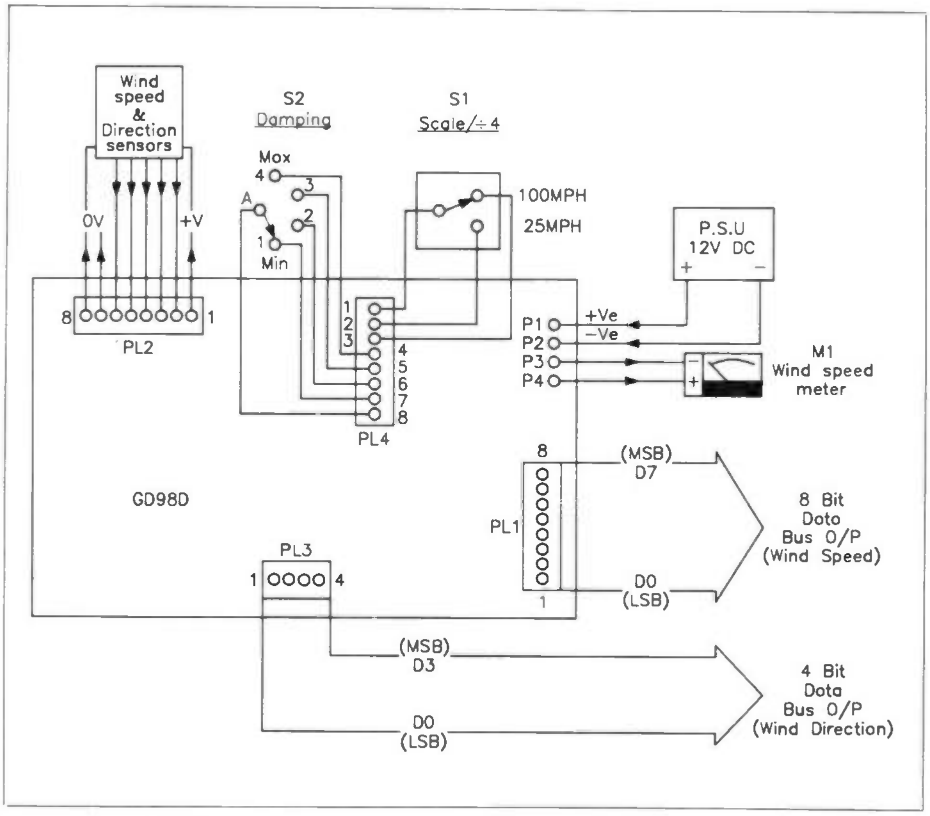


Figure 10. PCB connections.

wires from the ribbon, leaving eight to be fitted with a terminal and crimped with pliers as shown in Figure 8. It helps to lightly tin the bared wire-end before crimping, which then facilitates soldering if you are unable to crimp the wire properly. The remaining two wires are used for connecting the meter M1 to the PCB. Solder the other end of the ribbon to S1 and S2 as shown in Figures 9 and 10 – colour coding is left to your own choice – and note that the connections in Figure 10 are shown from the component side of the PCB.

Connecting details for the 6-way multicore sensor cable are given in Figure 11. These wires are much thinner than ribbon cable, therefore extra care should be taken when fitting terminals; the screening braid connects to 0V pins 7 or 8 on PL2.

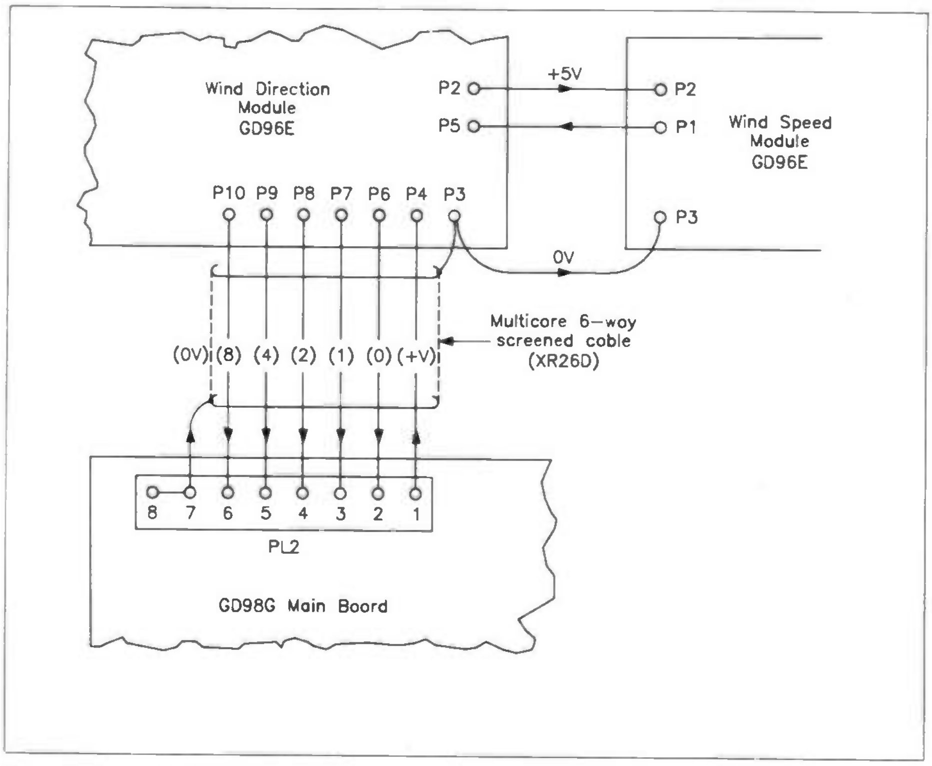


Figure 11. Sensor wiring.

De-Scaling

The meter supplied in the kit is scaled for current measurement and needs to be changed for this application. First, cut out the scale by removing the un-wanted outer card – see Figure 12 – and gently prise off the transparent plastic cover from the meter, Figure 13. Great care has to be taken when performing these operations as it is very easy to damage the pointer and movement. Apply impact adhesive, such as the Maplin FL44X, to the back of the scale card and carefully slide over the old meter scale and underneath the pointer, as shown. Ensure accurate alignment with the case edges before re-assembling the meter panel. Pointer zeroing is performed from the outside by turning the plastic adjuster with a screwdriver. Zero accuracy is dependent on the orientation of the meter, therefore 'fine' adjust the pointer after the meter has been fitted into the case.

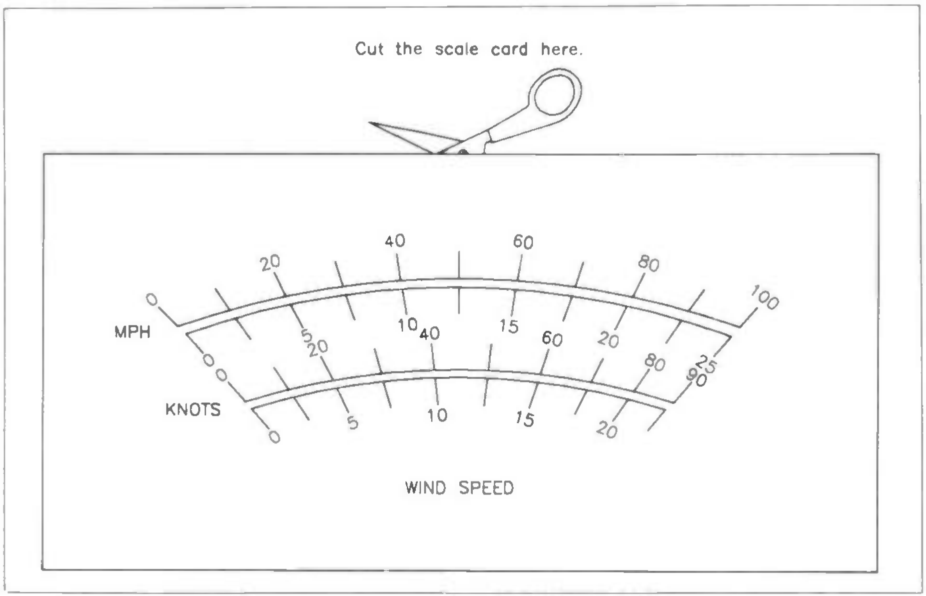


Figure 12. Scale.

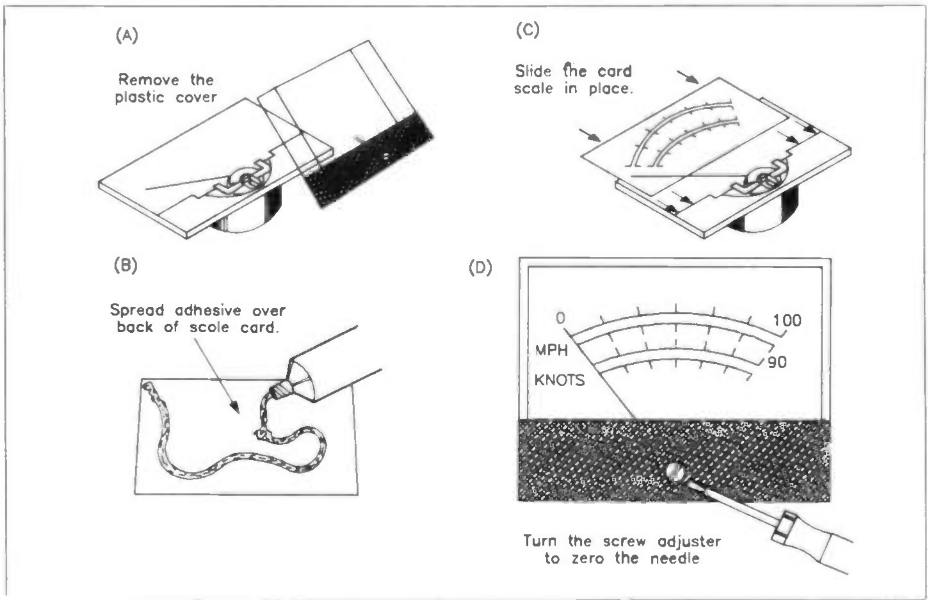


Figure 13. Fitting the scale.

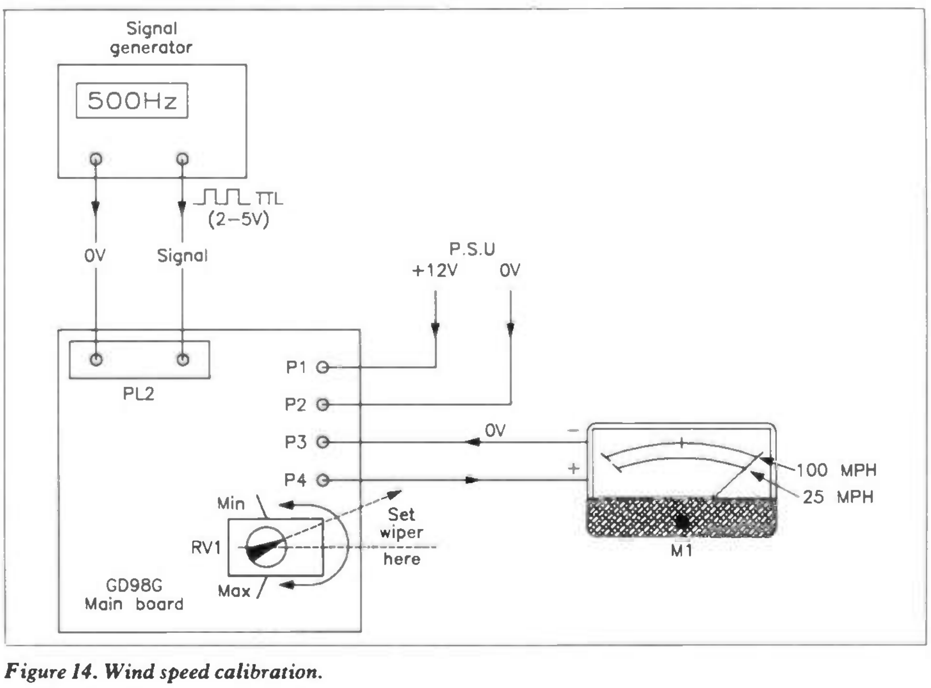


Figure 14. Wind speed calibration.

Testing

A power source capable of producing 7.5 to 12V DC at 100mA is required to be connected with +V to pin 1 and 0V to pin 2, see Figure 14. Use the ribbon cable remnant to wire pin 3 to M1 -V and pin 4 to M1 +V. Insert the previously wired S1 and S2 socket onto PL4 and switch on. LD16 should be lit and monitoring the +V supply rail with an ammeter should produce a current reading of 25mA for a 7.5V supply or 35mA for 12V supply – approximately.

With the fully working wind speed and direction system connected, the average current should approximate 65-70mA.

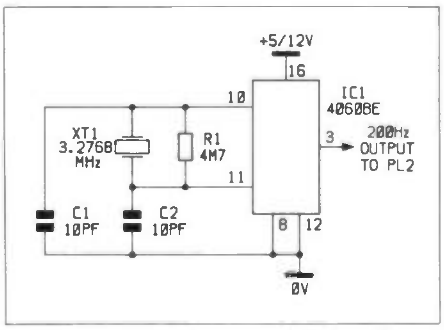


Figure 15. Calibration circuit.

Switch off the supply and if you possess a pulse or function generator, then set up a 500Hz TTL square wave (5V) and connect the signal to PL2 pin 2 and 0V (pin 7 or 8). Alternatively, the calibration circuit shown in Figure 15 could be built for this purpose. Using a 3.2768MHz crystal the divide-by-14 output (16384) pin 3 generates a 200Hz signal or 400Hz from the divide-by-13 pin 2, either of which can be used for setting up the meter. To begin with, position the meter facing upward and zero the pointer with the screw adjuster. Turn on the power and with S1 set for '100MPH' (PL4 pin 1 to pin 3) turn RV1 until M1 displays 100MPH or 80MPH for 400Hz (40MPH for 200Hz) – see graph. The preset wiper should end up around the half way position. Turn off the supply, disconnect the wiring from M1 and continue with the main assembly. Note that a hole has been added beneath RV1 and this makes further adjustment possible after mounting the PCB onto the plastic panel.

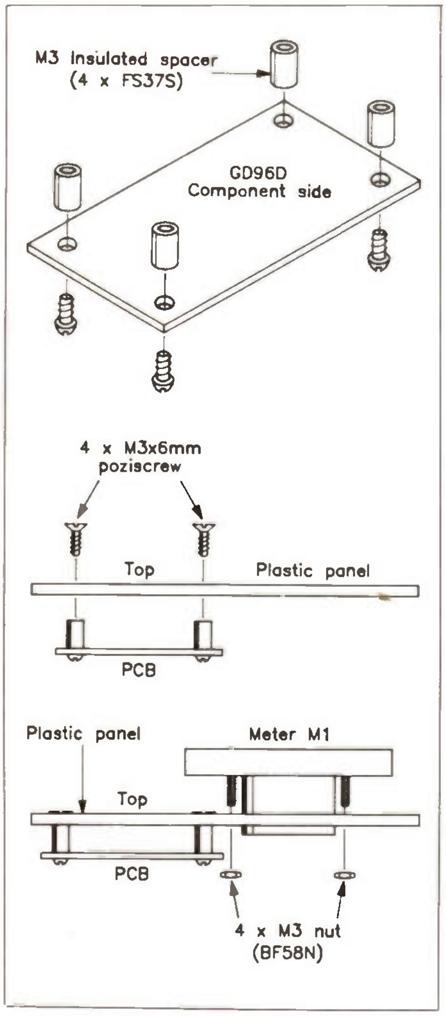


Figure 16. Main panel assembly.

Main Assembly

Mount the module onto the plastic main panel using 4 insulated 15mm spacers, see Figure 16. Fit the spacers onto the plastic panel using 4 x M3 poziscrews instead of the panel screws supplied. Mount the meter onto the panel and hold in place with 4 x M3 nuts. Do not overtighten either the screws or nuts or the plastic is likely to crack! Re-connect the wiring from meter to PCB.

Rotary switch S2 and toggle switch S1 are mounted onto the pre-punched panel shown in Figure 17. It may be necessary to cut off the locating spigot from S2 if it fouls the panel and the spindle should be cut to a suitable length for the pointer knob.

Before the temperature module can be mounted, the battery (if fitted) and both fixing screws will have to be removed, see Figure 18. Position the bezel over the module display and fit into the panel as shown; secure with 4 x 8BA x 0.5 inch bolts, which self-tap into the four corner holes. Sufficient space is available on this panel for fitting switches associated with selecting the various functions on the temperature module, e.g. clock, temperature in C or F, or time set. Further information on facilities is supplied with the module. Please note that this particular module is a product and not a kit.

Lastly, secure the panels into the case with the hardware supplied, both brushed aluminium panels are not now required, and assemble both halves of the case. External wiring connections can be taken through holes or slots cut into the rear of the case as required.

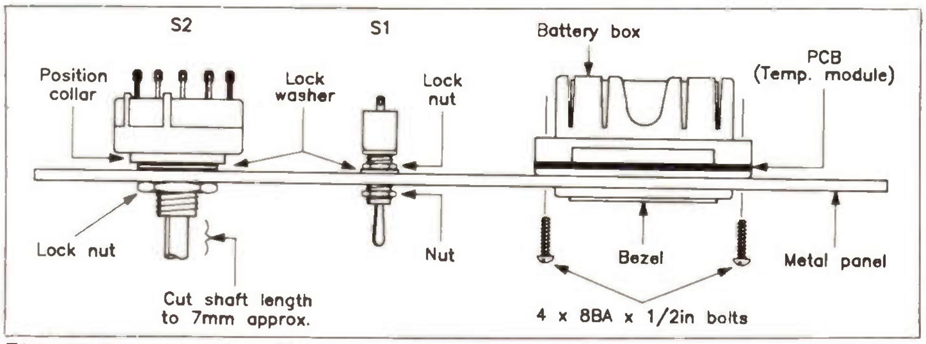


Figure 17. Metal panel assembly.

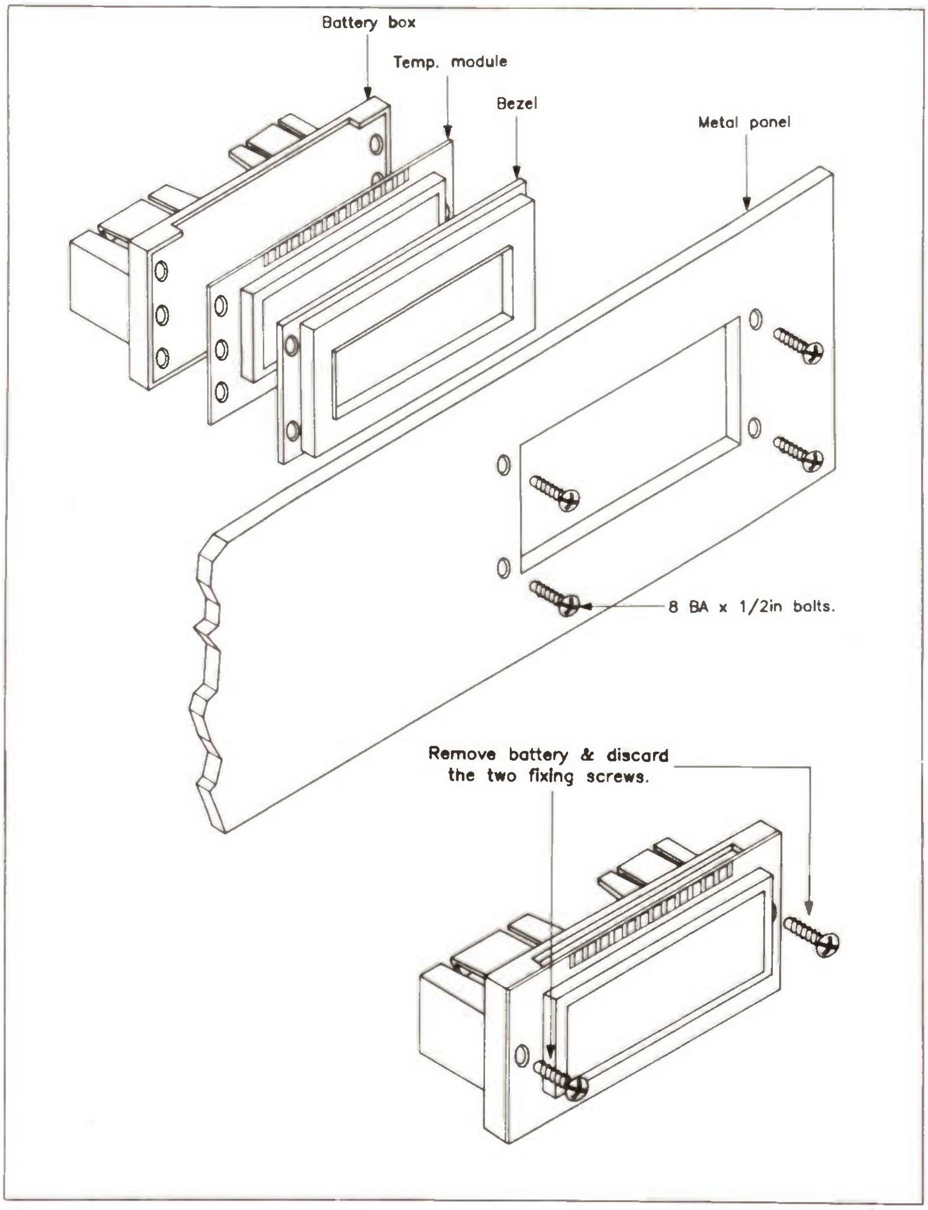


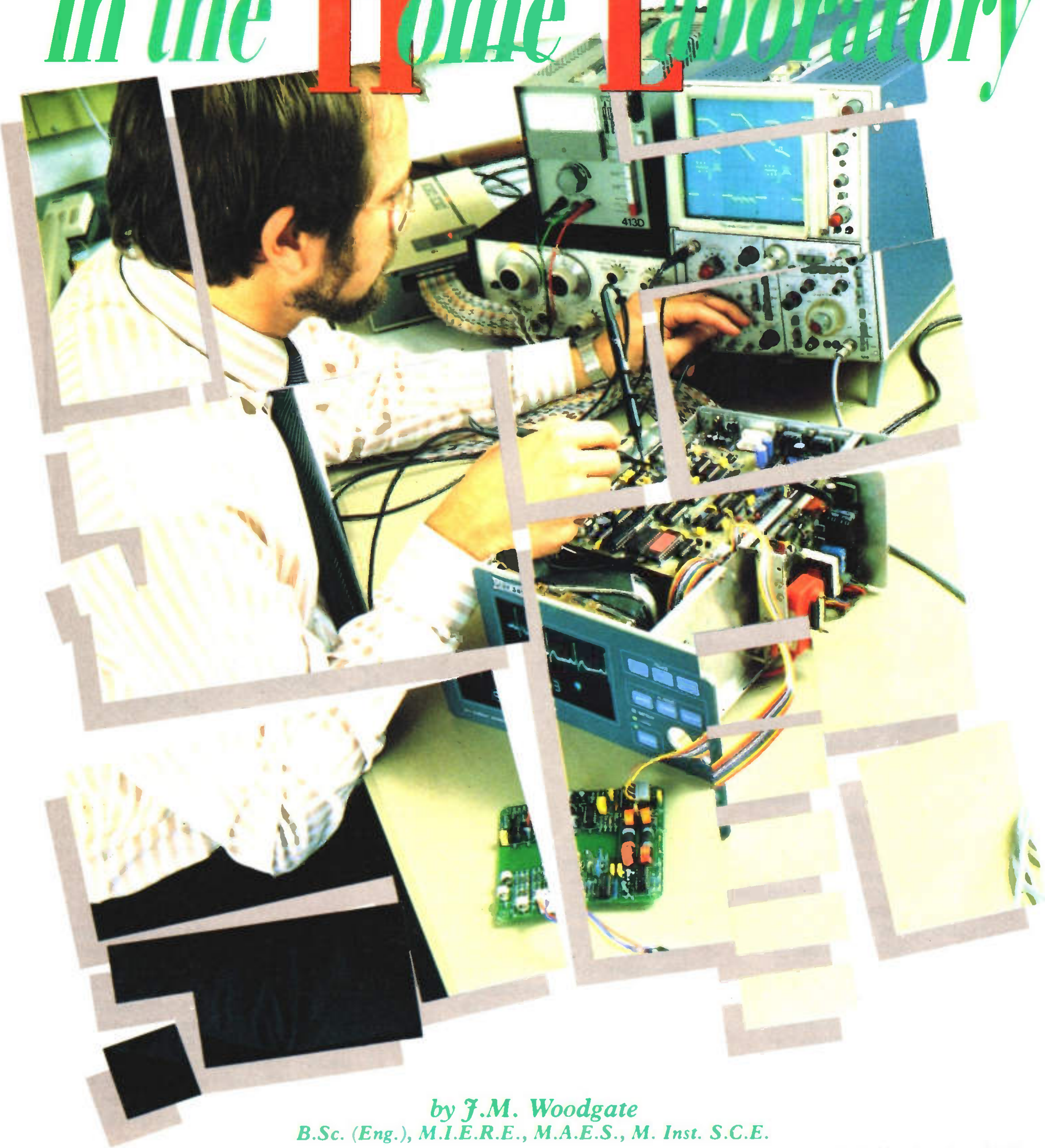
Figure 18. Fitting temperature module.

Finally

The LED's should be clearly visible through the red panel and you will need to set the wind direction pointer to North and turn the code disc until LD16 is on. Set the rotary switch S2 fully anti-clockwise and spin the pointer; the LED's will come on sequentially. Turn S2 to the next position and spin again; you will see the effects of the slower sample rate. This 'damping' is quite effective when windy conditions cause the pointer to swing erratically.

Continued on page 47.

Frequency Measurement in the Home Laboratory

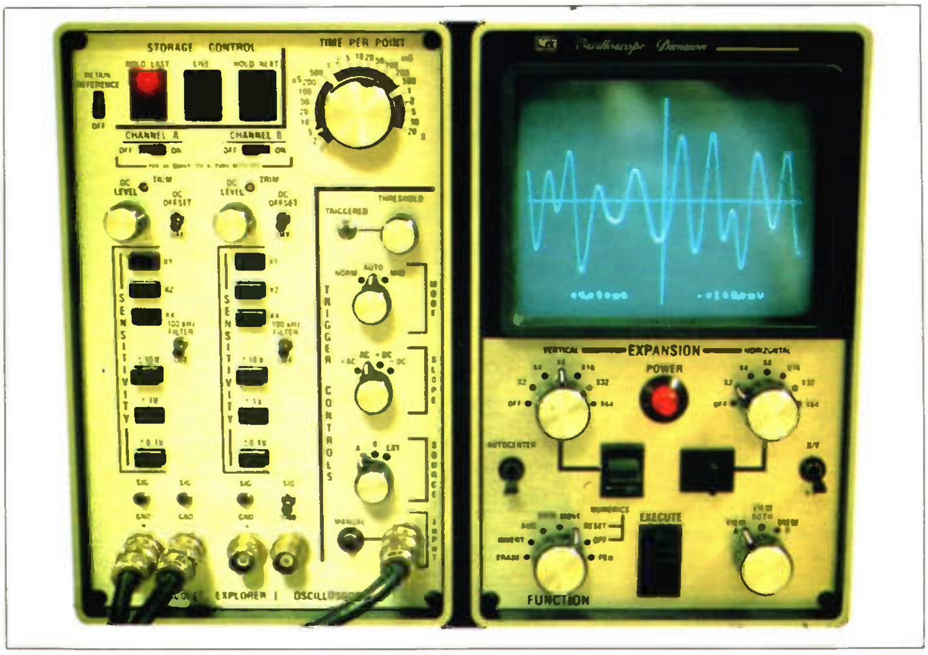


by J.M. Woodgate
B.Sc. (Eng.), M.I.E.R.E., M.A.E.S., M. Inst. S.C.E.

Measuring Frequency – You, Too, Can Do It!

Time is undoubtedly the most mysterious attribute of the Universe we live in. We all experience it, but its nature defies definition. While it is now generally accepted that it is, in fact, one of the dimensions of 'space-time', it is far from easy to explain why it behaves so differently from the 'space' dimensions. Frequency is the number of similar events that occur in a fixed period of time; for example, a 50Hz sine wave passes upwards through zero fifty times in a second. In doing so, it divides time into periods of 1/50 seconds, so that frequency can be regarded as the reciprocal of time.

Curiously, because we understand it so little, time is the physical quantity that we can measure most accurately – the present limit is somewhere in the region of 1 part in 10^{15}, (1 in 1 000 000 000 000 000) – and we can measure frequency just as accurately. But what can we use for a "ruler"?



A typical oscilloscope.

Standard Frequencies

We measure lengths by comparing them with 'standard' lengths marked on a ruler, and we can measure frequency by comparing the unknown frequency with a known one. There are lots of ways of doing this, as we shall see, but where do we get a known frequency from?

Starting at very low frequencies indeed, where at least several seconds elapse between each of the events we decide to use for the measurement, we could use a stop-watch, or a digital wrist-watch. A mechanical stop-watch has a balance wheel, normally oscillating at 0.2Hz, to provide the reference frequency, while digital watches usually have a quartz-crystal oscillator, operating at 32768Hz (2^{15}Hz). This is divided repeatedly by 2 to give a 1Hz signal, and then further divided, or counted, to give 'minute' and 'hour' indications. We could measure the 'frequency' of a timer that switches every 100s or so in this way. Exactly 100s between switchings would be a frequency of 0.01Hz or 10mHz (10 millihertz, not to be confused with 10MHz, 10 megahertz, which is a frequency 10^9, or a billion, times larger). This method is reasonably good down to time intervals of about 3s, below which the variation in human reaction-time seriously affects accuracy. Note that the reaction-time itself does not matter, because if it were constant it would affect each measurement equally, but the variation from event to event does matter.

Going up in frequency, we come to the first electrical standard frequency 'signal', supplied to practically every home by your friendly neighbourhood Electricity Board. Forty years ago, the mains frequency was subject to considerable variation, but nowadays it is normally held very close indeed to 50Hz, witness the fact that a mains-driven clock keeps good time. If the frequency were not closely controlled, the National Grid network could become unstable: this happened once and all the power to the south of England was cut off. In the USA, they had an even bigger blackout (of course!), for the same reason. Naturally, you won't use the mains voltage directly for any experiments, BUT ALWAYS USE AN ISOLATING TRANSFORMER. In any case, you only need a few volts at most for frequency measurements.

The next sources of standard frequencies are the 'tuning signals' of radio and television stations. The spread of 24 hour broadcasting, and Open University programmes at unsocial hours, has reduced the availability of these; in particular, the stereo test signals that used to be broadcast on Radio 3 have been dropped, and are unlikely to return. Still, tuning signals are sometimes broadcast; BBC1 and Radio 4 use a 1kHz tone, while other BBC channels use 440Hz. Some stations use 400Hz; it is not too difficult to confuse the last two, so be careful! You can also get cassette tapes with tone recordings, but these are of somewhat limited use due to the speed variations of the cassette player. Nevertheless, they can be used for some purposes.

Yet higher in frequency, we have 15625Hz, which is the line-scan frequency of 625-line television, and 32768Hz from the digital watch. The former can be picked up (all too easily!) on a piece of wire placed close to the television set, but NOT dangled through the vent slots, while the latter can be picked up in a similar way from a watch with a plastic case, although the signal will be quite weak. Depending on the construction of the watch, it might be possible to make direct contact with the circuit, but take anti-static precautions and DON'T connect straight across the crystal because it will be pulled off frequency and may stop oscillating altogether.

We are now well into usable radio frequencies (the lowest radio frequencies used are in the region of 9kHz, for communication with submerged submarines), and at 60kHz we have a standard frequency transmission from station MSF at Rugby. This carries modulation which gives very accurate time signals, but the carrier frequency itself is also very accurate indeed. Beyond this, and rather more accessible because components for receivers are readily available, is BBC Radio 4 on 198kHz (long wave). A simple 'straight' receiver is best, remembering that it is the CARRIER that we want in this case, not the modulation. It is, of course, possible to use broadcast transmitters up to about 26MHz, provided you can identify the transmitter and its operating frequency. The BBC and IBA produce free booklets giving the frequencies of their LF and MF broadcasting stations, and BBC World Service will provide information about HF transmissions. There are standard frequency transmissions, whose carrier frequencies are particularly accurate, at various frequencies in the HF band. Beyond that are CB radio channels: you can get a leaflet from the DTI giving the channel frequencies if you don't know them. There is then a gap, up to the Band 2 FM radio broadcasts. Don't worry too much about the frequency modulation; most of the methods of using these signals for measuring frequency are not badly affected by it. Above Band 2, there is a big gap before we come to the TV transmissions on Band 4/5. Above Band 5 is the 934MHz CB radio band, the channel frequencies for which are given in the DTI leaflet mentioned before. Frequencies for the Band 2, 4 and 5 transmissions are given in your trusty *Maplin catalogue*, as are the channel frequencies for direct-broadcast satellite transmissions. These latter bring us to nearly 12.5GHz, which should be high enough for most private experimental work. There are some serious licensed amateurs operating well above this frequency, but I am sure they don't need to read this article, except for interest!

Single and Multiple Frequencies

The only signal that consists of just one frequency is a continuous sine-wave. It isn't meaningful to ask why this is: it is one aspect of a fairly fundamental fact of the Universe we inhabit. Any other wave shape can be built up by adding sine-waves. Any other *repetitive* waveform can be built up from *continuous* sine waves, and one class of repetitive waveforms is composed of one sine wave, termed the fundamental frequency and usually having the largest amplitude, with other sine waves, or harmonics, whose frequencies are exact multiples of that of the fundamental. For example, a symmetrical square wave consists of a fundamental frequency and (in theory) all odd multiples of that frequency, the amplitude of each harmonic being inversely proportional to its frequency. In practice, the harmonics don't go on for ever; the bandwidth of the system will be limited by something, but, for example, a 1kHz square wave generated by a 74HC device is likely to have a detectable 1001st harmonic at 1.001MHz.

Measurements At Low Frequencies

Some measuring techniques are more suited to either low or high frequencies, so we may as well begin at the bottom and work up. One technique has already been mentioned, that of using a clock or watch to measure the period, and then calculate the frequency as the reciprocal of the period (i.e. 1 divided by the period). Another solution is to buy or build a frequency counter or a frequency meter (such as LW79L or LK20W). However, most counters have limited accuracy at low frequencies. They work by counting zero-crossings of the waveform in a time-period, called the 'gate-time', accurately derived from a crystal-controlled oscillator. This gate-time is usually not longer than 10s, so that, for example, 500 crossings of 50Hz could be measured. This means that a frequency near 50Hz can be measured only to 1 part in 500, which sounds quite good. But suppose the 50Hz signal was needed as the reference frequency for a timer: an accuracy of 1 part in 500 corresponds to nearly 3 minutes in 24 hours, which is not very good. Some counters measure low frequencies by counting the number of zero crossings of the *standard* frequency in one period of the unknown frequency. This gives much greater accuracy: a 1MHz standard allows measurement of 50Hz to 1 part in 20 000 in only 20ms, but some counters of this type can be confused by non-sinusoidal waveforms that have multiple zero-crossings within one cycle of the fundamental. I recall trying to measure the frequencies produced by a very primitive electronic musical instrument, only to find that the counter read '660Hz' on every note, even though they were clearly all different. But each note waveform included a large pulse of 757μs duration, which the counter was measuring, on the assumption that it was a half-cycle of the fundamental frequency.

There are two aspects to 'measuring' frequency, as we usually use the words. One is to determine exactly what the frequency *is* (which is what a counter does), and the other is to adjust an oscillator as exactly as possible to a *given* frequency, or, what amounts to the same thing, to calibrate the scale of, say, a variable-frequency oscillator. In most cases, the private experimenter wants to do the latter, so most of the descriptions in this article will be about adjusting or calibrating oscillators. However, the same principles can be applied to actually measuring frequency, especially if a calibrated variable-frequency signal is available, or can be generated, to serve as the reference frequency.

If you have an oscilloscope which allows external signals to be applied to the X-plates as well as the Y-plates, you can adjust low frequencies very accurately by using Lissajou's Figures. If you apply sinusoidal signals of the same frequency to both inputs you will, in general, get an ellipse traced on the screen (Figure 1). If the two signals are in phase or 180° out of phase, the ellipse will collapse to a straight line. If the maximum deflections in the X and Y directions are equal (through suitable combinations of input voltages and amplifier gains) and the two signals are in phase or 180° out of phase, the straight line will be at 45° on the display, while if the two signals are 90° out of phase, the ellipse will become a circle. If the frequencies of the two signals are not exactly equal, the display will show an ellipse which rotates at the difference frequency, collapsing and expanding as it goes round. It is thus very easy to apply a few volts of 50Hz, derived from the mains via a transformer, to (say) the X-input, and a signal from the oscillator to be adjusted, to the Y-input. Then you adjust the oscillator frequency until you get, as nearly as possible, a stationary display at any convenient phase relationship; usually the straight line is easiest to use. If the display rotates only once in 10 min, the frequency has been set to an accuracy of 1 part in 30 000, or about 3s in 24 hours. Don't try this unless you have plenty of spare time; the display patterns are so fascinating that you can easily spend an hour watching them.

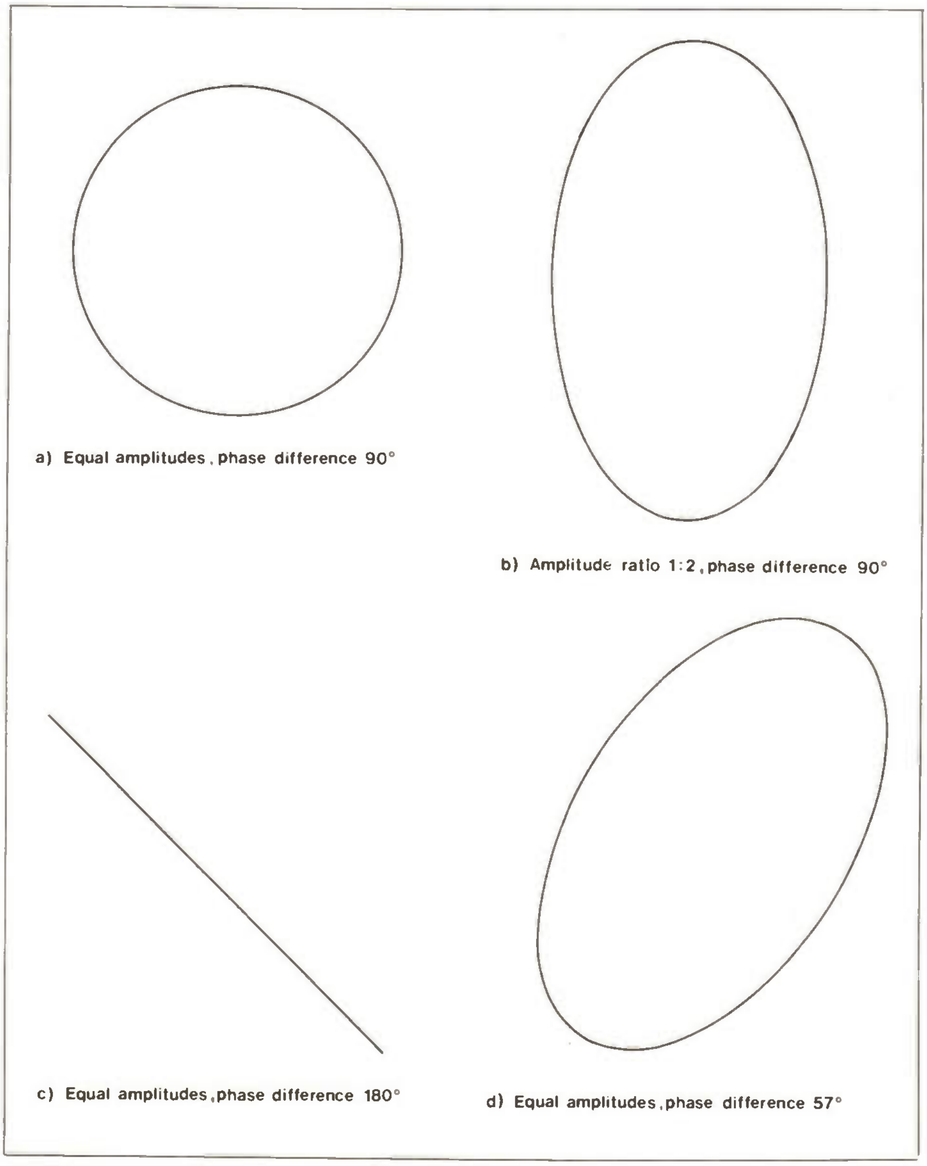


Figure 1. Lissajou's Figures with a frequency ratio of 1:1.

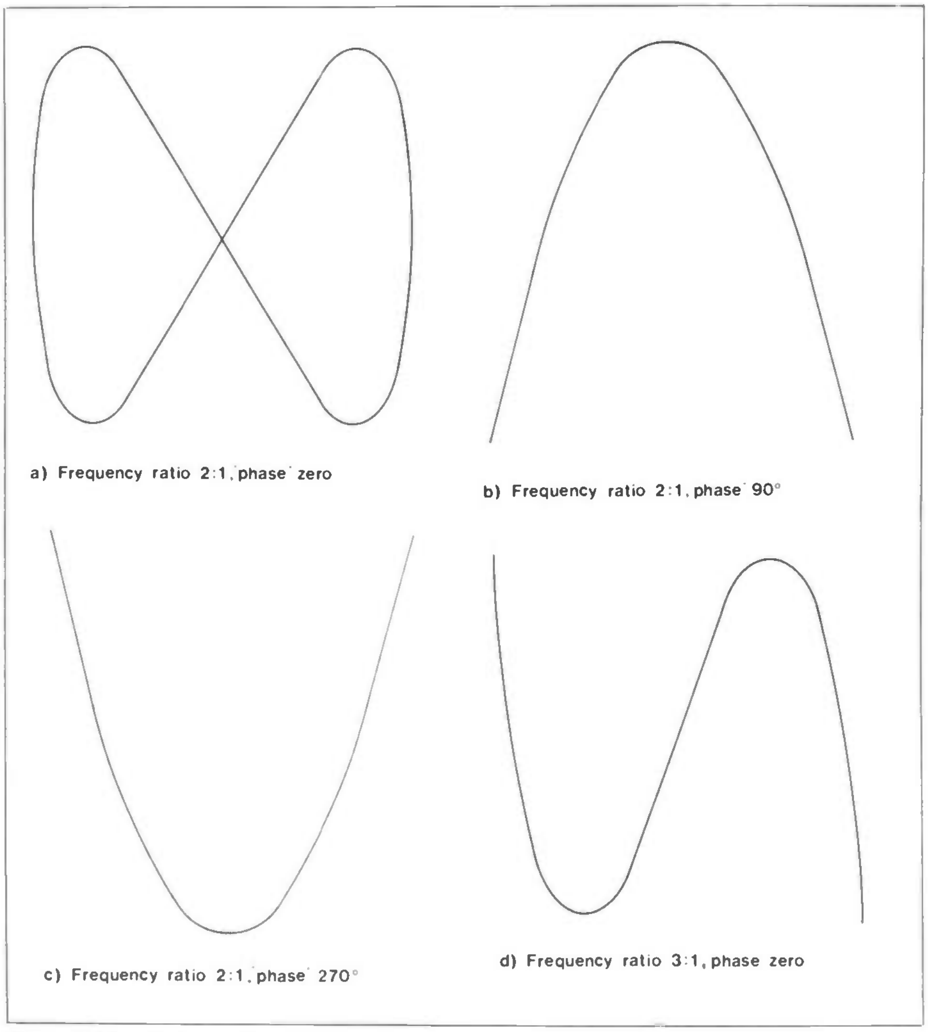


Figure 2. Lissajou's Figures.

This is all very well, but suppose the oscillator to be adjusted or measured is not intended to run at 50Hz? If the frequency of the unknown signal is a multiple of the reference frequency, a stationary display is still obtained, but instead of being an ellipse, it is a more complex figure (Figures 2 and 3). The ratio of the frequencies is equal to the number of 'points' on the figure, less 1, when the phase relationship between the two signals is such that it will give a single line trace (like Figures 2b, 2c or 2d) rather than a loop (like Figure 2a). Provided the 'unknown' oscillator frequency is stable (the reference certainly ought to be!), this method can be used up to a frequency ratio of at least 20 to 1, so a 1kHz oscillator could be calibrated against 50Hz. Ratios such as 3:2 can also be determined, but in practice this is not quite so easy. 3:2 gives a display (with a particular 'phase' relationship, although strictly speaking you can't compare the phases of two signals at different frequencies) like a Greek alpha 'α' of the reverse (Figure 3). To determine the frequency ratio, count the total number of 'points' along both horizontal edges of the display, and those along both vertical edges. Subtract 1 from each, and the ratio of the resulting numbers is the frequency ratio. For example, the 'alpha' display has 4 'points' on the horizontal edges and 3 along the vertical edges, so the frequency ratio is (4-1)/(3-1) = 3/2. More complex ratios, such as 7:11, look like a raster scanned with curved scanning lines. While requiring only sinusoidal scanning waveforms, which can have very low distortion and thus give very accurate linearity, the definition and brightness are least in the centre of the raster, which is normally a big disadvantage. The Lissajou's Figures method can be used up to the frequency limit of the oscilloscope, provided you have a suitable standard frequency source (and an oscilloscope!), but it will only work properly if both the reference frequency and the unknown frequency are quite stable (no 'drift' or f.m.).

Audible Beats

What do you call someone who calibrates mechanical digital audio signal generators? A piano tuner. Pianos are tuned by adjusting one note, using a tuning fork, and then tuning the other notes to the first one. This is done by listening to audible beats.

If we add together two sine-wave signals of nearly equal frequency, using, for example the simple 'mixer' shown in Figure 4b, the amplitude of the resulting signal shows a series of peaks and troughs at the difference frequency (Figure 4a). There is no actual signal present at this frequency, it is just the amplitude that varies, and if we apply the combined signal to an audio amplifier and loudspeaker, we can hear the variations in amplitude, which are called 'beats'. This method is useful for comparing audio frequencies between about 50Hz and a few kHz. It is possible to hear beats between two

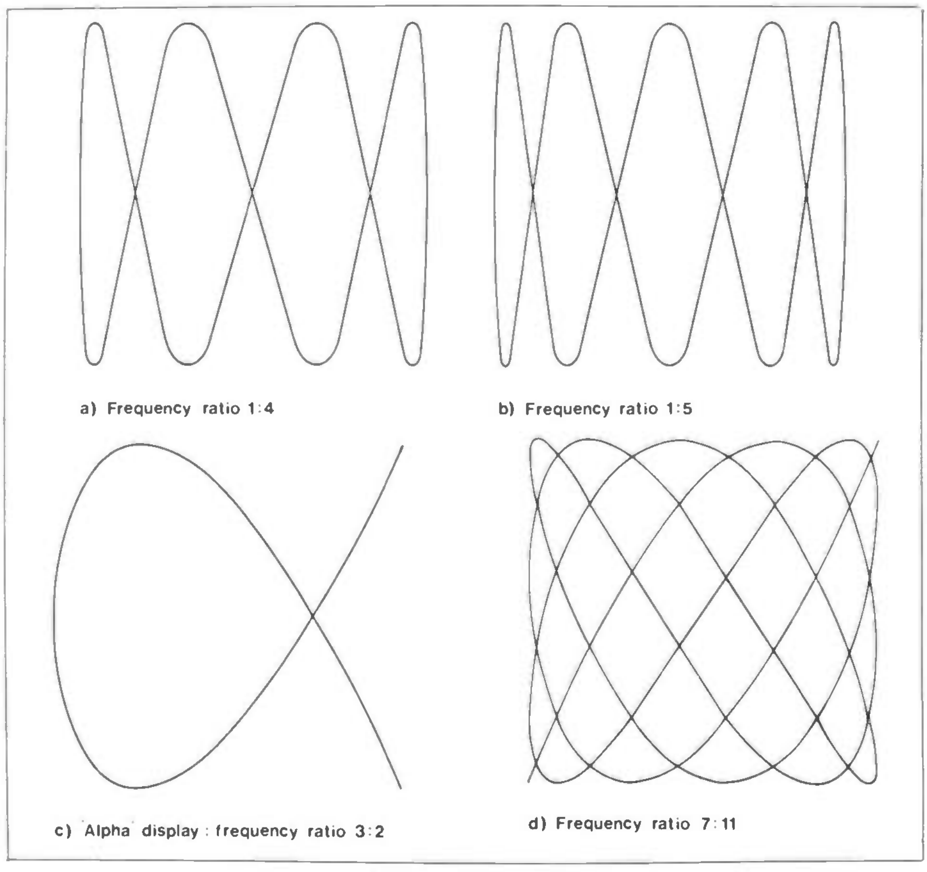


Figure 3. More complex Lissajou's Figures.

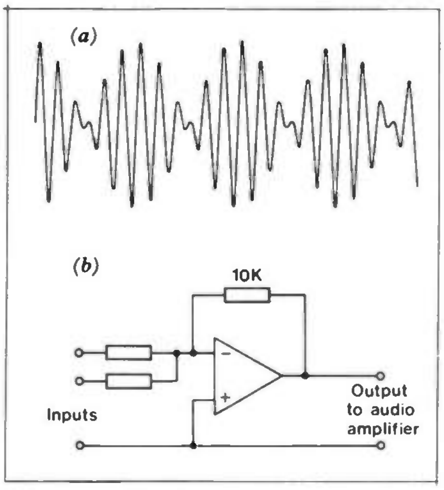


Figure 4. (a) Waveform of 'audio beats' produced by adding two sine-waves of nearly equal frequency.
(b) Audio adder. The op-amp can be any general purpose type. Adjust the input resistor values to get approximately equal signals at the output.

sine-waves with nearly a 2:1 frequency ratio, because the human ear is not distortion-free, and generates the second harmonic of the lower frequency signal. Another way to extend the range is to use a square wave for the reference. We've seen already that a square wave contains a fundamental and a series of odd harmonics, so a 50Hz square wave will give beats with sine-wave signals at 150Hz, 250Hz, etc. It is also possible to use this method the other way round, with a square wave of unknown frequency beating with a sine wave signal at 3, 5 or 7 times the wanted frequency. The accuracy of the measurement is multiplied by the order of the harmonic. It is quite easy to adjust for beats slower than 1s, which corresponds to an accuracy of better than 1 part in 1000 for a harmonic at or near 1kHz. The piano, and most other musical instruments, produces sounds which are rich in harmonics, so it is possible to hear beats between, for example, the 2nd harmonic of 262Hz (524Hz) and the 3rd harmonic of 175Hz (525Hz). Using these beats, and following a set pattern, the piano tuner can adjust all the notes.

Visible Beats

It is possible to make beats visible instead of audible. Looking at an LED vary in brightness is somewhat less tiring, and less anti-social, than listening to audible beats. Also, as Figure 5 shows, only a minimum of equipment is needed. Note that the op-amp must be of a type that will accept a load resistance of 1kΩ or less: unfortunately this characteristic is not given in the tables in the *Maplin catalogue* (perhaps next time? . . .), but most of the bipolar devices should be suitable. Because the LED is a non-linear device, the application of two signals to it generates signals at the difference frequency (and others, including the sum frequency, but we are not concerned with those at present). The diode in parallel with it is to provide a feedback path for the negative-going half-cycles, which would otherwise violently overload the op-amp. Using a square-wave signal, harmonics up to at least the 15th are detectable, and if the op-amp is a wideband type, the input frequencies can be up to at least 1MHz (but you probably won't be able to do both at once, i.e. detect beats with the 15th harmonic of 1MHz!). The limit is set by the sensitivity of the adjustment of one of the frequencies; it requires a very fine control to adjust a 1MHz oscillator to within a few hertz, so as to get visible flashing of the LED. You can't see the flashing, of course, if the difference frequency is above about 15Hz. This circuit works best if the two signals have about the same amplitude at the output of the op-amp, which can be arranged by adjusting the input resistor values to provide the right amount of gain for each signal. Note that a high gain will mean a low input impedance, so it may be necessary to precede the adder by a buffer, e.g. another op-amp in a unity gain circuit.

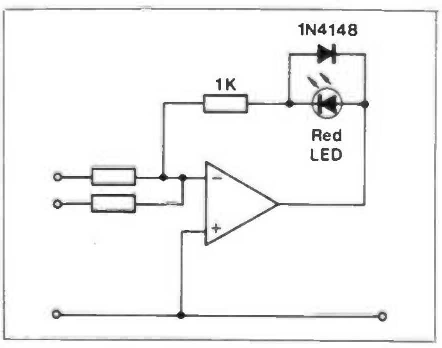


Figure 5. Making beats visible. This is a very simple circuit for comparing/adjusting audio frequencies. The op-amp should be a bipolar type.

Back To Audio

We can increase the range of difference frequencies that we can detect by going back to audio. Depending on your personal upper limit of hearing, beat notes up to several kHz are easily heard. These are not the same as the audio beats mentioned earlier, which were not signals but amplitude variations. Here, the two signals are added and amplified, and then applied to a rectifier, which produces an actual signal at the difference frequency. If the difference frequency is within the audio range, we can amplify it and listen to it. Figure 6 shows a simple way of generating audio beats from signals above the audio frequency range. Using an LM592 op-amp (Figure 7) will allow measurements up to several tens of MHz, and signal voltages as low as 30μV or so. If one of the signals is frequency-modulated, the beat-note will be accompanied by 'swishing' noise, but 'zero-beat', the point at which the difference frequency becomes very low, can usually be determined quite easily. An amplitude modulated signal will, of course, be demodulated, and the modulation will be audible, but it is still usually possible to hear the zero-beat point quite easily. The 'voltage doubler' rectifier is used in this circuit because it can be capacitively coupled at the input, whereas a half-wave rectifier needs a d.c. path. It is

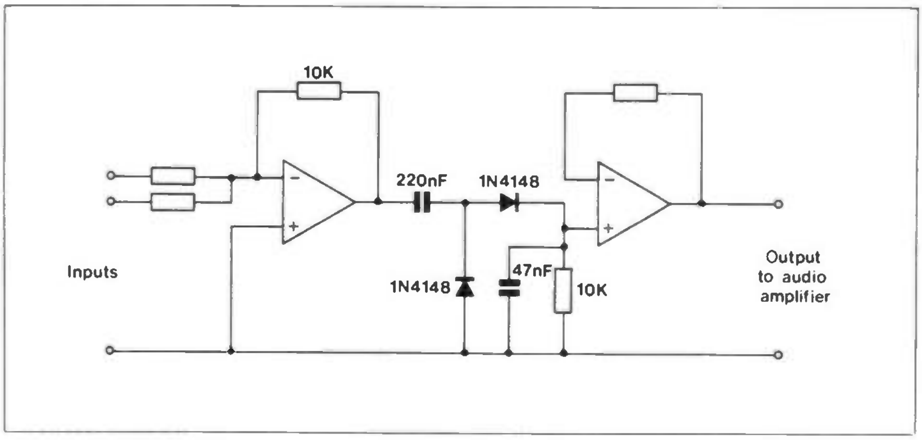


Figure 6. Audio beat note generator for low radio-frequency comparisons (upto a few MHz).

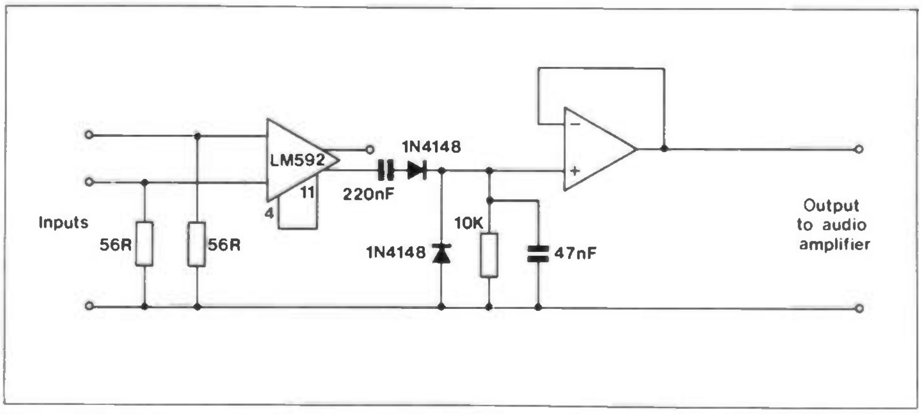


Figure 7. Audio beat note generator suitable for radio-frequencies up to at least 30MHz. Keep the input voltages as low as possible, while maintaining an audible beat note.

also possible, as shown in Figure 5, to add a visible indication of very low frequency beats, which could be used to adjust, or 'net', a very stable (e.g. crystal-controlled) oscillator to a precise frequency.

With this circuit it is quite possible to obtain beats with high harmonics of a square wave, e.g. the 15th harmonic of 1MHz. Note that the circuit has a gain of 100 in the form shown: the input voltages should be only about 10mV for best results. The gain of the LM592 can be varied from 1 up to 400, so large and really small signals can be measured. Normal r.f. precautions are necessary to prevent oscillation if high gains are used.

Measuring In Two Stages

A two-stage measurement can be made, on a source of very stable frequency, using audio beat-notes. For example, a frequency of 20.001MHz could be measured or set up by first generating an audio beat with a 20MHz signal from a signal generator or standard frequency transmission, and then measuring the frequency of the beat-note using audible beats or Lissajou's Figures.

Another type of two-stage measurement, for audio frequencies this time, involves making a simple variable-frequency square-wave oscillator (one or two logic gates), tunable between, say, 1kHz and 2kHz, and calibrating it against a 50Hz signal. The oscillator can then be used to measure higher audio frequencies, using audible beats, which would be very difficult using the 50Hz signal directly.

Lissajou's Figures With Different Waveforms

If the waveforms are not sinusoidal, the display obviously won't give circles and ellipses, but the straight line may not be affected. Square waves are useless; all the details in the display are packed into bright lines at the edges, and it is impossible to count 'points' or do practically anything else useful. Triangular waves, however, which are relatively easy to generate with i.c.'s (e.g. by integrating a square wave), give patterns of 'diamond' shapes at non-integer frequency ratios. Near a frequency ratio of 1:1, the display is a rotating rectangle which keeps opening out and then collapsing into a straight line. It is much easier to count 'points' on a triangular-wave display, so this could be helpful for determining fractional frequency-ratios (e.g. 6:5, for setting up a 60Hz power supply). One sine-wave and one triangular wave gives a display like a hysteresis loop, which could be useful for simulations.

Possible Sources Of Error

Errors due to the reference frequency not being exactly correct are clearly possible, but there is no easy way of avoiding them. With 1:1 Lissajou's Figures, it is practically impossible to make a mistake, but with complex ratios it is quite easy to miscount 'points'. If possible, a second measurement should be made to check. For example, if you have calibrated a 700Hz oscillator against a 400Hz tuning signal, can you hear a 100Hz beat with the second harmonic of 400Hz, using the circuit of Figure 6? You could generate the second harmonic by using a bridge rectifier with no reservoir capacitor. This should ensure that you have not tuned to 666.7Hz (frequency ratio 5:3) or 720Hz (ratio 9:5) by mistake.

The scope for making relatively large errors is greater with radio frequencies. This is because the signals may have considerable harmonic content, and because the essential non-linearity in the beat-note generator produces audible beats when the input frequencies have other than a 1:1 ratio. For example, 15MHz and 20MHz can give an audible beat because the 4th harmonic of 15MHz beats with the 3rd harmonic of 20MHz. These beat notes are always much weaker than the correct one, so it is necessary to search around for the strongest, and to keep the input signal levels down, so that less harmonic energy is generated and only strong beat-notes will be audible.

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MAPLIN'S TOP TWENTY KITS

THIS MONTH	LAST MONTH		DESCRIPTION OF KIT	ORDER CODE	KIT PRICE	DETAILS IN PROJECT BOOK
1.	(1)	◆	Live Wire Detector	LK63T	£3.95	14 (XA14Q)
2.	(6)	▲	Digital Watch	FS18U	£2.00	Catalogue
3.	(3)	◆	150W Mosfet Amplifier	LW51F	£19.95	Best of E&MM
4.	(9)	▲	Car Battery Monitor	LK42V	£6.95	Best of E&MM
5.	(4)	▼	I/R Prox. Detector	LM13P	£9.95	20 (XA20W)
6.	(11)	▲	Car Burglar Alarm	LW78K	£8.95	4 (XA04E)
7.	(7)	◆	Mini Metal Detector	LM35Q	£4.95	25 (XA25C)
8.	(5)	▼	Partylite	LW93B	£9.95	Best of E&MM
9.	(8)	▼	U/Sonic Car Alarm	LK75S	£17.95	15 (XA15R)
10.	(10)	◆	Siren Sound Generator	LM42V	£3.95	26 (XA26D)
11.	(14)	▲	Watt Watcher	LM57M	£3.98	27 (XA27E)
12.	(13)	▲	8W Amplifier	LW36P	£5.95	Catalogue
13.	(12)	▼	PWM Motor Driver	LK54J	£9.95	12 (XA12N)
14.	(2)	▼	15W Amplifier	YQ43W	£6.85	Catalogue
15.	(15)	◆	27MHz Receiver	LK56L	£8.95	13 (XA13P)
16.	(17)	▲	27MHz Transmitter	LK55K	£7.95	13 (XA13P)
17.	(20)	▲	U/sonic Transceiver	LW83E	£11.95	4 (XA04E)
18.	(-)	▲	Line Amplifier	LK87U	£3.95	19 (XA19V)
19.	(-)	▲	Stereo Pre-amp	LM68Y	£4.95	Catalogue
20.	(19)	▼	Car Digital Tacho	LK79L	£19.95	Best of E&MM

Over 150 other kits also available. All kits supplied with instructions.

The descriptions above are necessarily short. Please ensure you know exactly what the kit is and what it comprises before ordering, by checking the appropriate Project Book mentioned in the list above - see page 31 for details.

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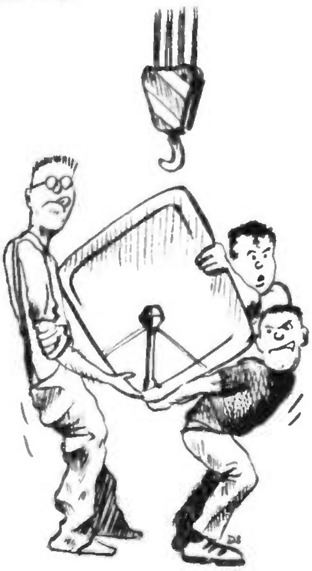
NEWS REPORT

BSB Goes Heavy Metal



British Satellite Broadcasting (BSB) have shelved plans for a revolutionary plastic square aerial (Squarial). The Squarial, designed by the Scottish company Fortel, was due for release at the autumn launch. Up to now the BSB advertising campaign has hinged on the Squarial, with slogans like; "It's smart to be square", it now seems that all this advertising is just sales-hype. As we reported in the last News Report, cracks in their advertising concrete are fast appearing.

BSB have admitted that the development of the 30cm plastic aerial has not been completed, but they have denied any rift with the designer John Collins. In place of the Squarial, BSB is negotiating with two leading big names, STC and GEC-Marconi to make a square aerial out of metal, utilising a completely different design. The Marconi aerial is known to be 36cm, larger than pictured in BSB's advertising, but BSB is 'hoping' that STC will produce a 30cm version.

The metal aerials will be more costly to produce than its plastic counterpart. Amid fears of price increases, BSB have promised that its pricing policy will not change. It seems that the first customers will be subsidised until the plastic version is available.

The aerial hitch is not the only problem to beset BSB, a long line of problems casts a gloomy picture for the success and viability of the system. BSB is still waiting for ITT to supply working interpreter chips for the receiver/decoder boxes, a few weeks ago the devices were said to be only 80% functional. It seems the chips are down for BSB!

Licence Money

The past two months have obviously been busy for the Department of Trade and Industry. For a start, the Department have decided that a licence will no longer be needed for satellite dishes, but hasten to add that the requirement for a TV licence is not affected. Also abolished are licences for lower power radio devices. Units now exempt include garage door openers, childrens' walkie-talkies, certain types of burglar alarms, industrial remote control equipment, radio microphones and low power microwave devices, providing they comply with DTI technical specifications. This news will no doubt come as a relief to many users who until now have been unaware that licences were needed in the first place!

Not quite abolished, but in the simplification category is Transportable Radio Alarms Licensing. Operators of certain short range transportable radio alarm systems will no longer need to be covered individually providing they are covered by a class licence. These alarms consist of one fixed radio station which can be either a transmitter or receiver and at least one transportable station.

Thanks to the boom in yachting, the DTI have been forced to assign additional VHF radio frequencies for use by marinas, yacht clubs and pleasure craft to reduce congestion on the existing communication channels in coastal waters.

A similar boom in the use of theatre radio microphones has led the DTI into making available an extra 22 radio frequency channels to theatres and concert halls. In case you are wondering, Andrew Lloyd Webber has to pay just £100 for each of his top show licences.

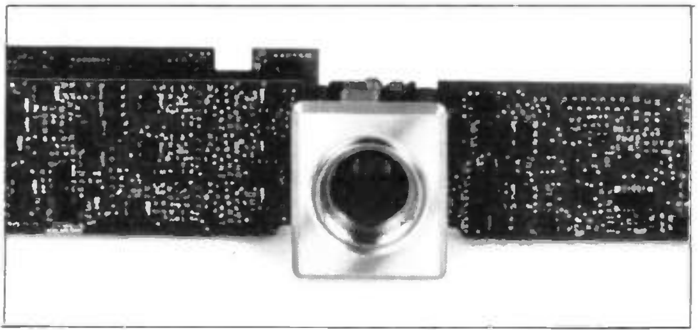
Time on Your Hands

A newly announced device, that will increase your efficiency by up to 43% when you make or receive a telephone call, is Starbase. This is a telephone and headset combined which works on any exchange line of a PABX extension. Suppliers Plantronics believe that their new system will improve the lives of people who use the phone intensively for part of the day. The system which measures 6" by 4" costs about £150.

European Paging

By January 1992 at the latest, a harmonised system of European telephone paging should be a reality. Called ERMES, (European Radio Messaging System), the system will be available for use on cheap portable sets – that is if the present Commission proposal is adopted by the 12 Member States of the EC. This is one comms area where the UK is very much in the lead and, if approval is given, will score some very useful marketing points.

Video in Focus



Thanks to Philips, the cost of video cameras look set to fall. This is the result of a breakthrough by the company in the design of the first European colour charge coupled device (CCD) module. This allows manufacturers with no video equipment design experience or assembly facilities, to fit a chassis and lens to the unit and form a full performance colour video camera.

The high-sensitivity module features a picture resolution of up to 450,000 pixels and produces an acceptable colour picture down to low light levels of 0.45 lux on the sensor, ideal for surveillance applications. The module consists of a CCD frame transfer sensor complete with all the necessary drive, pre-processing and power supply circuits. There are two basic versions for 525 line or 625 line TV systems meeting NTSC or PAL standards.

Compaq Best For Laps

In just over a year, Compaq have gained a near 40% share of the lap-top market. The company is now hoping that its newly released Deskpro-386/33 computer system will score an equal success. The market for 386 systems is being tipped to reach £2,400m by 1993, so even a 10% share of the market-place would be good going for all concerned.

Satellite Wars

Sky TV is introducing a smart card – a plastic credit card with a microchip built in – as a method of allowing the satellite signal to be decoded. The card, which will be replaced every three months, is designed to protect the system against hackers. Rival operator British Satellite Broadcasting has announced that their satellite receiver boxes will incorporate a feature designed to beat the theft of the decoder. Should the unit ever be stolen then BSB will be able to automatically disable the box over the air.

Meanwhile, some of the more technical problems associated with satellite receivers appear to have been resolved. According to the industry daily publication "Computergram International", a certain TV engineer has wired his TV to a dustbin lid. Apparently the low cost aerial dish has a great reception signal. But Amstrad have quickly pointed out that a feed horn from the dish to amplify the signal is still a necessity and that feed horns are matched to the satellite dishes. Even so maybe BSB, who are known to be having problems with their squarial aerial, should pop down to their local hardware store and buy in all available supplies.

High Tech Cycling

"Computergram International" also reveals the fact that an American consultant has designed the last word in bicycles. His bike features solar power computers, ham radio, cellular phone, fax machine, modem and a keyboard in the handlebars plus a portable unit for satellite reception.

16 Megabit DRAMs

Texas Instruments and Hitachi Ltd. have joined forces to develop a common 16 Megabit Dynamic Random Access Memory (DRAM) technology. Both companies will have access to the others DRAM technology as it relates to 16 megabit development, and will be free to use the jointly developed technology in their own products. The 16 megabit DRAM, capable of storing the equivalent of 1000 pages of text, is hoped to be available for customer samples in the latter half of 1991, although experimental prototypes have already been produced. Key features will be; CMOS fabrication, operating from +5V supply drawing 90mA, cycle time 120nS and refresh rate of 4096 cycles, 32mS.

Power Supply Capacitors

In direct response to the growing market for more compact industrial and consumer electronics goods, Panasonic are offering two types of radial aluminium electrolytic capacitors especially for power supply applications. The HFQ and HFZ series have three noteable characteristics: they have very low impedance, high ripple current and long life. The HFQ series have a 105°C/2000 hours specification and the HFZ series have a 105°C/5000 hours specification. The HFZ series is intended for more professional product applications, while the HFQ series offers smaller case sizes and consequently lower prices.

Capacitors Galore

Panasonic have introduced a new range of general purpose radial aluminium electrolytic capacitors, the KA and KS series of capacitors are miniaturised versions of the previous K series. The KA series has a wider range of values, all with 7mm can height but smaller diameters ranging from 4mm to 8mm. The KS series also offers an extended range of values but with a maximum height of 5mm.

Fax Facts

Still on phone matters – well, without a phone network the role of the fax would be limited to that of an expensive copier – the facsimile market in Europe is predicted to grow from today's one million units to over six million by 1994. But when it comes to the non-glamour matter of the storage ability of fax paper, the industry is very much on the defensive.

Fading faxes are blamed on the special thermal paper used which, when exposed to air or sunlight, could fade within a couple of months. Canon suggests that users should store paper out of daylight, preferably in cardboard boxes. Even then the life span could be limited to a year. But the fax industry isn't loosing too much sleep. The user can either choose to pay for high class fax paper or photocopy the faxes as they are received. In any case the revenues of the office equipment suppliers will expand.

BT Hits Quality Target

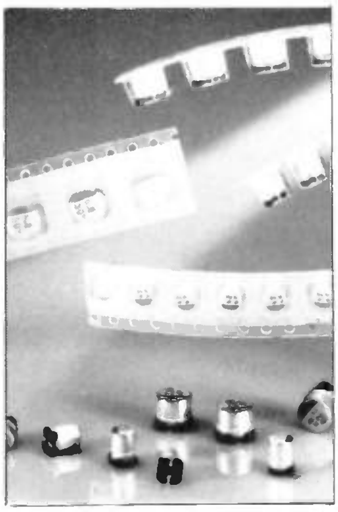
British Telecom's latest Quality of Service Report awards itself top marks for faster repairs, quicker installation of new residential and business telephone lines and equipment, improved directory enquiries, more working public payphones and fewer call failures. The company are also reporting high quality revenues, some of which no doubt is being directed to pay for next spring's Greater London telephone number change-over.

Meanwhile, both Olivetti and Amstrad are reported to be entering the telephone equipment market-place. Both companies it seems are looking to source equipment from Spanish suppliers. The potential is indeed massive with over 80 million telephones in daily use in the UK, W.Germany, France and Italy alone. In the UK, the retail telephone market will reach 3.5m units, worth over £100m by 1990.

DEC Tie Badge on Olivetti

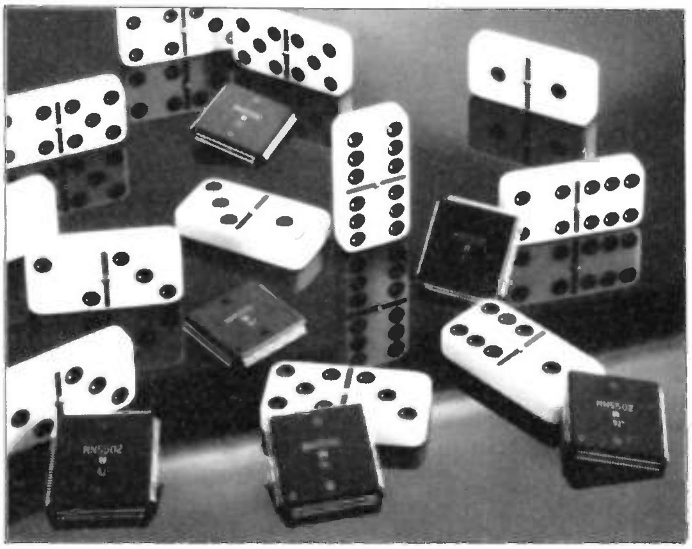
At long last it can be revealed; DEC long seeking a PC partnership, is pinning its badge on Olivetti. The computers, which will be manufactured to DEC specifications in Italy, will form the basis of Digital's new family of DEC station PC products for European customers. DEC are promising to reveal the price – and delivery dates – within five weeks, and are joining with Olivetti in hailing the agreement as a major marketing boost.

Victory VVs!



Specially designed for automatic placement, Panasonic's VV series chip aluminium electrolytic capacitors are supplied on tape ready for machine placement. The VV series are available in a range of 3 case sizes, B, C and D and can provide high CV value in a small case size. Operating temperatures for the VV series range from 40 to 105°C and the working voltage range is from 4 to 50V. Capacitance ranges from 0.1 to 220μF.

It only Takes One Chip . . .



Panasonic have announced the launch of the MN5502 display controller – the one chip solution for people in the PC market, ideally suited for lap-top models. The MN5502 employs the IBM compatible display mode and an original bit map as well as the VRAM (video RAM) cycle seal access which eliminates the need for an external circuit. The combination of these three factors; reduced chip count, low noise and simple design make this semiconductor the ideal one chip solution for graphics display control in PCs, wordprocessors, terminals and program controllers.

Irresistoribile

High reliability, glazed metal film resistors, suitable for flow and re-flow SMD soldering techniques are available from Panasonic. These chip resitors feature three layer electrodes and a thick film resitive element. Available in .1W and .125W ratings with tolerence of 5%, 2% or 1%.

Digital Radio

Most people will be familiar with compact disc (CD), the digital storage media jointly developed by Phillips and Sony. The system has been around for quite a few years now, and as a result many steps forward have been made in the field of digital audio signal processing. Families of ICs for digital audio use are available and these are equally at home in DAT (digital audio tape) and NICAM (digital TV sound) units as well as CD players. The latest step is toward a digital radio service which, it is hoped, will provide CD quality audio over the airwaves. Digital radio is not to be confused with RDS (radio data system), used by the BBC and IBA, which provides information about broadcast stations on a suitable receiver with built-in decoder. By the end of the century, the only snap, crackle and pop to be heard will be from breakfast cereals and not from Derek Jamieson's morning program! An international convention later this year will hopefully define system standards, enabling manufacturers and broadcast companies to develop the hardware necessary for the digital radio service to operate.

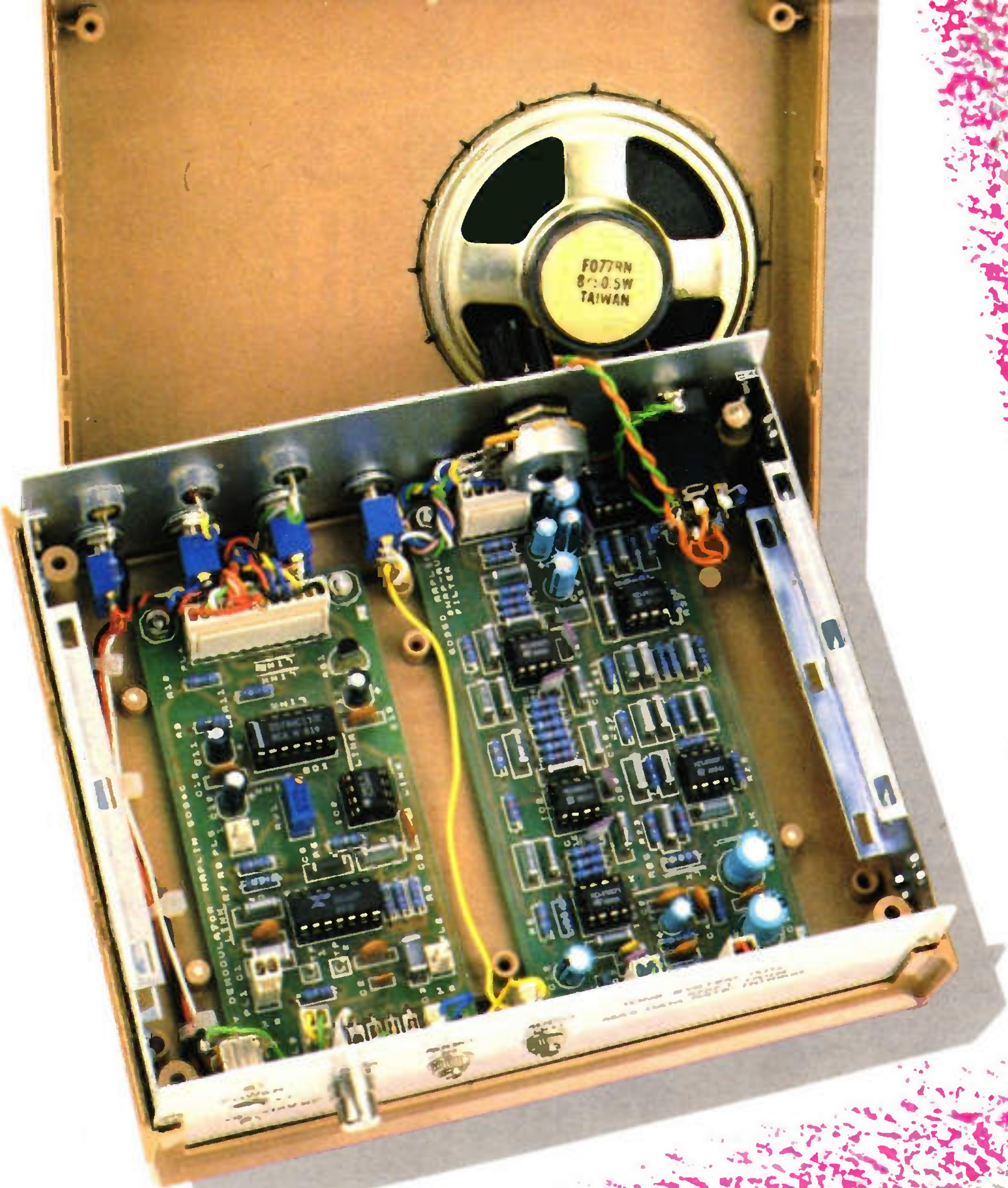
IBM – Vision of the Future

The event of the month for the computer industry has been the announcement of the new IBM family of integrated office software products, "Office Vision". This provides a common environment across PCs, minis and mainframes. The new IBM office vision brings in a multitude of office functions, including document preparation, filing, electronic mail, decision support and calendar scheduling.

The system is both multi-user and multi-tasking and features a mouse to point at pictures – or as IBM puts it, icons. By the end of 1990, all IBM applications will have the same look and feel.

Mercury Wings Upwards

UK alternative telecoms authority Mercury has surprised the market by upping many of its tariffs. On the up are domestic calls and international calls to the States. Moving downwards however are many European calls plus charges to Japan.



SH

by Chris Barlow G8LVK
Part Two in a series on
Receiving and Transmitting
Radioteletype (RTTY)

★ Simple construction
★ No setting-up required
★ Simple testing
★ On-board power amplifier

Introduction

In the first part, an RTTY demodulator was presented based upon the XR-2211 PLL decoder IC. It was mentioned that a useful addition to the system would be an audio bandpass filter, used to reject interfering signals which could overload or swamp the demodulator. On todays crowded short wave (SW) bands this condition is becoming more apparent as the number of radio stations increases. However, if you intend to use the RTTY demodulator on the quieter VHF/UHF amateur bands, audio filtering is not required to the same extent.

Specification of Prototype

Audio bandpass filter.	
Bandpass (-6dB):	1.1kHz to 2.3kHz
Attenuation rate:	75dB per octave
Gain:	0dB
Distortion:	0.23% at 1.275kHz
Signal to noise:	80dB
Input impedance:	65kΩ
Output impedance:	68Ω
Maximum input:	2.2V rms
Audio power amplifier.	
Bandpass (-3dB):	90Hz to 82kHz
Gain:	0dB
Distortion:	0.27% at 1kHz
Signal to noise:	70dB
Input impedance:	180kΩ
Output impedance:	8Ω
Output power:	500mW rms
DC specifications.	
Power input voltage:	+9V to +15V
Quiescent current:	17mA at +12V
Current at max. volume:	124mA at +12V

ARP AUDIO FILTER

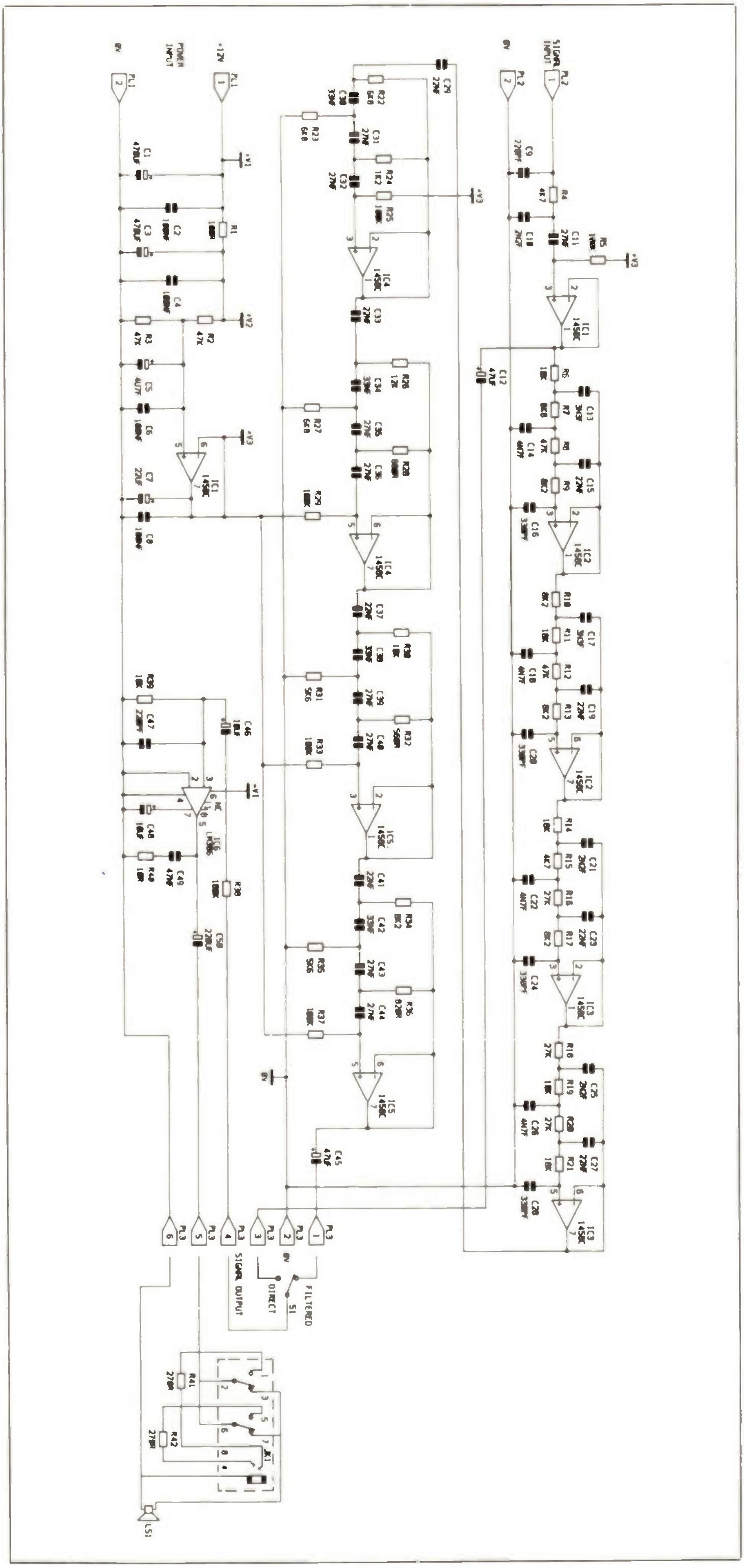


Figure 1. Circuit Diagram.

Circuit Description

In addition to the circuit shown in Figure 1, a block diagram is detailed in Figure 2. This should assist you when following the circuit description or fault finding in the completed unit.

The DC power is applied to PL1, positive voltage to pin 1 and negative to pin 2 (0V). This supply must be within the range of 8V to 15V and have the correct polarity, otherwise damage may occur to the semiconductors and polarised components.

Resistor R1, in conjunction with capacitors C1 and C3, provide the main +V1/+V2 supply rail filtering. Further supply decoupling is provided by two 100nF ceramic capacitors, C2 and C4, used to reduce any high frequency noise on the rails. For the op-amps in the audio circuits to function correctly a half +V2 supply reference is necessary. This is provided by half of IC1. The voltage reference applied to the input of this op-amp is derived from the two resistors R2 and R3 which form a potential divider. This op-amp is merely used as a unity gain buffer to provide a low impedance half supply, +V3, its input being decoupled by C5, C6 and its output by C7, C8. The other half of IC1 is used as an audio buffer to provide a low impedance drive to the filter stage.

The audio signal is applied to pin 1 of PL2 and its ground is connected to pin 2. The input impedance at 1kHz is approximately 65kΩ. However, due to the action of the HF input filter, R4, C9 and C10, the input impedance will fall as the frequency of the signal increases. This filter provides a 6dB attenuation at 25kHz increasing to 20dB at 150kHz and as the signal moves further into the RF spectrum so the attenuation increases. The purpose of such a filter is to reduce the possibility of an RF overload when using the unit in a transmitting environment. This HF filtered audio signal then passes via C11 to the input of the buffer stage, IC1, with R5 providing a DC bias. The output of IC1 is split into two paths, one with the DC bias intact and the other fed via C12 which is used to block the DC. The signal with the bias is fed to the input of the low-pass filter, with the AC coupled one taken to switch S1, providing the direct or un-filtered signal option.

The sharp filter uses a combination of low and high pass stages to achieve the desired band width and roll off for the 1kHz RTTY tone system. The space tone used is at 1.275kHz with the mark tone at 2.125kHz for an 850Hz shift, so the filter has its −6dB points set to 1.1kHz and 2.3kHz, see Figure 3. Four low pass and four high pass filter stages ensure a steep roll off rate of approximately 75dB per octave. Photo 1 shows the response curve of the prototype under test using an audio sweep oscillator and oscilloscope to display the result. The left most part of the trace represents a frequency of 100Hz with the right extreme set to 5kHz. Each low or high pass stage consists of two sets of filter components resulting in an

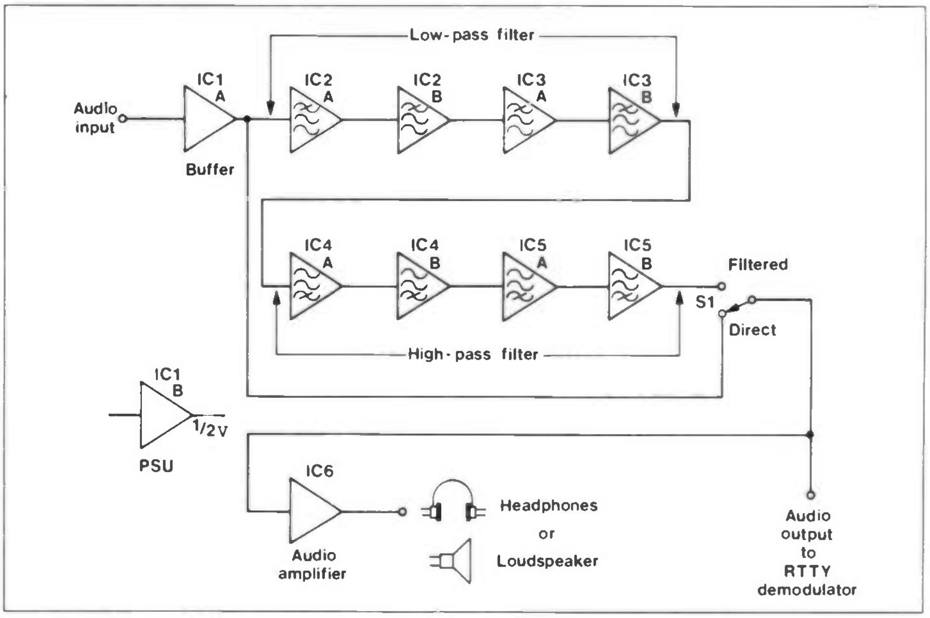


Figure 2. Block Diagram.

attenuation rate of approximately 20dB per octave. In this type of filter there is a small hump in the response near to the cut off frequency, so each stage must be set slightly differently to the next in an attempt to smooth it out. The final values used are the result of many hours of theoretical calculation and practical experimentation. The op-amps are used as buffers to provide a low source impedance to drive each stage of the system and are assigned as follows:

Low pass	High pass
Stage 1 = IC2A	Stage 1 = IC4A
Stage 2 = IC2B	Stage 2 = IC4B
Stage 3 = IC3A	Stage 3 = IC5A
Stage 4 = IC3B	Stage 4 = IC5B

The final output of the filter chain appears on pin 7 of IC5. It then passes through C45 to pin 1 of PL3 where it connects to switch S1. On this type of switch the centre tag is the common connection where the signal output is taken off to the RTTY demodulator and back to the filter PCB via pin 4 of PL3. This is the input of the on-board power amplifier, IC6, which is used to monitor the filtered or direct audio signals. The amplifier circuit uses the LM386 which was chosen for its low quiescent current, good ripple rejection and low crossover distortion. Input attenuation is provided by R38 with C46 coupling the signals in to pin 3. C47 is placed across R39 to reduce the pick up of any stray external RF interference. The output appears on pin 5 with a zobel network R40, C49 connected to the 0V rail. Pin 5 has a DC potential so a blocking capacitor, C50, is used to feed the output of IC6 to the 8Ω loudspeaker or headphones on pins 5 and 6 of PL3.

PCB Assembly

The PCB is a single-sided fibre glass type, chosen for maximum reliability and stability. However, removal of a misplaced component is quite difficult so please double-check each component type, value and its polarity where appropriate, before soldering! The PCB has a printed legend to assist you in correctly positioning each item, see Figure 4.

The sequence in which the components are fitted is not critical. However, the following instructions will be of use in making these tasks as straightforward as possible. It is usually easier to start with the smaller components, such as the resistors. Next mount the ceramic, polyester and electrolytic capacitors. The polarity for the electrolytic capacitors is shown by a plus sign (+) matching that on the PCB legend. However, on some capacitors the polarity is designated by a negative symbol (−), in which case the lead nearest this symbol goes away from the positive sign on the legend. When fitting the 8 pin IC sockets ensure that you match the notch with the block on the board. Install the IC's making certain that all the pins go into the socket and the pin one marker is at the notched end. When fitting the 'Minicon' connectors ensure that the locking tags are all facing the C1 end of the PCB, see Photo 2. Finally, using component lead off-cuts, fit wire links at the three positions marked LK on the PCB.

This completes the assembly of the circuit board and you should now check your work very carefully making sure

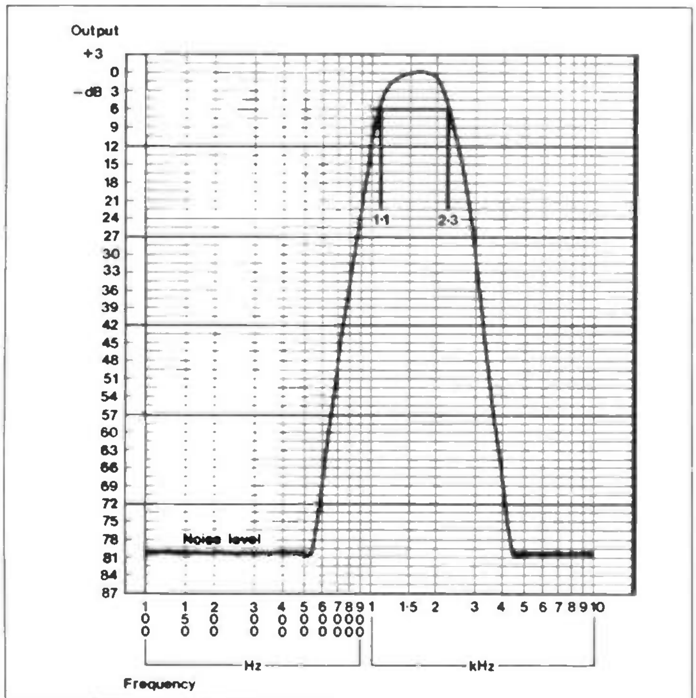


Figure 3. Bandpass Response.

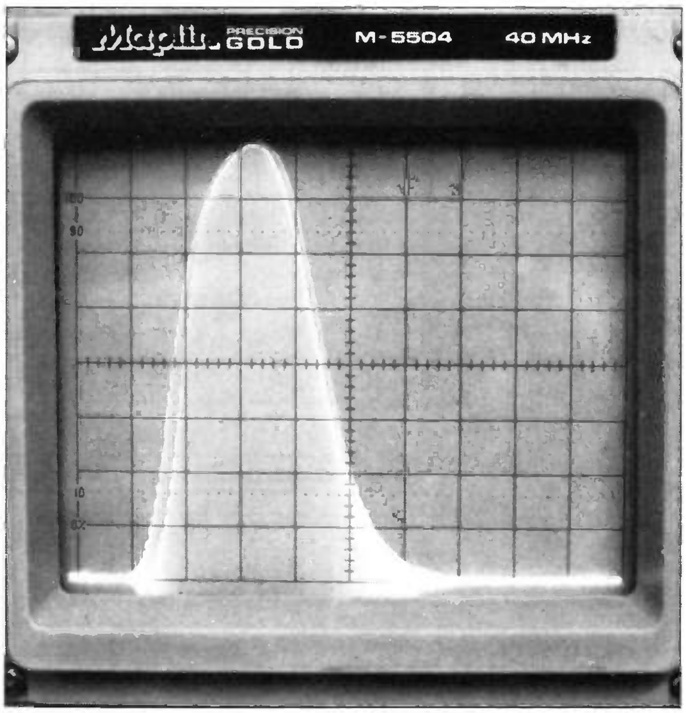


Photo 1. Sweep Oscillator Response.

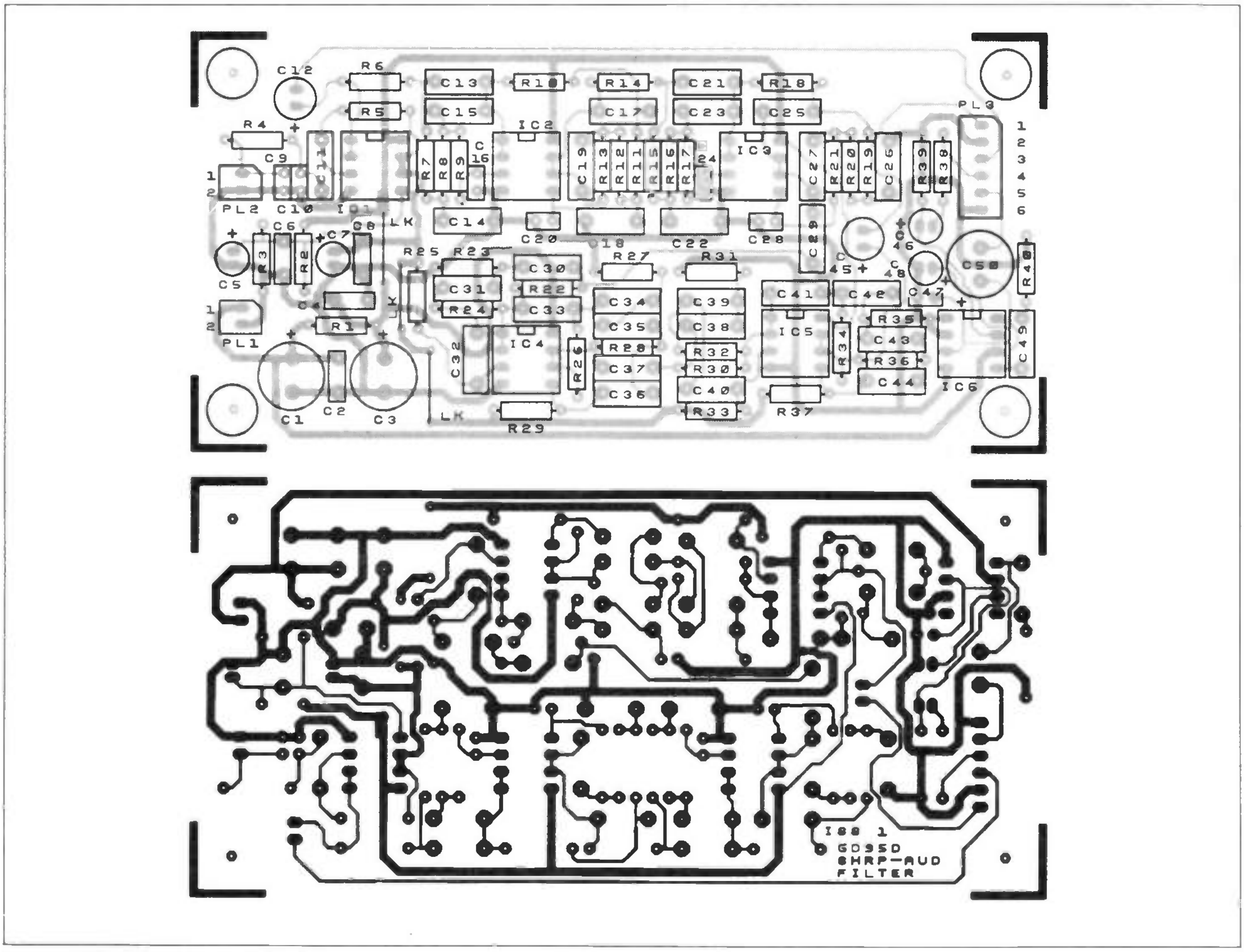


Figure 4. Track and Layout of the PCB.

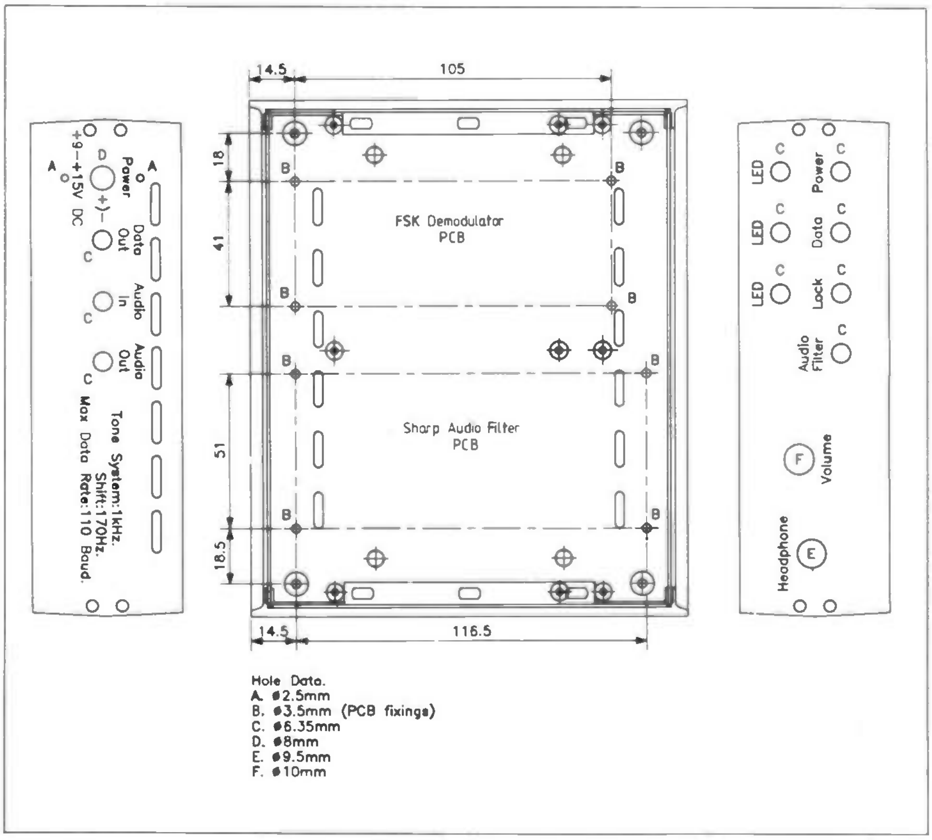


Figure 5. Box Drilling.

that all the solder joints are sound. It is also VERY IMPORTANT that the solder side of the PCB does not have any trimmed component leads standing proud by more than 3mm, as this may result in a short circuit. Further information on soldering and assembly techniques can be found in the 'Constructors Guide' included in the kit.

Final Assembly

No specific box has been designated for the project as your finished unit could contain several different PCB's. However, the filter and RTTY demodulator boards fit nicely in to the instrument case type 3502 (stock code YN33L) and drilling details for this case are shown in Figure 5. The additional connectors and hardware are listed under 'Optional' in the kit parts list. Once you have completed the mechanical assembly of the unit you should check your work very carefully before proceeding to the wiring stage. If you do decide to build your project into a box, Photo's 3 and 4 indicate possible front and rear panel lettering.

Wiring

No specific colour has been designated for each wire connection, it is entirely up to you. The use of different

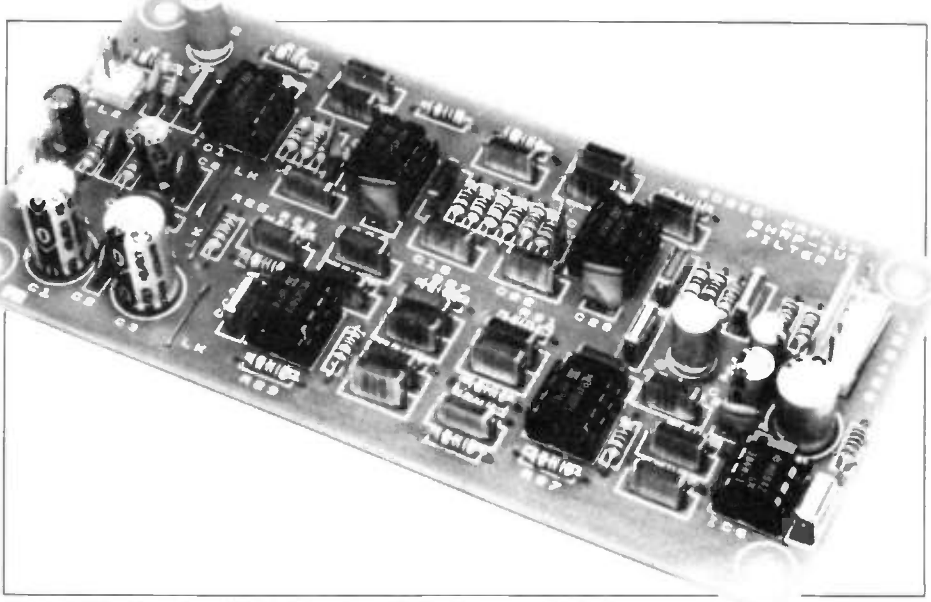


Photo 2. The Completed PCB. Note that all the Connector Tabs face one way.

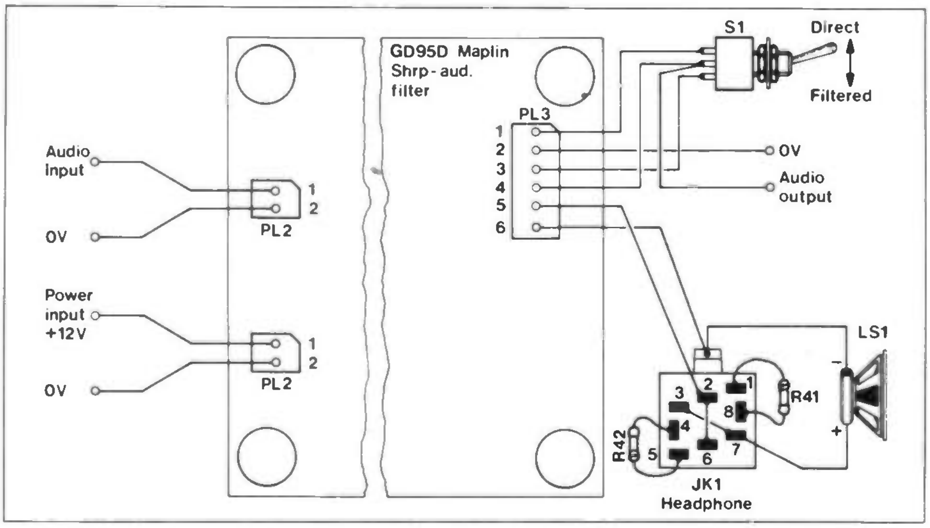


Figure 6. Wiring Diagram.

Photo 3. The Prototype Box Front.

Photo 4. The Prototype Box Back.

coloured hook-up wires will make it easier to trace separate connections to off-board components, just in case there is a fault in any given part of the circuit. A wiring diagram showing all the interconnections is given in Figure 6 and the optional volume control is shown in Figure 7. The wire connections to the PCB are made using 'Minicon' connectors and the method of installing them is shown in Figure 8. Do not forget to fit the two link wires or the resistors, R41 and R42 on the headphone jack socket JK1. Photo's 5 and 6 show front and rear panel wiring.

This completes the wiring of the filter and you should now check your work very carefully making sure that all the solder joints are sound.

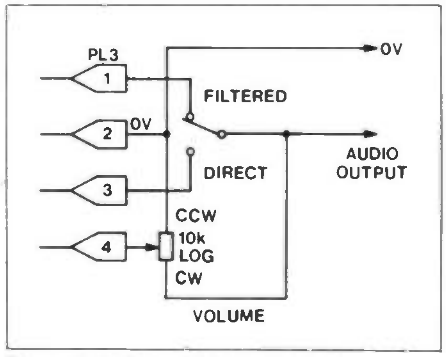


Figure 7. Adding a Volume Control.

Testing

All the DC tests can be made with a minimum of equipment. You will need a digital, or analogue multimeter and a regulated +12V power supply capable of suppling up to 300mA.

The first test is to measure the resistance on the power input pins of PL1. With the meter leads either way round a reading of greater than 70Ω should be present.

Next, select a suitable range on your meter that will accommodate a 100mA DC current reading and place it in the positive power line (pin 1 of PL1). Connect your +12V power supply and switch on, a current reading of approximately 17mA should be observed.

Now set your multimeter to read DC volts. All voltages are measured with respect to ground and should not exceed +12V. When the unit is powered up, voltages present on the PCB should approximately match the following:

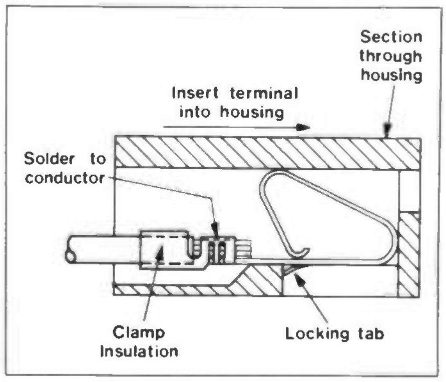


Figure 8. Assembling a 'Minicon' Connector.

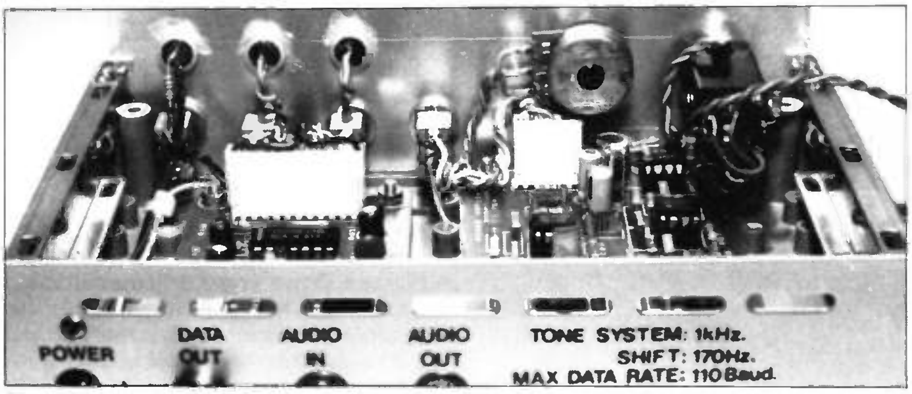


Photo 5. Inside the Box Front.

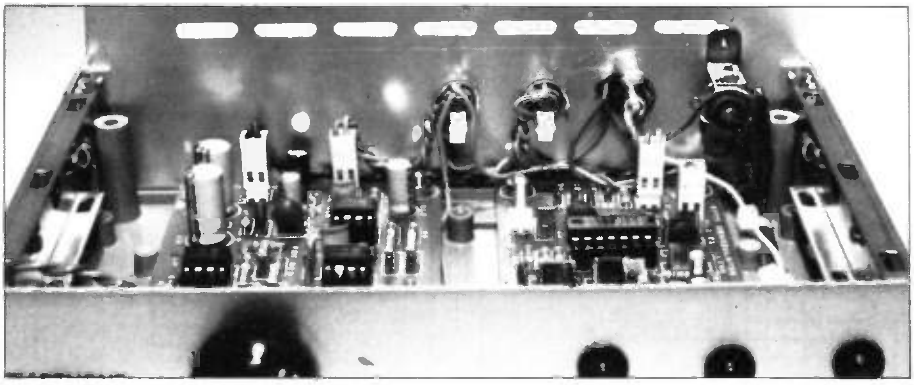


Photo 6. Inside the Box Back.

Pin 1 of PL1	=	+12V	(+V1)
Pin 8 of IC1 to IC5	=	+11V	(+V2)
Pin 6 and 7 of IC1	=	+5.5V	(+V3)
Pin 5 of IC6	=	+6V	

This completes the DC testing of the sharp audio filter, now remove your multimeter from the unit.

Using the Filter

The audio connection to your receiver can be made through the headphone or loudspeaker socket. The tape socket can be used if it has sufficient output and you have incorporated the volume control, see Figure 7. The audio output of the filter is fed to the signal input of the RTTY demodulator.

The characteristic narrow passband sound should be self evident when the filtered signal is selected by S1, see Figure 6. The RTTY tones (1kHZ system) will be heard when the frequencies are within the passband of the filter, but when tuned outside this passband the tones should rapidly drop in volume.

For further information on tuning in RTTY signals you should refer to part one of the series published in the June to July 1989 issue of Electronics (a reprint of the article is included in the RTTY demodulator kit LM95D).

SHARP AUDIO FILTER PARTS LIST:

Resistors: All 0.6W 1% Metal Film

R1	100R	1	(M100R)
R2,3,8,12	47k	4	(M47K)
R4,15	4k7	2	(M4K7)
R5,25,29,33,37	100k	5	(M100K)
R6,11,14,21	18k	4	(M18K)
R7,22,23,27	6k8	4	(M6K8)
R9,10,13,17,34	8k2	5	(M8K2)
R16,18,20	27k	3	(M27K)
R19,30,39	10k	3	(M10K)
R24	1k2	1	(M1K2)
R26	12k	1	(M12K)
R28	680R	1	(M680R)
R31,35	5k6	2	(M5K6)
R32	560R	1	(M560R)
R36	820R	1	(M820R)
R38	180k	1	(M180K)
R40	10R	1	(M10R)
R41,42	270R	2	(M270R)

Capacitors

C1,3	470µF 16V PC Electrolytic	2	(FF15R)
C2,4,6,8	100nF Minidisc	4	(YR75S)
C5	4µ7F 63V PC Electrolytic	1	(FF03D)
C7	22µF 16V PC Electrolytic	1	(FF06G)
C9,47	220pF Ceramic	2	(WX60Q)
C10	2n2F Ceramic	1	(WX72P)
C11,31,32,35,36, 39,40,43,44	27nF Poly Layer	9	(WW34M)
C12,45	47µF 25V PC Electrolytic	2	(FF08J)
C13,17	3n3F Poly Layer	2	(WW25C)
C14,18,22,26	4n7F Poly Layer	4	(WW26D)
C15,19,23,27,29, 33,37,41	22nF Poly Layer	8	(WW33L)
C16,20,24,28	330pF Ceramic	4	(WX62S)
C21,25	2n2F Poly Layer	2	(WW24B)
C30,34,38,42	33nF Poly Layer	4	(WW35Q)
C46,48	10µF 50V PC Electrolytic	2	(FF04E)
C49	47nF Poly Layer	1	(WW37S)
C50	220µF 16V PC Electrolytic	1	(FF13P)

Semiconductors

IC1,2,3,4,5	1458C	5	(QH46A)
IC6	LM386	1	(UJ37S)

Miscellaneous

PL1,2	Minicon Latch Plug 2-way	2	(RK65V)
PL3	Minicon Latch Plug 6-way	1	(YW12N)
	Minicon Latch Housing 2-way	2	(HB59P)
	Minicon Latch Housing 6-way	1	(BH65V)
	Minicon Terminal	1 Pkt	(YW25C)
S1	Sub-Min Toggle A	1	(FH00A)
LS	L/S Lo-Z 768	1	(YW53H)
JK1	DPDT Jack Socket	1	(BW80B)
	PC Board	1	(GD95D)
	DIL Socket 8 pin	6	(BL17T)
	Constructors Guide	1	(XH79L)

Optional

7/0.2 Wire 10m BLK	1 Pkt	(BL00A)
7/0.2 Wire 10m RED	1 Pkt	(BL07H)
10k Pot Log	1	(FW22Y)
Knob KB4	1	(RW87U)
Instrument Case 3502	1	(YN33L)
Pozi Screw M3 10mm	1 Pkt	(LR57M)
Isoshake M3	2 Pkts	(BF44X)
Isonut M3	2 Pkts	(BF58N)
Power Socket 2.5mm	1	(HH86T)
Jack Socket 3.5mm	2	(HF82D)
Chassis Phono Skt	1	(YW06G)

The parts listed above, excluding Optional, are available as a kit, but is not shown in our 1989 catalogue:
Order As LM93D (Sharp Audio Filter Kit) Price £16.45
The following item is also available separately:
Sharp Audio Filter PCB **Order As GD95D Price £3.45**

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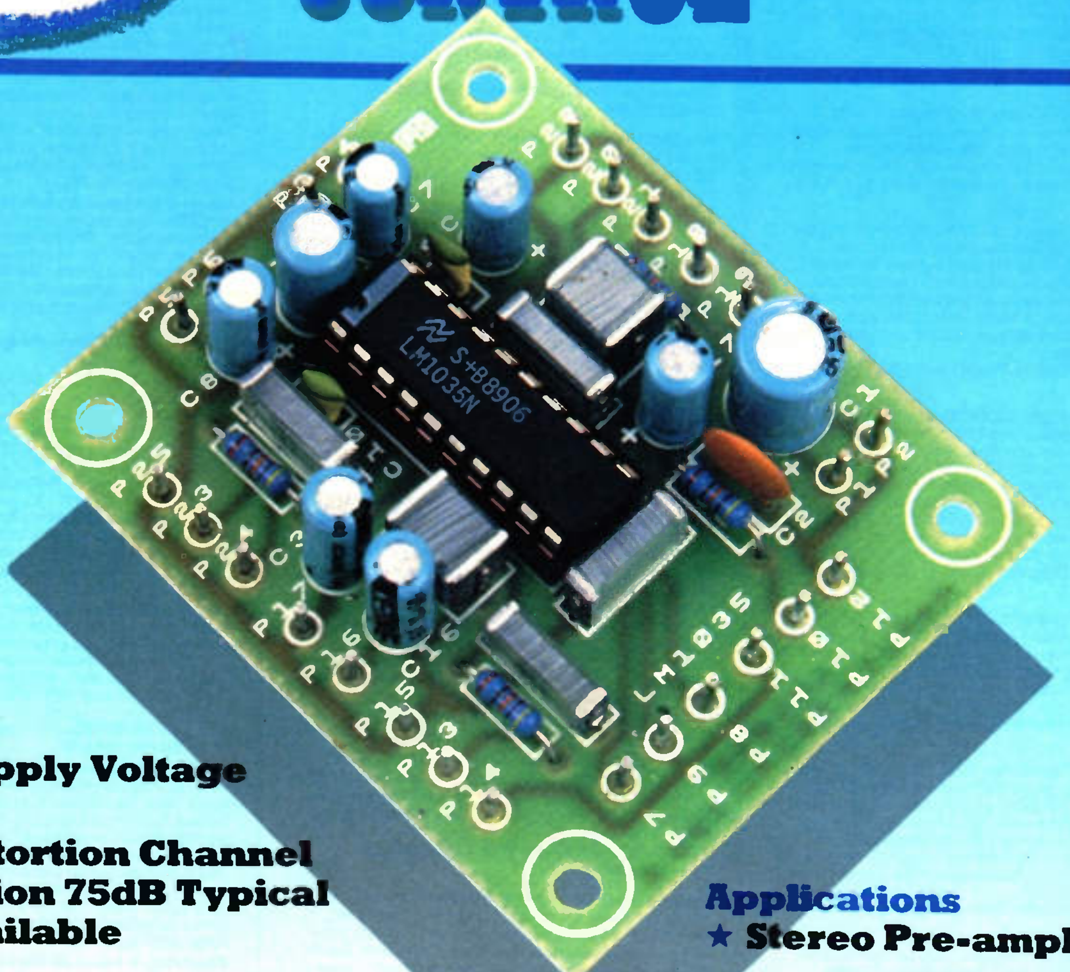
DATA FILE

LM1035 DUAL DC OPERATED TONE/VOLUME/BALANCE CONTROL



Features

- ★ Wide Supply Voltage Range
- ★ Low Distortion Channel
- ★ Separation 75dB Typical
- ★ PCB Available

Applications

- ★ Stereo Pre-amplifiers

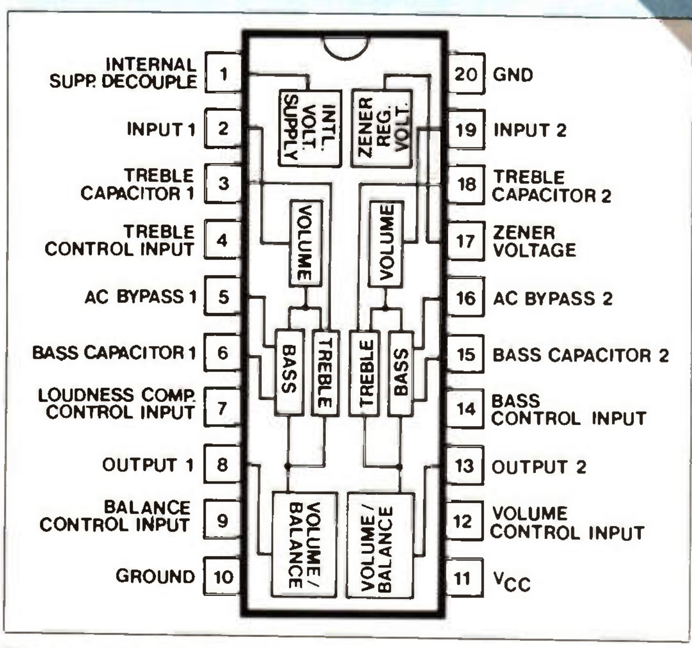


Figure 1. IC pin-out diagram.

Introduction

The LM1035 is a voltage controlled tone, volume and balance control IC incorporating provision for loudness compensation. Control is achieved by applying a voltage to one of four separate control inputs.

The control voltage may either be derived from an external source or taken from an internal zener stabilised reference voltage using a potential divider network. IC pin-out information is shown in Figure 1. Table 1 and Figure 2 show typical electrical characteristics for the device.

Parameters	Conditions	Minimum	Typ	Maximum
Supply Voltage (Vcc)		8V		18V
Supply Current			35mA	45mA
Control Pin Voltage				Vcc
Regulated Output Voltage			5.4V	
Regulated Output Current				5mA
Maximum Input Voltage	Test frequency 1kHz			
	Flat Response	2V rms	2.5V rms	
Maximum Output Voltage	Test frequency 1kHz			
	Vcc = 8V		1.3V rms	
	Vcc = 12V	2V rms	2.5V rms	
	Vcc = 18V		3.5V rms	
Volume Control Range	Test frequency 1kHz	70dB	80dB	

Table 1. Electrical characteristics of the LM1035.

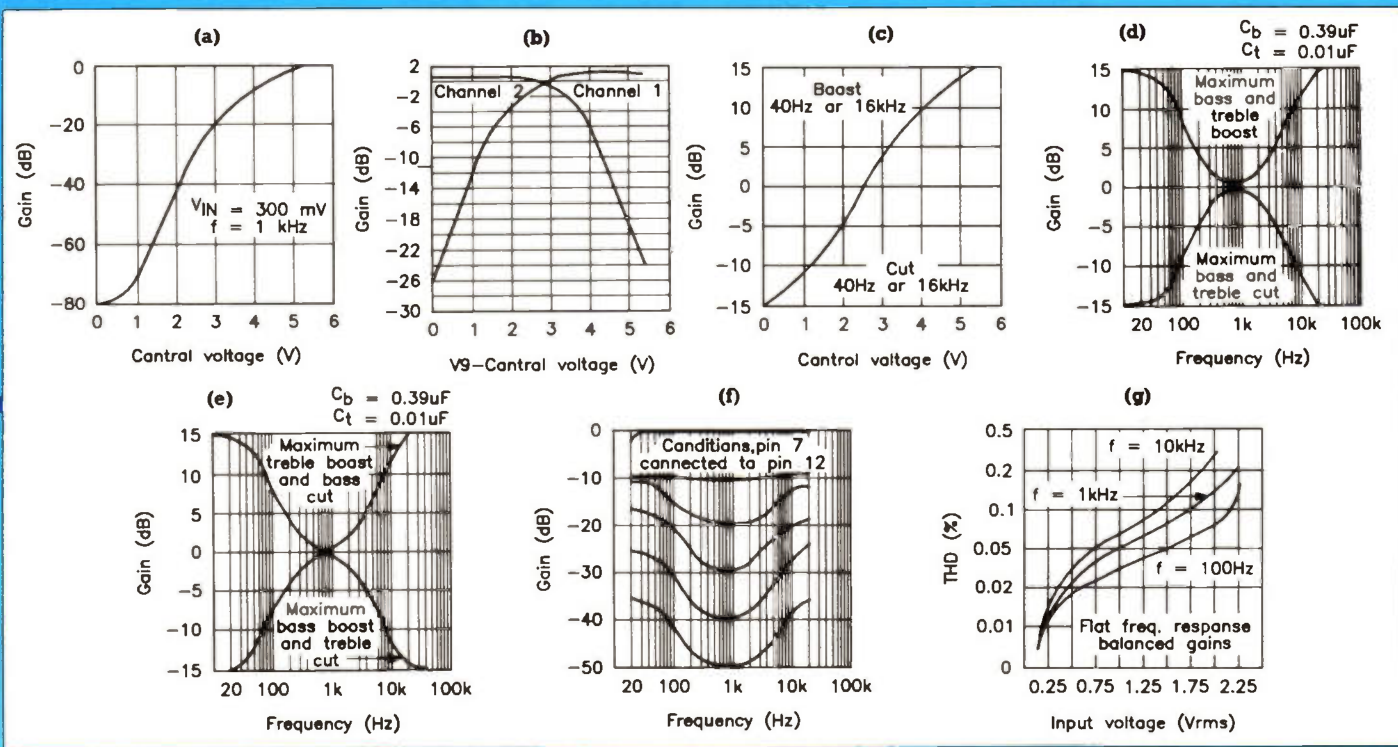


Figure 2. (a) Volume control characteristic. (b) Balance control characteristic. (c) Tone control characteristic. (d) Frequency response of tone controls (separate). (e) Frequency response of tone controls (combined). (f) Loudness compensated volume characteristic. (g) THD verses input voltage.

Frequency Response

The overall frequency response of each channel is determined separately by two pairs of capacitors. Referring to Figure 3, the bass and treble response characteristics for channel 1 are determined by the values of capacitors C6 and C10 respectively. Similarly the values of C5 and C9 determine the bass and treble response for channel 2. With the values shown, approximately 15dB of cut and boost should be obtained at 40Hz and 16kHz. Different capacitor values can be used to tailor the frequency response to suit individual applications.

Loudness Compensation

In order to achieve loudness compensation it is necessary to apply a DC control voltage to pin 7. The control voltage operates on the tone control stages providing additional treble and bass boost. Pin 7 of the IC can be connected to pin 12 providing a loudness compensated volume characteristic without the addition of any further components.

Zener Voltage

A zener controlled 5.4V regulated output is provided on pin 17 of the IC from which the four control voltages may be derived using potential divider networks. A control voltage equal to half of the zener voltage should result in a flat response and balanced gain between the two channels. The regulation is typically within ± 100mV of 5.4V and if an externally derived control voltage is used, the regulation should be of a similar tolerance.

Volume Control

Volume control is achieved by applying a DC voltage to pin 12. The first stage of volume control comes before the tone control stages and exhibits approximately 15dB of attenuation; this helps to reduce the possibility of

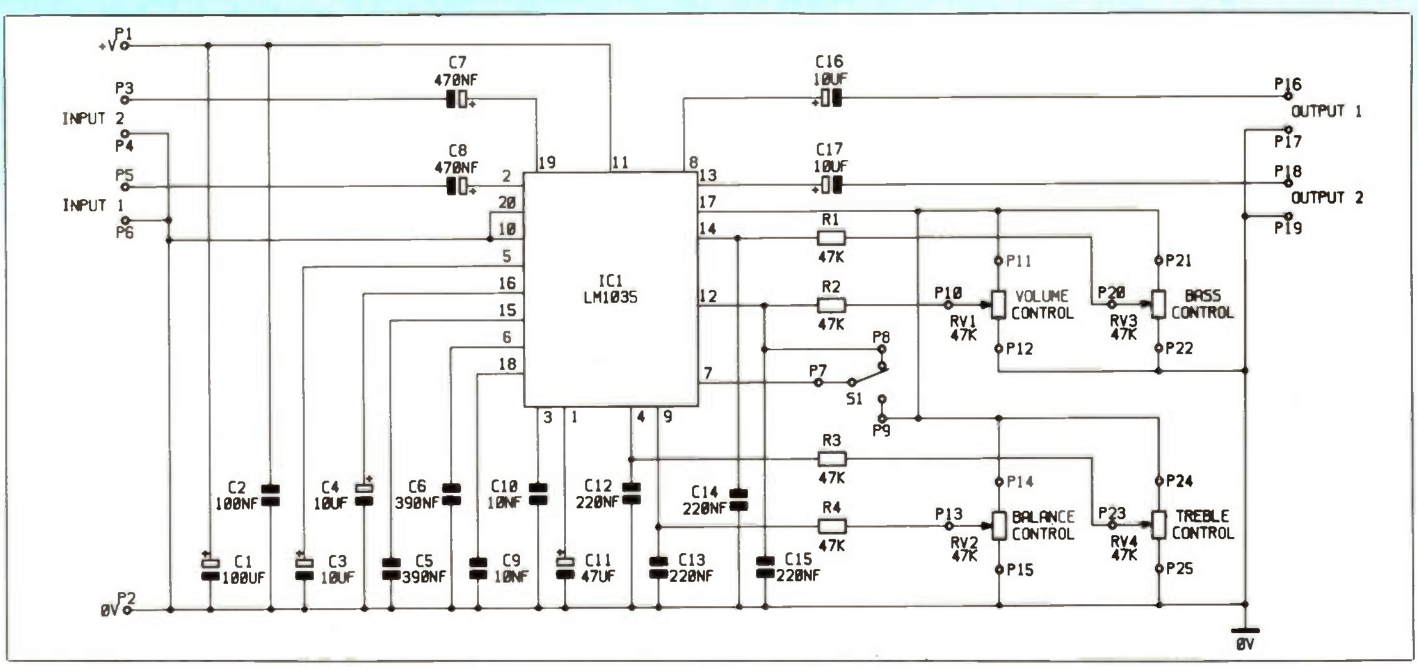


Figure 3. Circuit diagram.

Power Supply Voltage	8V - 18V
Quiescent Current Drain (at 18V)	44mA
Maximum Input Voltage (flat response)	3.1V rms (18V supply)
Gain (flat response, volume set to maximum)	0dB

Table 2. Specification of prototype.

overloading the circuit and also helps to increase the signal to noise ratio. The maximum input voltage is generally dependant on the setting of the tone controls. Any combination of tone/volume settings may be used so long as the output voltage does not exceed approximately 2V rms (for a supply voltage of 12V) or 1V rms (for an 8V supply).

IC Power Supply Requirements

The LM1035 IC will operate over a wide range of power supply voltages between 8V and 18V. IC current consumption is typically around 35mA. Please note that it is important that the supply is adequately decoupled close to the device in order to prevent excessive noise and instability.

Printed Circuit Board

A high quality fibre-glass PCB, with printed legend, is available as an aid to constructors wishing to build the basic LM1035 tone/volume/balance control circuit. Figure 4 shows the component layout diagram. An 8V to 18V DC supply is required to power the unit. The power supply should be capable of delivering at least 50mA and should be suitably decoupled to prevent the introduction of mains derived noise onto the supply rail. Power supply connections are made to P1(+V) and P2(0V).

Input signals are applied on P3 and P5 with the corresponding 0V connections on P4 and P6. Output signals are taken from P16 and P18 with associated 0V connections on P17 and P19 respectively. The wiring information for the switch and the four rotary controls is shown in Figure 5. Table 2 shows the specification of the prototype circuit built using the PCB.

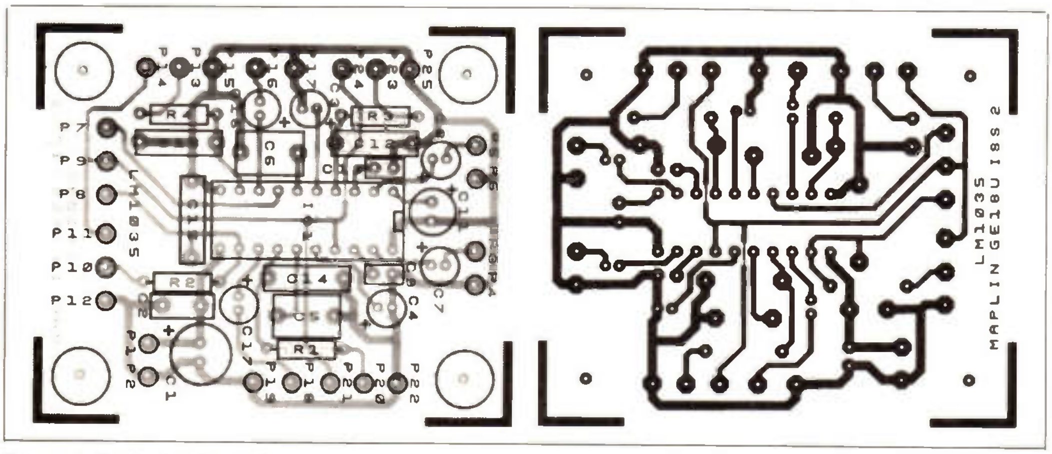


Figure 4. Component layout.

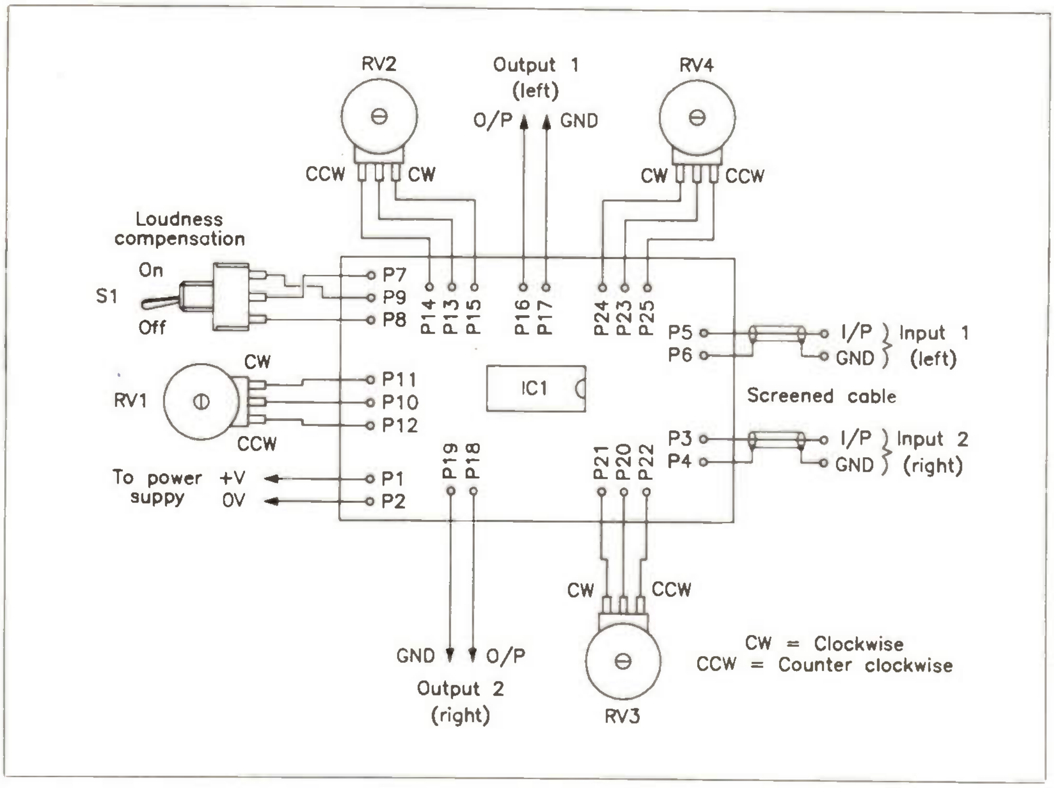


Figure 5. PCB wiring.

LM1035 PARTS LIST

Resistors: All 1% 0.6W Metal Film

R1-4	47k	4	(M47K)
RV1-4	47k Pot Lin	4	(FW04E)

Capacitors

C1	100μF 25V PC Electrolytic	1	(FF11M)
C2	100nF Disc Ceramic	1	(BX03D)
C3,4,16,17	10μF 50V PC Electrolytic	4	(FF04E)
C5,6	390nF Polylayer	2	(WW48C)
C7,8	470nF 100V PC Electrolytic	2	(FF00A)
C9,10	10nF Ceramic	2	(WX77J)
C11	47μF 25V PC Electrolytic	1	(FF08J)
C12-15	220nF Polylayer	4	(WW45Y)

Semiconductors

IC1	LM1035	1	(QY19V)

Miscellaneous

	PC Board	1	(GE18U)
S1	Sub-Min Toggle A	1	(FH00A)
	DIL Socket 20 Pin	1	(HQ77J)
	Pins 2145	1 Pkt	(FL24B)
	Constructors Guide	1	(XH79L)

The following item is available, but is not shown in our 1989 catalogue:
LM1035 PCB **Order As GE18U Price £1.95**

ELECTRONICS BY EXPERIMENT

By Graham Dixey C.Eng., M.I.E.R.E. Part 9

Introduction

Most of the active devices encountered in 'power electronics' are members of the thyristor family. The latter group includes a wide range of 'four-layer devices', such as the Silicon Controlled Rectifier (SCR), Triac, Diac, Silicon Controlled Switch (SCS), Silicon Unilateral Switch (SUS), Silicon Bilateral Switch (SBS), Light Activated SCR (LASCR) and a few others besides. A wide range of applications is possible with these devices that can be investigated without undue difficulty by the home experimenter. Some of these will use d.c. supplies, 12 or 24 volts being quite adequate, a useful load being a low power bulb; for some experiments a 12V 21W automobile bulb is suitable, others are more conveniently tested with bulbs of much lower power, say 12V at 60mA. This type of load will give a readily observed indication of circuit operation. In the case of a.c. circuits, the mains supply is an obvious source of power but care must be exercised in its use, naturally. However, it is difficult to carry out any worthwhile experiements on power control circuits without employing it. Since such experiments are the subject of the next article in this series, more will be said about this subject next time.

Two separate articles will be devoted to thyristor circuits, this first one dealing with low voltage d.c. circuits, using the SCR, the following one dealing with a.c. circuits, and including a wider range of thyristor devices.

The Silicon Controlled Rectifier

Figure 1 (a) shows the nature of the basic four-layer construction of this device. It has three electrodes, the anode and cathode at the 'p' and 'n' ends of the silicon bar, respectively, and the gate, whose terminal is connected to the p region adjacent to the cathode. As might be expected, in normal usage the d.c. supply is connected so that the positive terminal goes to the anode and the negative terminal to the cathode. The gate we will return to in a moment.

Figure 1 (b) shows the relation between the anode-cathode voltage and the anode current. The third quadrant i.e. the one in which $-V$ is plotted against $-I$ shows the characteristic that is normally associated with any reverse-biased rectifier diode. For a large variation of voltage only a minute reverse current flows; it is virtually 'blocked off', hence the term 'reverse blocking state'. However, if the reverse voltage is made large enough, breakdown occurs and a large current flows. This sudden combination of high current and high voltage (giving high power) usually results in rapid destruction of the device. It is avoided by choosing a device whose reverse breakdown voltage is somewhat higher than the highest voltage that will be met with in practice. In the first quadrant ($+V$ against $+I$) there is a forward blocking action at first until the forward voltage is high enough, when a large forward current flows. However, in this case, the forward voltage falls to a very low value (about 1V) so that destructive over-dissipation does not occur. Figure 1 (b) actually shows three forward characteristics, marked $I_G1 = 0$; $I_G2 > I_G1$; $I_G3 > I_G2$. The difference is that when the gate current, I_G, is zero a large value of forward voltage is required to make the device break down, but as the gate current is increased the anode voltage requirement for breakdown gets less. Put around the other way, if a moderately large voltage, in the forward direction, is applied between anode and cathode, with the gate current initially zero, then if a sufficiently large gate current is applied, the device will instantly switch from being virtually open circuit to heavily conducting.

The symbol for the SCR is shown in Figure 1 (c) and is seen to be nothing more than a diode symbol with a third connection, the gate, made to the cathode bar. Sometimes it is enclosed in a circle.

To understand how the SCR is able to switch from a very high to a very low resistance state, the 'two-transistor analogy' of Figure 2 is often used. This makes it particularly easy to appreciate the nature of the regenerative switching action. The equivalent two transistors are formed by considering that the middle two regions are common and hence electrically joined and yet, a part of each can be considered as if it belonged to each transistor separately. In this way it is easy to see that a loop is established whereby the collector of TR1 (the PNP transistor) supplies the base current of the NPN

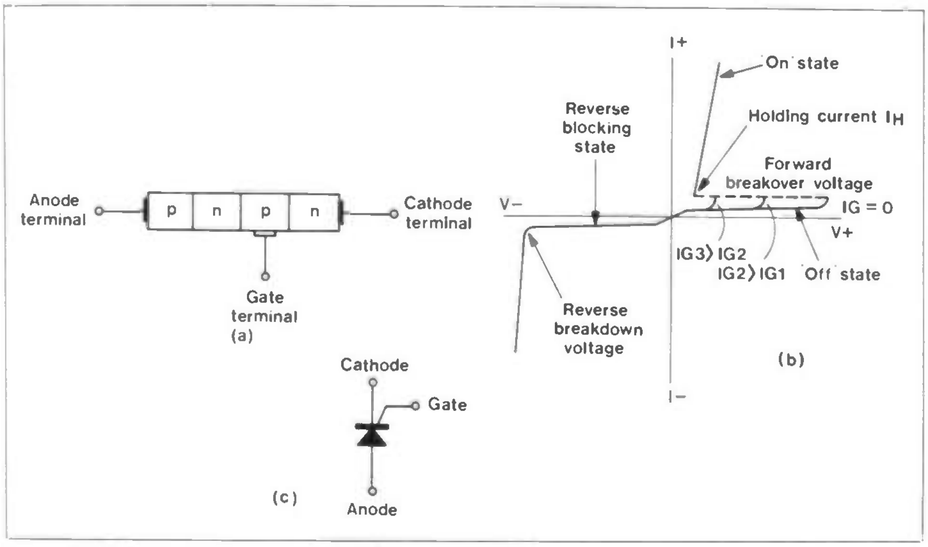


Figure 1. (a) Four layer construction. (b) Characteristics. (c) Circuit symbols for an SCR.

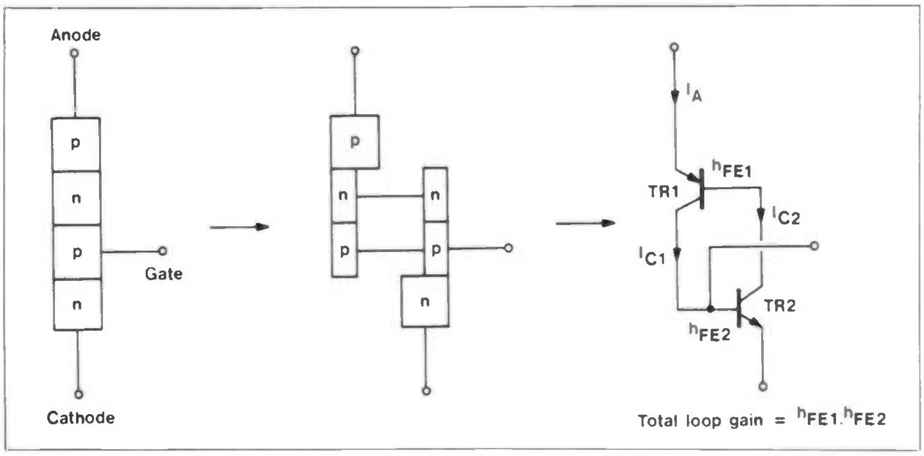


Figure 2. The two-transistor analogy that explains the regeneration in the SCR.

transistor, TR2, while the collector of the latter supplies the base current for TR1. Thus, there is a closed loop of dependence. The reason that the SCR doesn't switch on immediately a voltage is applied to it is due to the fact that when the gate current is zero the collector current of each transistor is merely a minute leakage current. This gives rise to very low values of current gain in each transistor; consequently the product $h_{FE}1$ x $h_{FE}2$ is less than one. It is only when this product is greater than one that the switching action can commence. To increase the current gains of TR1 and TR2 the collector currents must, in some way, be raised since h_{FE} depends upon collector current. This is where the gate current comes in.

The gate terminal is effectively the base terminal of TR2. Therefore, a supply of gate current from some external source will cause base current to flow in TR2 resulting in a higher collector current in TR2; this will provide base current to TR1 in turn and its collector current will rise; gradually the values of h_{FE} for the two transistors will rise. The collector of TR1 now supplies a higher base current to TR2, whose collector current rises, supplying more current to the base of TR1, and so on. The regenerative action can be clearly seen from this. The total current, I_A, rises rapidly from virtually nothing to a value limited only by the resistance of the load connected in series with the SCR.

An interesting and useful characteristic of the SCR is its 'self-latching' property. Once the gate current has turned the SCR on, removing it has no effect. The only way of turning the SCR off is either to remove the d.c. anode supply completely or to reduce the anode current below a critical value known as the 'holding current'. See Figure 1 (b). The reduction in V_A or I_A in order to turn the SCR off need only be momentary – in some cases for just a few microseconds. As long as the gate circuit is open or high resistance the SCR will stay off. This self-latching property is especially useful in alarm systems, since the momentary opening of a door or window can trigger an SCR switching circuit on, which will stay in the 'alarm' state even though the door or window is immediately closed.

Figure 3 shows a simple circuit that will demonstrate the basic action just described. The gate is taken to the junction of two resistors, R1 and R2. A normally open push button switch, S1, is wired in the path from R1 to the positive side of the supply. The load, a 12V lamp in this case, is wired in series with the SCR, a normally closed push-button switch, S2, and the d.c. supply. When the latter is first applied the lamp will be off. Operating S1 will then immediately supply enough gate current to the SCR, causing it to switch on, and supply power to the lamp. Releasing S1 will be found to have no effect; the lamp remains on – this is the self-latching action mentioned earlier. However, if the switch S2 is operated, the lamp immediately goes out, since open-circuiting the anode supply will reduce the anode current to zero, that is below the holding current value, I_H. As an alternative to placing a normally closed switch in series with the SCR, it is possible to connect a normally open push button across it; operating this will short-circuit the SCR, depriving it of its anode current and so turning it off.

Having found out these basic facts, it is possible to be a little more analytical in approaching this circuit. For example, assuming that the d.c. supply used for the experiment can be varied down to virtually zero volts, it is worth trying the effect of reducing the supply once the SCR has been triggered; it should be found that the supply can be reduced to less than 2V before the SCR 'unlatches'. Not surprising really since the holding current is often only a few milliamps, depending upon the SCR type. Something else that can be tried is to reduce the supply voltage BEFORE triggering the circuit to find out what is the lowest supply voltage at which the SCR will strike. This should be found to be quite low as well, though not as low as in the last test. It is also useful to measure and record the forward voltage between anode and cathode of the SCR when it is conducting; this will probably be found to be only a volt or so. The product of this forward voltage and the anode current that the SCR is supplying to the load represents wasted power (converted into heat), so the lower the SCR's forward voltage the better.

Although not applicable in this particular case, if the load is inductive, a motor or relay for example, a diode should be connected across it as shown, in order to protect the SCR from the back e.m.f. generated when the load current is switched off.

In a simple but practical alarm system, S1 would usually comprise several switches in parallel, one for each possible entry point, any one of these triggering the alarm on (the alarm replacing the lamp) when a door is opened or closed. The switch S1 is then used to 'kill' the alarm subsequently. What prevents this from being a totally practical system is the lack of a time delay required to 'arm' the system and allow the owner to exit the protected vehicle or building without tripping his own alarm.

The action of switching off a conducting SCR is termed 'commutation' and is an inherent problem in d.c. circuits. As will be seen in the next part, a.c. circuits are 'self-commutating', although they also have their own particular problems. Figure 4 shows a circuit in which a 'commutative capacitor' is used. This circuit has the advantage that the 'off' push-button doesn't have to switch the heavy anode current; in some SCRs this can run to hundreds of amperes. The real work is done by a second, 'slave', SCR. The way it works is as follows.

When power is first applied to the circuit neither SCR is on. Operating push-button S1 supplies the gate of SCR1 (the main SCR) with enough current to switch this SCR on and energise the load. This now provides a charging path for C1 through R3 and SCR1. This capacitor, the so called 'commutating capacitor', rapidly

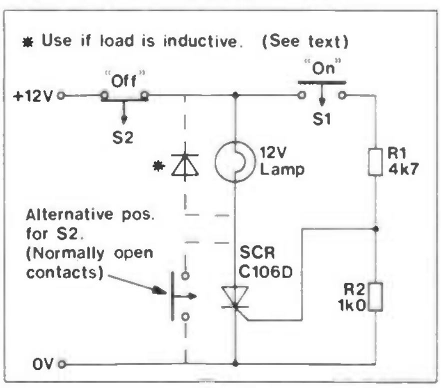


Figure 3. Simple d.c. on/off switching circuit.

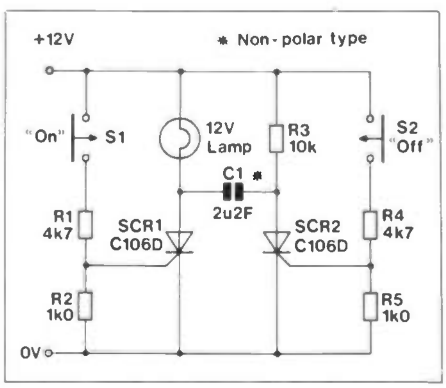


Figure 4. Use of 'slave' SCR and 'communtating' capacitor.

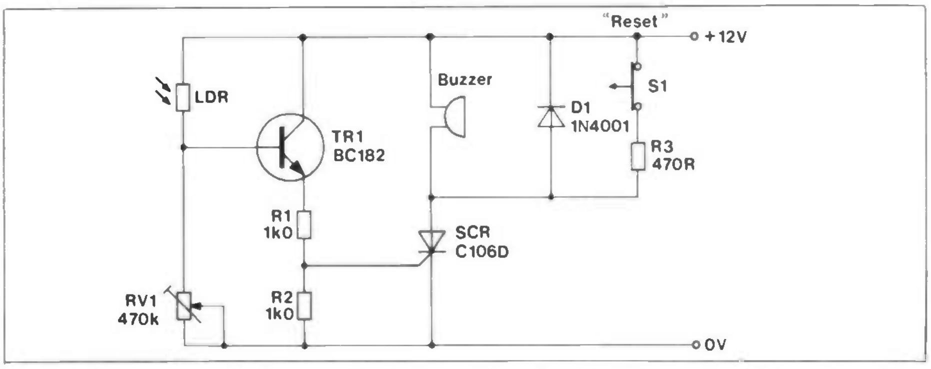


Figure 5. Light-operated alarm circuit; buzzer sounds when light falls on LDR. If positions of LDR and RV1 are reversed, circuit then responds to interrupted light source.

charges up to the full value of the supply voltage, the right hand plate being positive. If now the push-button S2 is operated, the slave SCR, SCR2, turns on and its anode voltage falls to about +1V. Because of the potential across C1 its left hand plate falls to about −11V thus reverse-biasing SCR1 and turning it off. How can SCR2 be turned off?

One possibility uses the fact that, when SCR1 is off, a charging path for C1 exists through the load and SCR2, so that again C1 charges up, but this time in the opposite polarity. For this reason it is necessary for this component to be a 'non-polar' type, either electrolytic or polyester. The result is that the next time SCR1 is switched on, a similar action to that already described will switch SCR2 off, so that it is then ready to commutate SCR1 when the latter next requires it. In this example the conduction 'toggles' between the two SCRs. However, there is an alternative, simpler method that is used in this circuit. If the anode load of SCR2, R3, is sufficiently large, it will not pass a high enough anode current to maintain conduction. SCR2, having been initially switched on by S2 will immediately 'drop out' again, after having done its job of commutating SCR1.

There is one reservation with this method and that is that the charge stored in the commutating capacitor must be sufficient to ensure that the anode of SCR1 is held negative long enough for this SCR to come out of conduction. The more current SCR1 is conducting, the greater must be the stored charge in C1. It is recommended that a lower power lamp, say a 12V 4W auto bulb, be tried in the circuit shown, otherwise the value of 2.2μF given for C1 may well be inadequate; it is worth trying a few different loads of low and high power to prove the truth of this statement.

It is only necessary to supply enough gate current to an SCR to turn it on, provided that there is a sufficient anode voltage supply. Other ways of providing the required gate current apart from a mechanical switch are possible. One way is to use a Light Dependent Resistor (LDR) to switch the base current of a transistor, which then supplies the required gate current. A possible circuit is shown in Figure 5. The LDR chosen should have a fairly high 'dark' resistance – an ORP60 rather than an ORP12 for example, although adjustment of sensitivity can be made by variation of the setting of RV1, which will also compensate for different types of LDRs. In this circuit, the buzzer sounds when the light falling on the LDR reaches a sufficient level to trigger the SCR. Alternatively the action of the circuit may be reversed by interchanging the positions of the LDR and RV1. The buzzer then sounds when a light beam falling on the LDR is interrupted. The best way of arranging the 'optics' is to place the LDR at the bottom of a fairly narrow tube and focus the light beam from a lamp onto its surface with a lens. This ensures that the circuit still works even when there is a fairly high level of ambient light.

The way in which this circuit is commutated is interesting and depends upon the fact that a buzzer works by means of an oscillating contact. This means that the current through the buzzer coil is continuously interrupted and the only way to hold the SCR in the conducting state is to provide an alternative conducting path, in this case through the normally closed push button switch S1 and R3. To commutate the SCR, S1 is operated. No current can now flow through R3 and the next time the buzzer contact opens the SCR turns off because it has lost its anode current. Diode D1 is included because the buzzer coil represents an inductive load. Obviously the load doesn't have to be a buzzer; it can be whatever the constructor likes.

In the previous part of this series the unijunction transistor (UJT) was the subject of a number of experiments. These useful switching devices are often used in conjunction with thyristors, and Figure 6 shows an example of such an application.

The circuit is a 'precise timer', so called because the triggering point of a UJT can be very precisely defined. In the circuit shown, the d.c. supply to the UJT is stabilised by the resistor R4 and a zener diode D1. The capacitor C1 has a short circuit across due to the contacts of the 'initiate' switch S1. When these contacts are opened at the commencement of the timing cycle, C1 then charges up towards 12V through R1 and RV1 in series, the time constant being adjustable by varying RV1. When the peak point voltage of the UJT is reached the SCR is triggered and current is supplied to the load. Diode D2 and resistor R4 provide a conducting path for the SCR so that, if the load is removed, the current through the SCR is still maintained at a level in excess of the holding current. Thus, in this case, interrupting the current through the load itself has no effect. Commutation is achieved by applying a short circuit across the SCR with the switch S2.

No values are given for C1 and RV1 since they can have any of a vast range of values according to the time delay required. Very long time delays can be achieved by using a high value of RV1 with a large value electrolytic capacitor. Accuracy will be adversely affected if the leakage current of the capacitor is excessive. There is an upper limit to the value of RV1 since if it is excessively large it will be unable to supply enough emitter current to the UJT to allow it to fire. The starting point for the timing cycle is precisely defined if a mechanical switch is used because this removes all charge from the capacitor so allowing it to start in a fully discharged state.

Now we come to something a little more spectacular – a 'ring counter' using not TTL logic but power devices, namely SCRs! It may be remembered that a ring counter is a closed ring of active devices, only one of which has a 'one' (i.e. a 'high' level) entered into it, all others being 'low'. It is then clocked with a pulse input and the 'one' passes from one stage to the next, finally leaving the last stage in the ring (an apparent contradiction!) to re-enter at the first stage. In other words as long as clock pulses are applied a 'one' circulates indefinitely around the ring. Ring counters have a variety of functions, the circulating 'one' often being used to enable a series of display devices in sequence. In this case power is transferred from one load to the next in sequence.

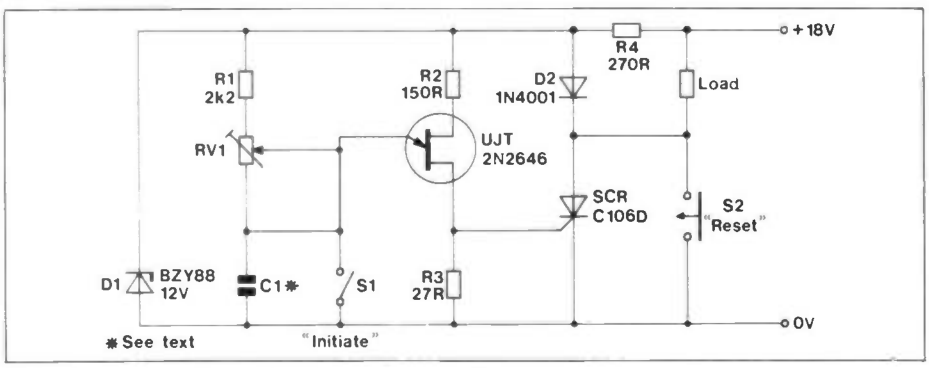


Figure 6. Precision timer using UJT trigger circuit.

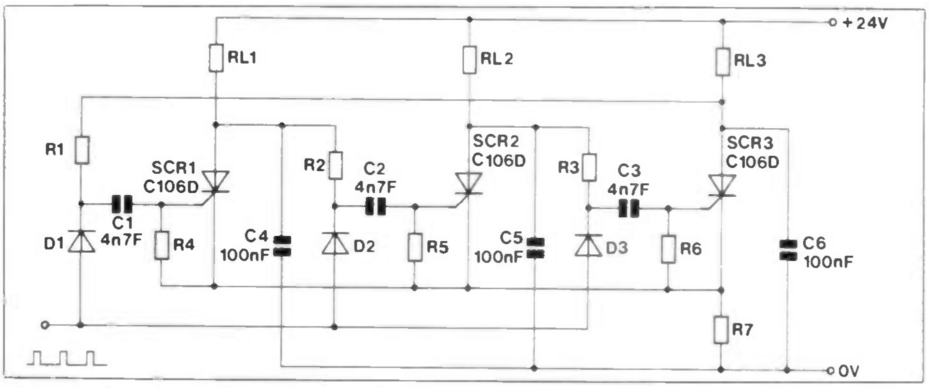


Figure 7. Cathode-coupled SCR ring counter.

Although the circuit of Figure 7 shows only three SCRs in the ring, the number can be extended indefinitely, all stages being identical. The original circuit was intended to switch relatively high voltage (180V) low current (50mA) loads but will work with lower voltages for demonstration purposes.

Assume that SCR1 is conducting, the other SCRs being off. Capacitors C3 and C1 charge to the supply voltage through R3/RL2 and R1/RL3 respectively, while capacitors C5 and C6 charge through RL2 and RL3. Because SCR1 is conducting, C2 and C4 cannot charge. When a shift pulse is applied via the shift line, only SCR2 can be triggered, since its steering diode D2 is the only diode not reverse-biased by a charged capacitor. In fact it is always the SCR following (i.e. to the right of) the conducting one that is the only one that can trigger. As SCR2 turns on, capacitor C5 is connected across R7, which drives the common cathode line momentarily to the supply voltage value, so reverse biasing SCR1 and turning it off. This process is repeated down the ring when the next shift pulse arrives.

The lamps used should not be high power types as the charge on any of the commutating capacitors may be insufficient to force the conducting SCR to drop out. In practice a small lamp of 12V 60mA rating, or so, should work well with R7 chosen to drop the excess 12V at this current, that is the value of R7 is given by 12/0.06 which equals 180 ohms, to the nearest preferred value. For switching higher power devices the capacitors C4, C5 and C6 should be increased in value; they must, of course, be non-polar types for reasons already explained. For the values given in Figure 7 polyester types are readily available. The values of R1, R2 and R3 should be chosen to be about 5-10 times the values of RL1, RL2 and RL3 respectively, these normally being identical values. Taking the 'hot' resistance of the lamps mentioned as the base, the values of RL1, RL2 and RL3 work out at 12/0.06 = 200 ohms, so that suitable values for R1, R2 and R3 would be 1-2k. As a source of shift pulses, the 555 timer described in Part Eight of this series should be suitable, with the value of the timing capacitor, C1, changed to 22μF to give a frequency of about 4Hz, or 100μF for a frequency of just less than 1Hz.

Another circuit that makes use of a UJT to trigger an SCR is shown in Figure 8.

The UJT operates as a relaxation oscillator producing positive triggering pulses to drive the gates of a pair of SCRs. The frequency of the pulses is variable over a wide range by means of RV1; the time constant for the UJT is, of course, (R1 +RV1).C1. The output pulses are capacitively coupled to the SCR gates by C2. The SCRs are once again connected in a self-commutating circuit. In this particular case, the commutating capacitor is C3, a 6.8μF non-polar type. A polyester capacitor was used in the original circuit.

Assume that the lamp driver SCR2 has been triggered on by a pulse from the UJT. Its anode potential will be low and a conducting path will exist for charging current through R4, C3 and SCR2 in series. C3 will, therefore, charge up to nearly 12V, the left hand plate being positive. The next pulse to arrive from the UJT can only have an effect on the presently non-conducting SCR, namely SCR1. This will switch on, its anode voltage will fall by about 11V and the charge on C3 will pull the anode voltage of SCR2 down to about −10V, thus depriving it of current and causing it to drop out; the lamp will extinguish. Because the anode load of SCR1 is fairly high (2k2), there will be insufficient current to hold this SCR in conduction. It will therefore drop out. SCR2 will therefore switch on and off on alternate pulses and the lamp will flash at a rate equal to half the frequency of the pulses. The lamp used in this circuit was also a 12V 60mA type but the larger value of commutating capacitor, 6.8μF, will allow higher powers to be switched.

The final circuit of Figure 9 shows a very valuable, and frequently used, application of SCRs in the protection of circuits in which over-voltages cannot be tolerated. This actually implies a whole range of circuits where ICs are employed since these components often do not like voltages in excess of their normal operating value. TTL logic is a good example, not being at all tolerant of over-voltages. However, for many purposes the reliability of stabilised voltage supplies and the cheapness of most TTL chips makes the use of elaborate protection circuits an expensive luxury that cannot be justified. On the other hand, TV receivers often contain a number of fairly expensive chips and over-voltage protection is commonly incorporated. Such a circuit works by detecting the over-voltage and triggering an SCR which applies a short circuit across the output of the power supply immediately. This entirely removes the supply to the receiver circuits, so protecting them. The power supply often contains its own short circuit protection, so that no actual harm is likely to be done. However, total protection can be obtained by making the SCR not only clap a protective short circuit across the sensitive circuits but also trip a circuit breaker that disconnects the power completely.

In the circuit of Figure 9 two UJTs are connected so as to share a common Base 1 resistor, R5; there is a direct connection from this point to the gate of the SCR. This means that if either UJT triggers it will produce an output pulse across R5 which will trip the SCR and give the required protection. One UJT (TR1) has its emitter connected to the wiper of a preset potentiometer, so that it picks off a pre-determined proportion of the supply voltage. This proportion is slightly less than the peak point voltage of the UJT. However, if there is a sudden rise in supply voltage, due to a power supply fault, the voltage at RV1 wiper, and hence at the emitter of TR1, will exceed the peak point voltage and the UJT will fire and trigger the SCR into the conducting state. This particular circuit also protects against over-currents by sensing the current drawn through the series resistor R7. This second UJT, TR2, is used in precisely the same manner as TR1. The preset potentiometer RV2 is adjusted so that, at the required current limit, the voltage at its wiper is just less than the peak point voltage of TR2. Any significant increase in load current and the potential at TR2's emitter will rise, due to the increased volt drop across R7, TR2 will fire and the SCR will turn on, protecting the supply as before.

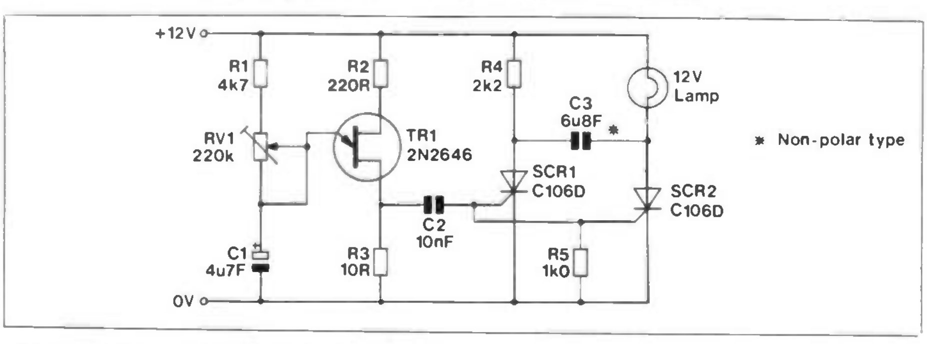


Figure 8. D.C. low power lamp flasher.

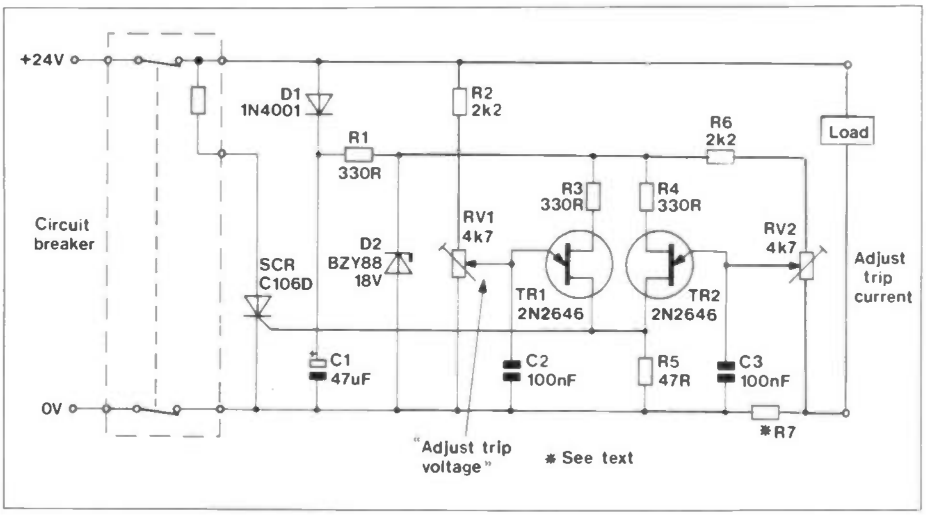


Figure 9. Electronic 'crowbar' circuit giving both over-voltage and over-current protection.

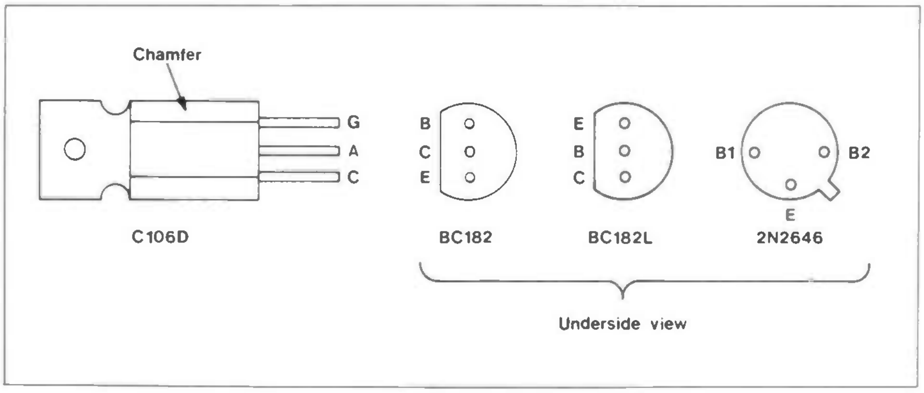


Figure 10. Pin-outs for devices used in this article.

Because such a circuit is intentionally sensitive to voltage and current variations, there is always the possibility of false tripping occurring due to short and harmless transients. To reduce this tendency the circuit shown includes D1 and C1 to filter out line transients, and both RV1 and RV2 have a parallel capacitor of appropriate size to provide a time constant for the emitters; thus, short duration transients do not have time to trip the circuit. The UJT circuit is fed with a stabilised 18V supply, provided by R1 and D2.

This circuit is included because it obviously offers scope for the home experimenter, and is also a useful add-on device to construct and have available when testing other circuits in which over-voltages or short-circuits are undesirable. Having built it and connected it to the output of a variable power supply, with a variable load e.g. a rheostat in the position shown, the range of each potentiometer, RV1 and RV2, can be measured. The circuit breaker does not have to be included if it is not conveniently available. The circuit will then simply apply a 'brute force and ignorance' approach by placing, very rapidly, a nice, positive short circuit across the output of the power supply – hence the term 'crowbar'!

Finally, Figure 10 shows the connections to the various devices used in this article. And so till next time when thyristors in a.c. power circuits will be the topic for experiment.

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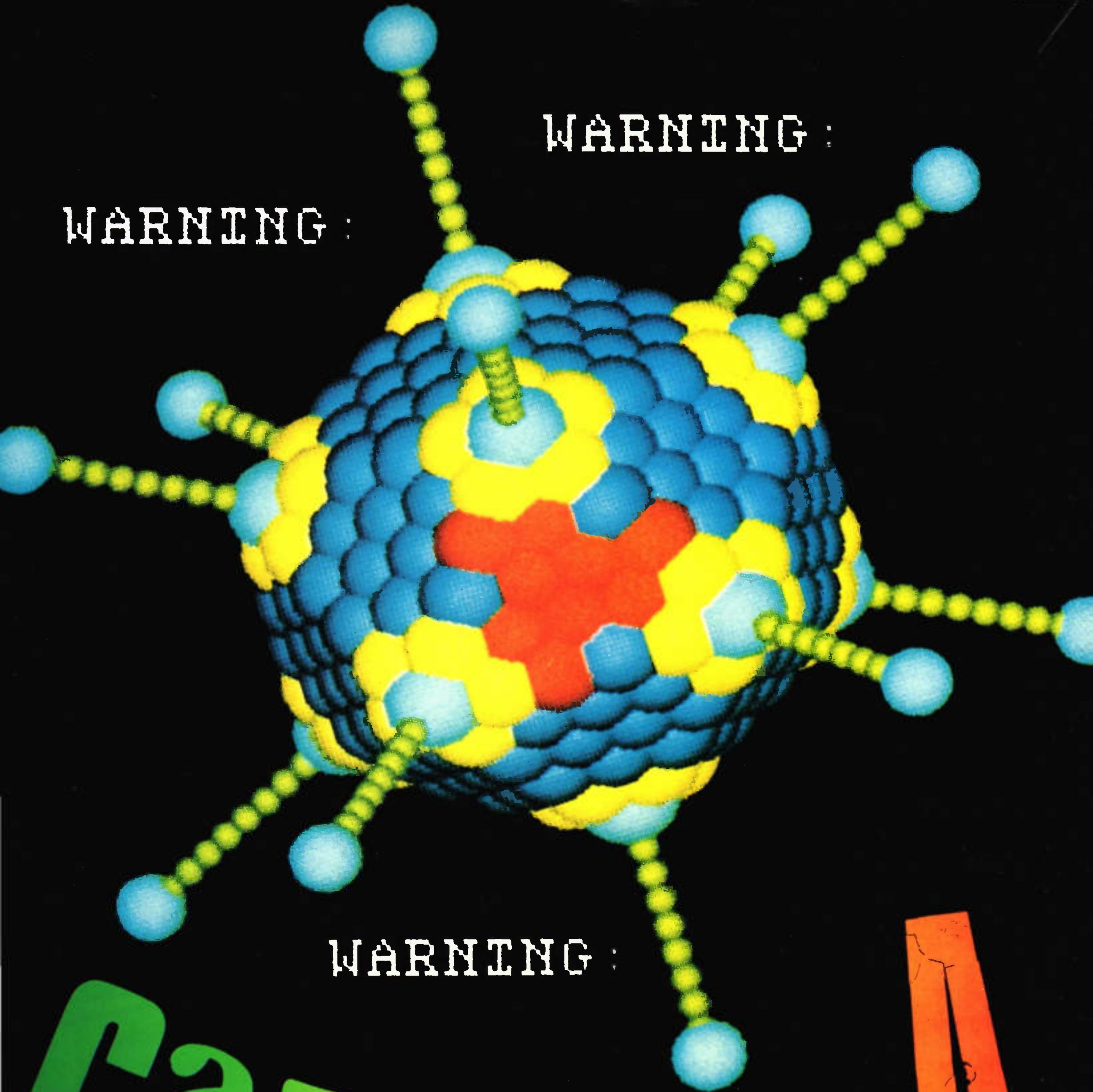


Catching A Virus Cold

By Alan Simpson

Viruses – Myth or Menace

What have the following in common: 1813, Trojan Horses, Stoned Worms, Logic Bombs. No, not the local SAS outward bound assault course but the world of computer viruses. But one thing is for sure. It certainly helps when getting to grips with virulent viruses to have more than a passing knowledge in medical terminology. Carriers spread infection, reproduction can be dormant or spontaneous.

If the computer experts are to be believed, the industry is under assault by a plague of viruses, hackers and eavesdroppers. No wonder that computer security is the flavour of the month – or more probably the year.

According to Peter Jenner, Principal of the PA Consultancy Centre, computer virus is a phenomenon which has recently achieved a high profile through coverage in the media. It has also become a more significant problem to computer system users because of the greater level of networking which has developed and the growth of use by non-professional IT personnel.

Computer virus is, says PA, simply a piece of software which is able to create other software. It may do this by generating exact copies of itself, or by growing or changing itself in response to internal or external stimuli.

Benign or Mischievous

The action of the virus, it seems, is only limited by the capability of the system which has been infected and the skill/knowledge of the originator. It can range from benign, through mischievous, to malicious, dependent on the motives of the creator. Within the confines of the host system, anything is possible. It should however be noted, says Peter Jenner, that the "host system" is often larger than you might think if it has links to other systems.

A virus can spread from one machine to another whenever there is contact between the systems. The transfer can take place via any type of media. These include:

★ direct machine to machine communications
★ any type of telecommunications, link or network
★ floppy disk, hard disk, paper tape or magnetic tape.

It is also possible for a virus to be generated accidentally. This can occur either through a mistake in programming, or as a result of some hardware fault. But fortunately such events are rare. It is also possible to introduce a virus directly into any system merely by writing the virus program on the machine concerned.

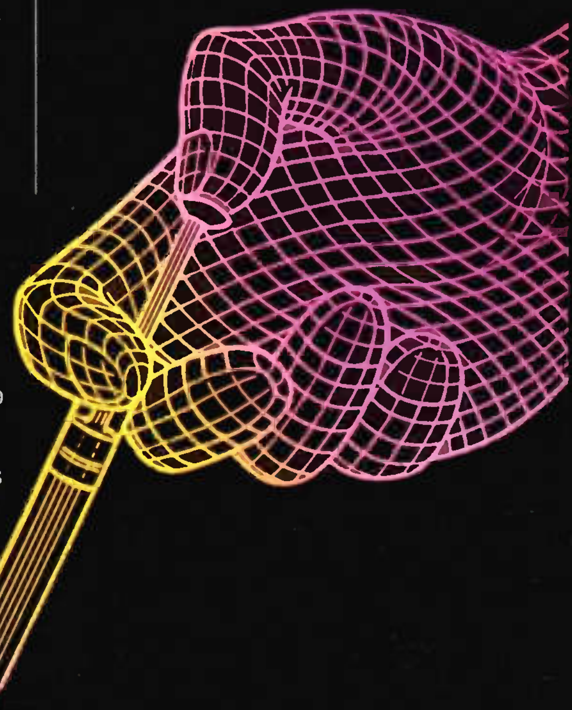
The two most common ways of spreading a virus, reports PA, are across a networked system of similar machines, or via floppy disks transfer of programs. This, points out PA, is particular prevalent in the transfer of games programs from one PC to another.

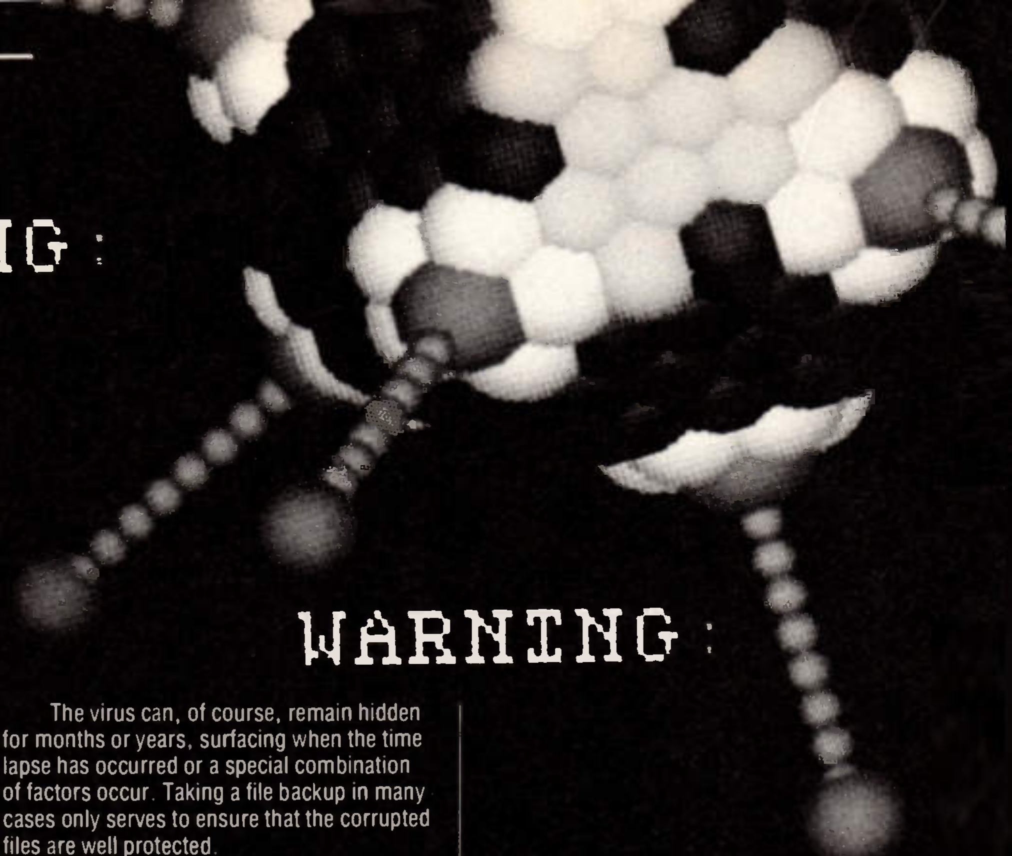
Just about the only common factor in viruses, it seems, are their somewhat sinister sounding names. The Complete Computer Virus Handbook notes such delights as Creeper, Reaper, Flu Shot 4, Elk Cloner, Pervading Animal as well as the highly lethal Bombsquad.

However, an exception to the sinister sounding rule is the IBM Xmas Tree Virus which served to generate seasonal greetings to all IBM network users, causing almost the entire network to grind to a non-seasonal halt. There is also the Lovebug virus which apparently appears on Valentines Day. In reality this turns out to be a strain of the infamous '1813' virus which struck terror into such venerable organisations as British Rail on Friday 13th. You can be assured that the next Friday 13th which occurs in October, has already been noted by apprehensive travellers and no doubt certain data processing teams.

Already we are seeing a new breed of virus guru emerging to meet the heavy demand for speaking at conferences and workshops, or contributing to industry handbooks on the subject. The virus problem clearly evokes an emotional trigger in the hearts – and minds – of many users who regard themselves vulnerable to such abuse. But it is important, say the industry experts, that such emotion does not turn to paranoia.

In fact, the Chairman of The Computer Users Forum believes that the threats posed by viruses should be kept in perspective. They are, he stresses, a rare phenomenon,





WARNING :

one highlighted by specialist consultants hoping to make a fast buck in marketing so-called cures. In many cases the worst damage that the computer virus is doing is to occupy empty memory space or change disk labels. The Forum has established an investigative division to look at all virus claims in order to obtain a true picture.

Even so, a recent industry report from Ambit Research of London, suggested that senior executives are anxious that their company is not on a security hit list. Contingency plans in the event of natural and presumably unnatural disasters are seen as an urgent action matter.

Facts and figures, rather like the virus itself, are difficult to come by. But last year alone in the US there were 400 occurrences of infection involving 90,000 computers reported to the Computer Virus Industry Association. The Group believes that an equal or even higher number of cases went unreported.

The National Computing Centre has been busily compiling a list of the main types of perverse software, as they call the virus bugs. They include such delights as the 'Time Bomb', a piece of illicit software that is activated by the computer clock to initiate a fraud, a disruption or some other sort of perverse activity. Meanwhile, the 'Logic Bomb' is activated by a combination of events rather than by the computer clock. The 'Trojan Horse' however is coding which has been illicitly introduced into a seemingly innocent program and designed to have characteristic illicit effects.

Not Quite a Modern Myth

The first recorded instance of a computer virus, emerged back in the 1960's when an installation message appeared at random intervals, "I am the unknown Glitch. Catch me if you can". This was not a true virus however as it did not proliferate, preferring to quietly relocate itself in core memory until triggered by a clock interrupt. Other early day examples of viruses include the Trojan Horse, Logic and Time Bombs.

In the past of course, such incidents were essentially isolated and restricted to the one installation. Now, thanks to computer networks, PCs and terminal environments, the virus can better develop and spread. At the same time, the virus is becoming more complex and powerful, attacking the file contents rather than just appearing on the screen or printer in the form of a message.

In general, viruses are named after their length. Virus 648, a bug imported from Austria, makes files grow by 648 bytes; or they are defined by their action date. Friday 13th, Valentines Day or April 1st are each suspect dates in the computing calendar.

WARNING :

The virus can, of course, remain hidden for months or years, surfacing when the time lapse has occurred or a special combination of factors occur. Taking a file backup in many cases only serves to ensure that the corrupted files are well protected.

It is, says John Sommerwill, Managing Director of BOS systems house Saffronrose, important to distinguish between a virus which attaches itself to a program to execute, and a worm which replicates itself to the point of overloading a computer memory until the systems become blocked.

As John Sommerwill explains, the typical virus is a self replicating piece of computer code, designed to infiltrate a computer and disrupt the system, either by corruption or by clogging. It is rather like a chain letter used in the electronic mode. However, viruses are not a problem for the BOS operating system say Saffronrose. Unlike much MS/DOS software, BOS programs are professionally developed. Any system tampering will have to take place at assembler code level.

Stoned by Virus

IBM were reportedly not highly amused when they discovered a 1710 virus in their staff and customer training centre in Belgium. The effect was to fill up the screen with a series of random numbers. Not so very different one would have thought, from the average spreadsheet application.

Similarly, DEC were not impressed when a worm hit their internal network on – wait for it – a Friday the 13th. Interestingly, the company reported that a vaccine has now been concocted to stamp out the worm. This virus in fact was a local version of the Xmas Card Virus, a particularly infectious virus which certainly needed stamping on. The same virus attacked the NASA defence networking leaving the message, "Hi, how are you"? The NASA reply is not known possibly because the organisation had its data hands full trying to stem the tide. This all too typical electronic chain letter format, ensured that each person who received the greeting, unknowingly triggered the network to send copies to all names on his file. What started off as a seasonal prank pretty soon got out of hand as the world-wide network of computers had to be shut down.

A similar networked messaging system which is believed to have originated in New Zealand, sent such comforting user messages as, "Your computer is now stoned. Legalise Marijuana". The speed of the virus attack was experienced by the City University when they discovered that 70 of the PCs had become infected by a virus.

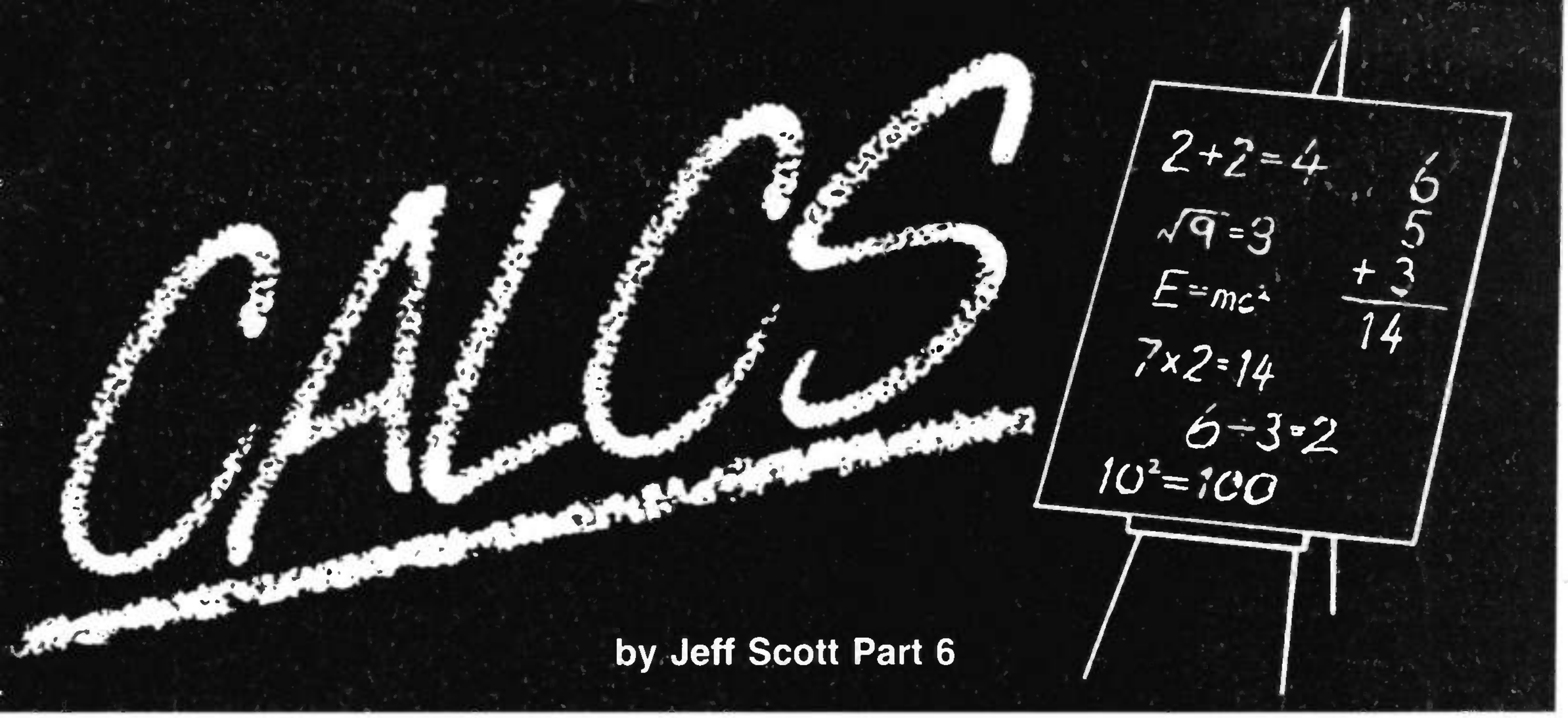
British Rail however have firmly linked their virus problem to infected copies of the computer game, "Leisure-suit Larry in the Land of the Lounge Lizard". The virus which incidentally led to a ban on transferring information between some 550 local area networks and 10,000 PCs and workstations, was described by BR as an inconvenience, not a disaster. Presumably British Rail computer staff found manoeuvring people into bars was somewhat more entertaining than filtering traffic between Victoria and West Croydon. Certainly, British Rail are not the only organisation who have now warned their computer staff not to bring into work any computer games.

Don't Panic

Few viruses could put a company out of business, say PA, though any number of rogue programmers could achieve the same effect given the inclination and a safe escape route to South France. Viruses are not normally disastrous just a major nuisance, says John Sommerwill of Saffronrose. "Panic can do more damage than the virus itself, and that 99% of all mistakes and data corruption are caused by key input error".

But this is not necessarily always the case, says PA. In certain cases panic is the best reaction. By switching of the computer you could well destroy the virus. But, as PA warns, you could destroy along with the virus your files and memory. And don't rely on your back-up files as being corrupt free.

Perhaps it is time for a government warning label to be attached to each pack of floppy disks sold, "Computing around can damage the health of your computer system".



Introduction

Suppose a bank sent a message "Pay Jeff Scott £100" and this was wrongly received as "Pay Jeff Scott £100,000." It may result in one happy customer but also in one distraught bank manager.

Error correcting codes are gaining increasing importance in digital communications, not only for communicating between banks, but also receiving signals in the presence of noise e.g. picture transmission through space.

Most communications, particularly vital data, now use error correcting codes of some sort. Perhaps the only area not requiring error correcting codes is speech communication and that is because speech usually contains so much redundancy that even if a few words are garbled, it is possible to glean some meaning out of the sentences.

One does not have to transmit messages through the atmosphere or down a line to pick up noise. Noise and hence errors can even be picked up from magnetic storage devices.

It all started in 1948 with Claude Shannon's paper 'A mathematical theory of communication'. That's when the study of information theory and error correcting codes was born. Shannon stated that if the code rate (the bit rate at which the code is transmitted) is less than the channel capacity then one can transmit information with small probability of error by using long enough codes.

The channel capacity is a measure of the amount of information that the channel can transmit. We can illustrate this pictorially as in Figure 1 by saying we have a two pint bucket for transporting information (Figure 1a). If we only need to transport one pint (Figure 1b), we can add another half a pint as checking information to eliminate errors (Figure 1c). If however we need to transport two pints, we have reached the channel capacity and there is no room for check digits.

Linear codes or algebraic codes are ones which are randomly distributed. Although Shannon's theorem deals with non linear codes, similar theorems have been proved for linear codes. Shannon's proof is based on probability theory and not based on actually constructed codes.

Error correcting codes are steeped in probability theory e.g. what is the probability that a message will be read correctly from a storage device, what is the probability that this message will then be transmitted correctly and also received correctly.

The addition of check digits is called redundancy because although they serve to check or even correct the basic message transmitted, the check digits do not add any further information to the message. On the contrary the redundancy increases the bandwidth of the basic transmission.

Error correcting codes is the art of adding redundancy in an efficient manner so that the message can be corrected, at the same time keeping the transmitted bandwidth to a minimum. It is easier to detect errors than to correct them and even this is better than nothing because the receiver can request a re-transmission.

People practice redundancy in everyday life when they repeat things in different ways to make themselves understood. In data transmission it is not possible to delay messages by repeating each several times. Therefore error correcting codes have to be analysed mathematically. For instance one has to decide whether there is a probability of single, double or multiple errors and whether these errors will turn up at random or in bursts. Even the bursts can be random bursts.

Information channels can be telephone lines, space and radio links and magnetic units like read/write heads. Types of disturbance can be thermal and impulse noise, lightning, crosstalk and magnetic tape defects. Extraction of information can be in real time or non-real time.

Examples of non-real time processing are extraction of information from space photographs or old recordings. Real time processing involves speech and data communications. In particular, data communication with bank tills and electronic fund transfer point of sale (EFTPOS) need to be immediate and accurate, since the customer is waiting for an answer.

In block diagram form, a message can be transmitted and received as shown in Figure 2. A commonly used alphabet is a set of two symbols 0 and 1. A message like 1010 may represent a number like 281 or alphabet like Ƶ or even a complete message like "aircraft approaching from the west."

If the noise corrupts this message to 0110, it may be meaningless. Worse still, it can be misleading like, "aircraft approaching from the east."

The Binary Symmetric Channel

The simplest mathematical model for a channel is called a binary symmetric channel (BSC) shown in Figure 3. It is called a binary symmetric channel because it transmits and receives two symbols 0 and 1. The simple model has no memory and there is a probability q that the message will be received correctly and the probability p that it will be received in error. One would hope that the probability of receiving it correctly (q) would be greater than 50% (or 0.5).

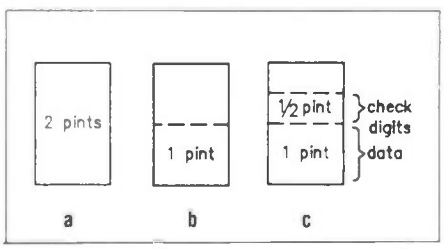


Figure 1a. Channel capacity. 1b. Data carried. 1c. Check digits added.

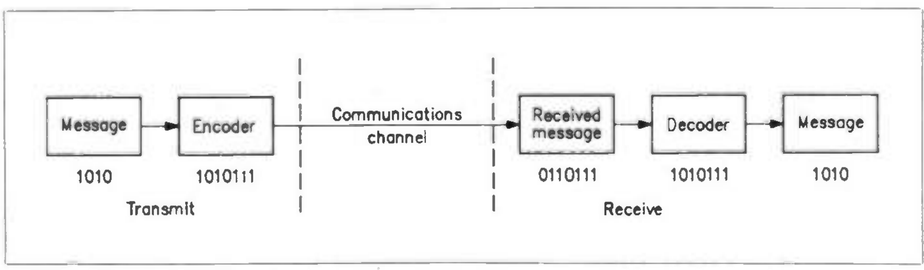


Figure 2. Effects of noise on data.

Therefore q = 1 − p

So if p is say 0.75 (75%), then the probability of receiving the message in error is:

q = 1 − 0.75
  = 0.25 or 25%

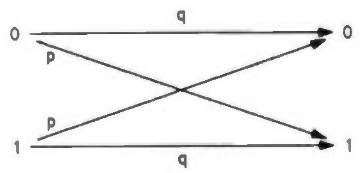


Figure 3. The binary symmetric channel.

Galois Field Arithmetic

Digital computers and digital data transmission use the two symbols 0 and 1 for which addition and multiplication is defined as:

0 + 0 = 0
0 + 1 = 1
1 + 0 = 1
1 + 1 = 0
0 . 0 = 0
0 . 1 = 0
1 . 0 = 0
1 . 1 = 1

The above addition and multiplication is called modulo 2 addition and multiplication, which is the same as ordinary arithmetic except that 2 = 0. Modulo 2 or exclusive OR has been dealt with in Boolean algebra. An alphabet of two elements 0 and 1 with modulo 2 addition and multiplication is called a field of two elements or a binary field. It is represented as GF(2), GF standing for Galois field.

Definitions

The *length* of a codeword in a block of digits is denoted by n. A code of length n which has k bits of message is described as an (n,k) code where k is the *dimension* and the check digits are n-k. Figure 4 illustrates these points.

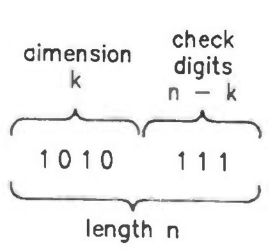


Figure 4. Code length and dimensions.

Hamming was one of the first people to study error correcting codes and most of the definitions and early work is attributable to him.

The *rate* of a code is:

$$R = \frac{\text{information digits}}{\text{length}}$$

$$= \frac{k}{n}$$

$$= \frac{4}{7} \text{ for a Hamming code}$$

The Hamming code is a simple code for detecting single errors. The famous Golay code with n = 23 and k = 12 has a rate of $^{12}/_{23}$. So we can see that most rates are around ½ meaning that around half the digits are check digits.

The message plus check digits is often called a vector and the *weight* of this vector is the number of non zero bits. For instance a vector like 1101100 has a weight of four.

The Hamming *distance* between two vectors is the number of components in which they differ. For instance if vector v = 1101100 and vector u = 100100 the positions in which they differ can be seen easily by placing them above each other:

v 1101100
u 0100100
  1   1   differing positions

The Hamming distance is 2 in this case and in general is written (n,k,d).

Two codes are *equivalent* if one can be obtained from the other according to a fixed rule. For instance consider the following two codes:

code 1	code 2
0111	0100
1001	1010

Code 1 can be changed into code 2 by changing the bits in the two right hand columns (least significant end).

Codes which are not broken into blocks but remain in a continuous stream are called *convolutional* codes. How the original information is assigned its block is called *source* coding and there may be reasons for such assignments depending on the frequency of occurrence.

The method of decoding a received vector to the closest code vector is called *maximum likelihood* decoding or nearest neighbour decoding.

Majority Logic Decoding

We could transmit each bit three times and take a majority count at the receiver. For instance to transmit 0 we could transmit 000 and to transmit 1 we could transmit 111. This is a single error correcting code of rate ⅓ and is called a threefold repetition code (R3).

At the receiver, the decoding process can be considered as a voting process as in Figure 5. Suppose the 1 digit is sent as 111 and received as 110. It could be that 000 was sent and the first two digits corrupted to 11. However it is more likely to be a single error and that only one digit was corrupted.

The number of transmitted digits can be increased to improve one's chances but of course the transmitted bandwidth also increases. For a fourfold repetition code, R4, the rate is ¼. If one bit is in error, the other 3 show the way with greater confidence than the 1 to 2 vote for an R3 code.

However if 2 bits are in error and say 1100 is received it is not possible to say whether 1111 or 0000 was transmitted. The fourfold repetition code can therefore correct one error and detect two errors.

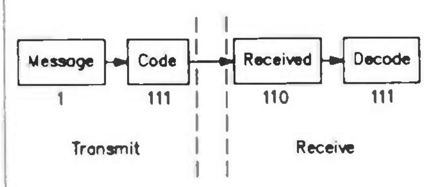


Figure 5. Majority logic decoding.

A Simple Code

Suppose we want to transmit 1001 and do not add any redundancy, we cannot check if errors have occurred. To detect single errors we could transmit twice but we still do not know if the error is in the first or second transmission if the following is received:

First reception 1001
Second reception 1101

Message digits	Parity digits	
1001	0	Even parity
1001	1	Odd parity

Figure 6. Odd and even parity.

One has already transmitted twice the required capacity and even a simple parity check would achieve better results. Odd parity or even parity working can be decided on. Using even parity the number of digits add up to an even number and for odd parity the number of digits add up to an odd number.

In operating even parity, a zero would be added as a parity digit to 1001 as shown in Figure 6, or a 1 if odd parity were being operated. This method is widely used in computers.

Let us try to devise a code for correcting single errors. Suppose we need to transmit 12 bits (Figure 7a) and break this into 3 blocks of 4 digits as in Figure 7b. Now we add parity bits to each row and column to make each row and column have an even number of ones. Finally a 1 is added to each right hand corner to make the last column even and it turns out that the last row also ends up even, Figure 7c.

Now if a single error occurs at the receiver and an even parity check is carried out, one row and one column fails. For instance if the top row is received as 1100, the third column and first row fail their parity check.

111001011100

Figure 7a. Message digits.

1110
0101
1100

Figure 7b. Arranged in blocks.

1110	1
0101	0
1100	0
0111	1

Figure 7c. With parity digits.

Or even if the final row, the parity digits, are corrupted by a single error to 1111, the final row and first column fail their parity checks. This code has n = 20, k = 12 and is a 20,12 code with 20 − 12 = 8 check (redundant) digits.

In the above example all double errors cause two row and/or two column checks to fail and although the errors can be detected, they cannot be located and therefore they cannot be corrected.

Three errors cause two, four or six column and row failures depending on the locations. In general three errors can be recognised as distinct from single errors. However if they lie at the three corners of the rectangle the decoder could assume there is only a single error. Similarly, most combinations of four errors can be detected but four errors at the corners of the rectangle result in received digits with no parity errors!

We can now begin to appreciate the scale of the problem. For single errors this code is fine but for two or more errors there could be problems. It did in fact take ten years to progress from the Hamming single error correcting codes to double error correcting codes.

Polynomials

Polynomials are mathematical expressions with several (poly) terms (numbers), usually of different powers (indices).

For example:

$$x + x^2 + x^4 + x^5$$

These may even have constants (scalars) attached to them e.g.

$$3x + 2x^2 + 8x^4 + 9x^5$$

The general form is:

$$f(x) = a_0 + a_1x + a_2x^2 \longrightarrow a_nx^n$$

where f(n) means function of x.

The degree of f(x) is the largest n; so if x^7 is the largest, the degree is 7. A polynomial of degree n is called monic if the scaler a_n attached to it is 1. Also a polynomial is said to be irreducible if it cannot be factorised and scalar multiples are not counted as factorisation. Polynomials are used in cyclic redundancy checks (CRC).

Linear Codes and Cyclic Redundancy Check

The main challenge of coding is to find good codes. Good codes are defined as codes which will transmit information at reasonable rates yet correct a suitable number of errors. If a transmission is distorted we can regard the received word as equal to the transmitted word plus an error word.

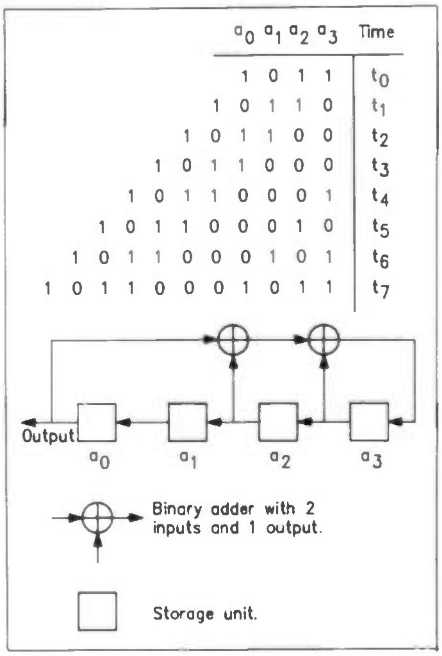


Figure 8. Cyclic shifts.

Code length (n)	Information symbols (k)	Number of errors that can be corrected	Messages in code (2^k)	
7	4	1	16	Hamming
23	12	3	4096	Golay

Figure 9. Comparison of Hamming and Golay codes.

For example if the transmitted word is 1100 and it is received as 1111 with two bits in error, it has been affected by an error word 0011. That is:

1111 = 1100 + 0011

Cyclic codes can be coded and decoded quite efficiently by shift registers since a mathematical solution is useless unless the electronic hardware exists to implement it. Golay, Hamming and BCH codes can be represented as cyclic codes and some of these codes will be described briefly later.

Figure 8 shows a shift register with two binary adders and four storage units. At time t_0 four bits are placed in $a_0\ a_1\ a_2\ a_3$. At time t_1 (one time interval) a_0 is output, a_1 shifted to a_0, a_2 into a_1, a_3 into a_2 and a new bit into a_3.

The binary adders and the storage units can be connected differently, but in this instance, the new bit into a_3 is $a_0 + a_2 + a_3$. The table in Figure 8 shows the shifts over seven time intervals and the vector 1011000 is repeated making a codeword of length 7 with the information digits in the first four positions.

The code is linear since when $a_0\ a_1\ a_2\ a_3\ a_4\ a_5\ a_6$ is a codeword so is $a_6\ a_0\ a_1\ a_2\ a_3\ a_4\ a_5$ etc. Stated another way: whenever a vector is in the code, so are all the cyclic shifts. Cyclic codes were first studied by Eugene Prange who discovered many of their properties. Since then many people have worked on them particularly W.W. Peterson.

Since the major codes BCH, Hamming, Golay etc. are cyclic and therefore easily implemented by shift registers, the cyclic redundancy check is a popular method. It is used in point to point communications, formatting floppy disk and hard disk sectors, and in local area networks as well as wide area networks.

The basic principle of the CRC is to carry out a calculation on the transmitted bit stream and at the receiving end a similar calculation is carried out. This method is superior to parity checks because if two errors occur a parity check will not detect them.

The disadvantage is that the CRC operation is carried out serially on the bit stream and is therefore time consuming on processing time. Polynomials and modulo 2 have been defined and these terms will be used again here.

Most communications systems break long data streams into packets which are between 1000 and 2000 bytes long. The data can be represented by a polynomial of n with coefficients (scalars) or 1 or 0. For instance 1011 and by represented by:

$$1(x^3) + 0(x^2) + 1(x^1) + 1(x^0)$$
$$= x^3 + x + 1$$

The data is then divided by another number called the generator polynomial. Any remainder is subtracted modulo 2 from the original data stream so that when the same division is carried out at the receive end, there should be no remainder. If there is, then an error has occurred.

A number of internationally agreed generator polynomials are available. The CCITT (consultative Committee for International Telephony and Telegraphy) uses $x^{16} + x^{12} + x^5 + 1$.

CRC – 16 is for use with 8-bit byte systems:

$$x^{16} + x^{15} + x^2 + 1$$

CRC – 12 is for 6-bit byte systems:

$$x^{12} + x^{11} + x^3 + x^2 + x + 1$$

The generator polynomial is usually chosen so that x + 1 is a factor and if the polynomial is of degree n, the system will detect all single and double bit errors. All burst errors of an odd number of bits are also detected.

All burst errors of length up to n and

about 99.9% of burst errors greater than n will also be detected. It can be seen that CRC is a powerful method.

The Golay Code

The Hamming code (7,4) is a single error detecting code. The famous Golay (23,12) code is used in satellite communications and can detect up to 3 errors. The 23 digits are made up of 12 information and 11 redundancy (check) digits. A comparison of the Hamming and Golay codes is shown in Figure 9.

Since the Golay code can do more than the Hamming, correcting up to three random errors in a block of 23 digits, a computer is required for decoding.

The generator polynomial is either:

$$g_1(x) = 1 + x^2 + x^4 + x^5 + x^6 + x^{10} + x^{11}$$
$$\text{or } g_2(x) = 1 + x + x^5 + x^6 + x^7 + x^9 + x^{11}$$

Both $g_1(x)$ and $g_2(x)$ are factors of $x^{23} + 1$ as follows:

$$x^{23} + 1 = (1 + x)g_1(x)g_2(x)$$

BCH and Reed Solomon Codes

The BCH code is named after Bose and Chaudhuri who discovered these in 1960 and Hocquenghem who discovered these in 1959. The BCH and Reed Solomon are non-binary codes.

For instance if p is a prime number and q is any power of p, there are codes from a q-symbol alphabet. These codes are called q-ary codes. For any choice of positive integers s and t there exists a q-ary BCH code of length:

$$n = q^s - 1$$

This corrects any combination of t or fewer errors and requires no more than 2st parity check digits. A special subclass of the q-ary BCH codes for which s = 1 is the well known class of Reed Solomon codes.

Burst and Random Errors

By interlacing a t random-error correcting code (n,k) to degree λ, we get a (λn, λk) code which can correct any combination of t bursts of length λ or less.

Tree Codes

With reference to Figure 10, a tree code is merely a successive sub-division of a path through digital 1 and 0. So encoding is a process whereby the encoder traces a path through the tree depending on the contents of the message.

At each node of the tree, the encoder chooses an upper branch as the output code if the message input digit is 0. If the message input is 1, the lower branch is chosen.

For instance if the message is 1101, for the leftmost 1, the choice is 110. For the 0 the choice is 011 and for the right most 1, the choice is 110. The choices are circled in Figure 11 with the original message digit in brackets alongside each choice.

Summary of the History of Error Correcting Codes

Hamming invented his error correcting code in 1950 and it was not until 1960 before anything significant was invented. Then the BCH and Reed Solomon codes were discovered. These are non-binary codes and can detect multiple errors.

In 1960 W.W. Peterson invented a practical method of decoding the BCH codes. Massey, in 1963, presented a unified treatment of majority logic decoding. Convolutional codes for data in a continuous stream were discovered in 1960.

So there appears to have been a great deal of activity around 1960. In 1967 Viterbi proposed an algorithm for maximum likelihood decoding which proved to be the best for convolutional codes.

Applications of Error Correcting Codes

Block codes are used widely in magnetic tapes or disk stores for computers. Convolutional codes are often used for eliminating errors in satellite, space and even land based communication links.

Both single-error and double-error correcting codes are used in the IBM 360 and 370 computer core memories.

A convolutional (2,1,6) code was designed by the Jet Propulsion Laboratory in 1977 for the Voyager space mission to Mars, Jupiter and Saturn. But, even earlier than that, in 1968, the Pioneer 9 Solar mission launched by NASA was the first space mission to use error correcting codes. The (2,1,24) convolutional code was used.

The fastest sequential decoder was a 50 Mbit/s Fano decoder built in 1970 for a NASA space station to earth telemetry link. In 1973 the Linkabit Corporation built a convolutional encoder/Viterbi decoder for the US Satellite Communications Agency. This operated over a radio troposcatter link.

Error control is applied to numerous branches of communications from radar to cellular mobile radio, from packet data switching and spread spectrum against enemy jamming to digital autopilots.

Conclusions

After some basic definitions a simple code was constructed to detect single errors and the difficulty of detecting two and more errors was highlighted. It was shown how cyclic codes could be implemented by means of shift registers and the superiority of the CRC over simple parity checks.

The history of coding traced the great deal of activity in the early 1960s. After that, it seems to have gone very quiet. Perhaps we're just round the corner from discovering another great code. In the meantime, thanks to some imaginative mathematicians, bank managers can sleep a little more peacefully.

Further information on error correcting codes can be obtained from the following books:

Error Correcting Codes by H.B. Mann
Theory of Error Correcting Codes by MacWilliams & Sloane
Error Correcting Codes by W.W. Peterson.

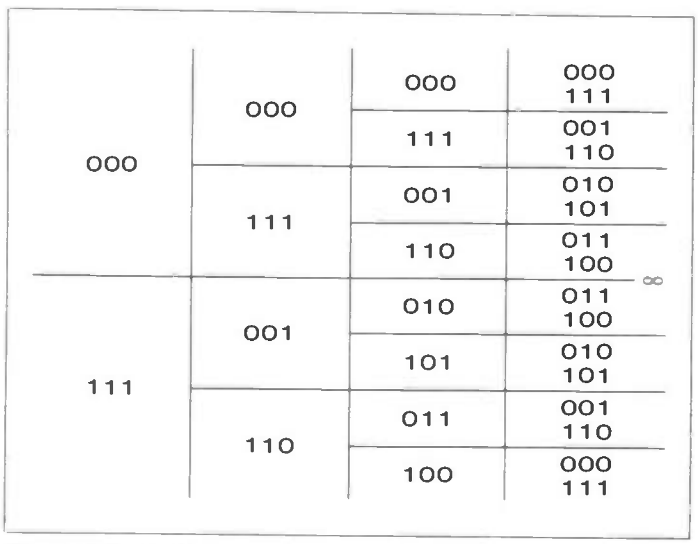


Figure 10. Tree code.

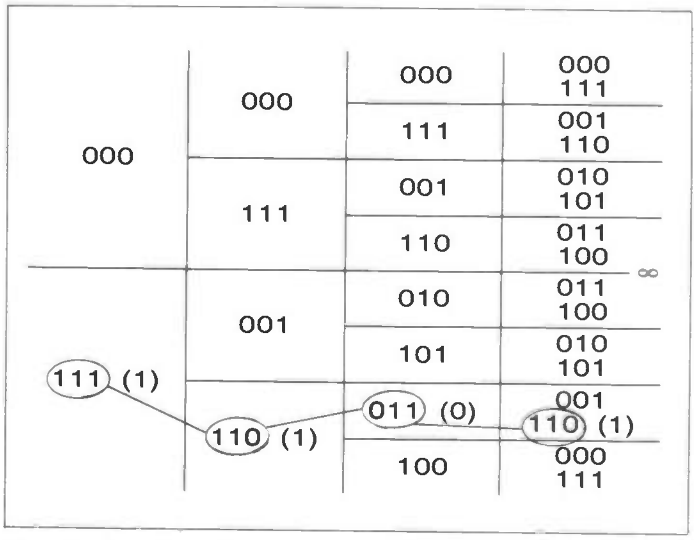
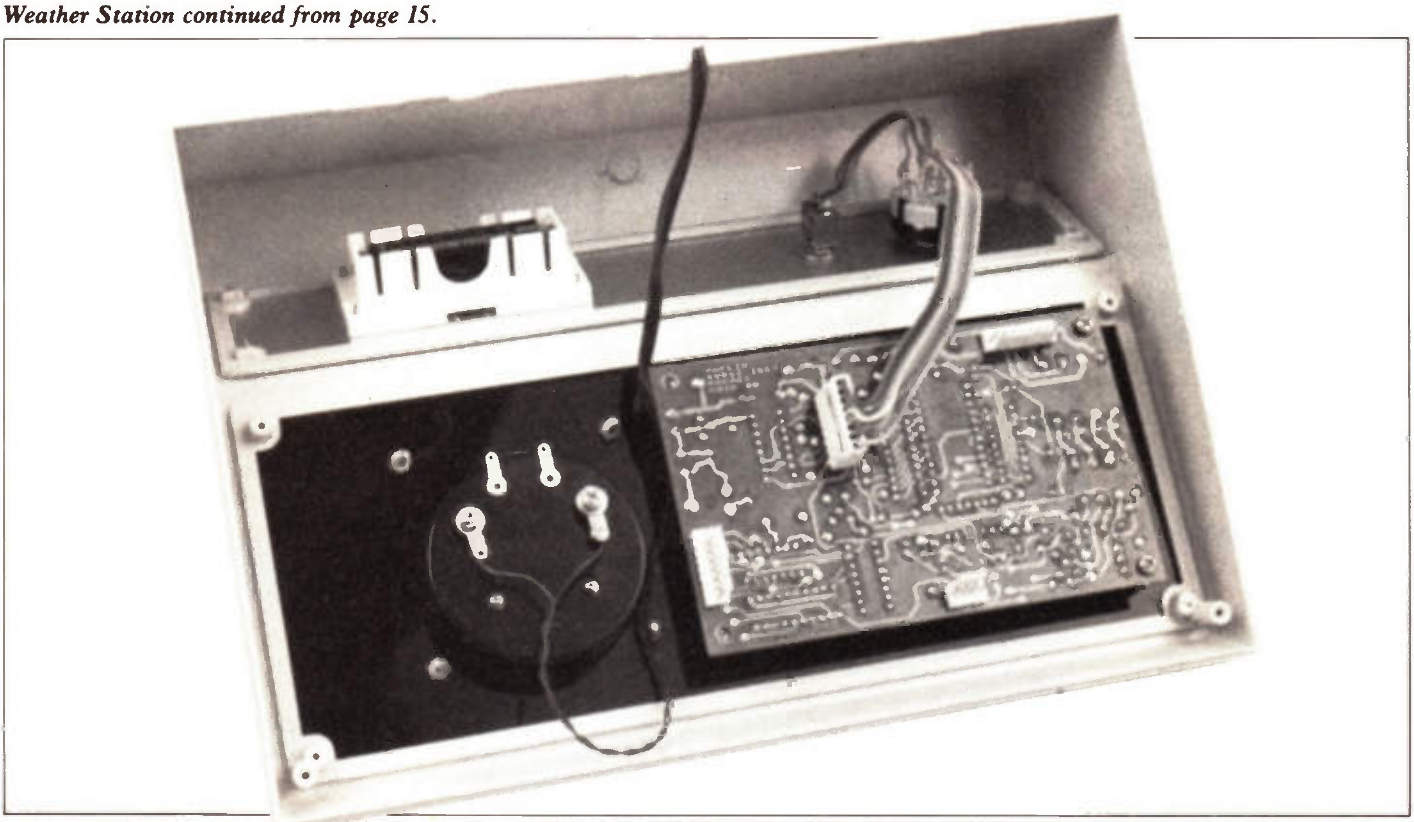


Figure 11. Encoding using the Tree code.

Weather Station continued from page 15.



WEATHER STATION MAIN BOARD PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (unless specified)

R1	100R Wirewound	1	(W100R)
R2,4,5,8,10	10k	5	(M10K)
R12-16	47k	5	(M47K)
R3,5,7,9,11,18	4k7	6	(M4K7)
R17	390Ω	1	(M390R)
R19	220k	1	(M220K)
R20,21	330k	2	(M330K)
R22	470Ω	1	(M470R)
R23	13k	1	(M13K)
R24	12k	1	(M12K)
RV1	47k Hor Enc Preset	1	(UH05F)

CAPACITORS

C1,9,11	47μF 25V PC Electrolytic	3	(FF08J)
C2-6	1nF HV Disc	5	(BX12N)
C7	1μF Polylayer	1	(WW53H)
C8	100nF Minidisc	1	(YR75S)
C10,12	1nF Polylayer	2	(WW22Y)
C13	3n3F 1% Polystyrene	1	(BX62S)

SEMICONDUCTORS

D1	1N4001	1	(QL73Q)
D2-7	1N4148	6	(QL80B)
LD1-16	LED Red	16	(WL27E)
TR1-5	BC548	5	(QB73Q)
IC1	40106	1	(QW64U)
IC2	4514	1	(QW85G)
IC3,4	ULN2803A	2	(QY79L)
IC5	4040	1	(QW27E)
IC6	74HC373	1	(UB80B)
IC7	ZN426E-8	1	(UF39N)
IC8	4060	1	(QW40T)
RG1	78L05AWC	1	(QL26D)

MISCELLANEOUS

	A/P Beads	1 Pkt	(LB62S)
	Minicon Terminal	3 Pkts	(YW25C)
PL1,2,4	Minicon Latch Plug 8 way	3	(YW13P)
PL3	Minicon Latch Plug 4 way	1	(YW11M)
	Minicon Housing 8 way	3	(YW23A)
	Minicon Housing 4 way	1	(HB58N)
	Systoflex 4mm Red	1m	(BH15R)
	M3 Insulated Spacer 15mm	1 Pkt	(FS37S)
	Poziscrew M3 × 6mm	1 Pkt	(BF36P)
	Isonut M3	1 Pkt	(BF58N)
	Bolt 8BA × 0.5"	1 Pkt	(BF09K)
	Ribbon Cable 10 way	1m	(XR06G)
S1	Sub-Min Toggle A	1	(FH00A)
S2	Rotary 3 pole 4 way	1	(FF75S)
M1	50μA Large Panel Meter	1	(RX54J)
	Dil Socket 14-pin	2	(BL18U)
	Dil Socket 16-pin	2	(BL19V)
	Dil Socket 18-pin	2	(HQ76H)
	Dil Socket 20-pin	1	(HQ77J)
	Dil Socket 24-pin	1	(BL20W)
	Main Board	1	(GD98G)
	Scale	1	(JL89W)
	Pin 2145	1 Pkt	(FL24B)

OPTIONAL

	Front Panel Metal	1	(JL95D)
	Front Panel Acrylic	1	(JL96E)
	Contact Adhesive	1	(FL44X)
	Temp/Clock Module	1	(FE33L)
	Ext Probe for Temp/Clock Module	1	(FE34M)
	Min Max Temp Module	1	(FP64U)
	Ext Low Temp Min/Max Probe	1	(FP65V)
	Ext High Temp Min/Max Probe	1	(FP66W)
	Bezel for Temp Modules	1	(FE35Q)
	Case ABS Console 2803	1	(YN31J)

The above items, excluding Optional items, are available as a kit:
Order As LM96E (Weather Station Kit) Price £33.95

The following items are also available separately:
WS Main PCB Order As GD98G Price £6.45
Metal Front Panel Order As JL95D Price £3.25
Acrylic Front Panel Order As JL96E Price £5.45
Meter Scale Order As JL89W Price 85p

HIGH POWER SPEAKER CABINET

by Dave Goodman

Introduction

The most common size of loudspeaker that is practical for use with disco's, groups and stage PA work, is the 12 inch model. On its own, the high frequency response of the speaker is limited to approximately 5 - 6kHz on single cone versions and although this may be suitable for bass and lead guitar work, the response is too low for most music applications. To extend the high frequency performance to 20kHz or more, it becomes necessary to add an HF drive unit to the system and mount both speakers together in a cabinet. At the low frequency end, performance is very much determined by both the design of the 12 inch speaker to be used and the cabinet into which it is to be mounted.

For obvious reasons the loudspeaker design cannot be easily changed after manufacture, so to assist with cabinet design, most manufacturers produce specifications relating to test and performance characteristics for the model. Once armed with this data, it becomes possible to produce a cabinet of optimum design that offers the best possible performance, within the practical limitations of cost and size.

The Maplin range of loudspeakers includes several 12 inch models that all differ in such parameters as: frequency response, resonance, impedance and power handling capability. As an alternative to producing several different cabinet designs - one to suit each loudspeaker - the design offered here is based on a 70 Litre cabinet that is common to all speaker models listed in Table 1. Only the front sound board, or baffle, needs to be modified to accommodate the appropriate port duct that relates to the particular loudspeaker to be used.

Performance

Amongst the many parameters that effect and determine a cabinet design, the loudspeaker free air resonance is significant. The specification changes after the loudspeaker has been fitted onto a baffle board and therefore affects the system low frequency cut off (-3dB) point. Table 1 details the six loudspeakers that are suitable for use with the 70 Litre cabinet - lower priced versions are listed first, through to the last model that has the best specification (and is the most expensive of course!). The XJ49D model is featured throughout this article and

Power	Resonance	Type	Code	Diagram
50 Watt	70Hz	8R GP	XG47B	Figure 6
50 Watt	70Hz	16R GP	XG48C	Figure 6
100 Watt	50Hz	8R TC	XG50E	Figure 7
100 Watt	50Hz	16R TC	XG51F	Figure 7
100 Watt	75Hz	8R GP	XG49D	Figure 8
150 Watt	30Hz	8R BASS	XJ49D	Figure 9

Table 1.

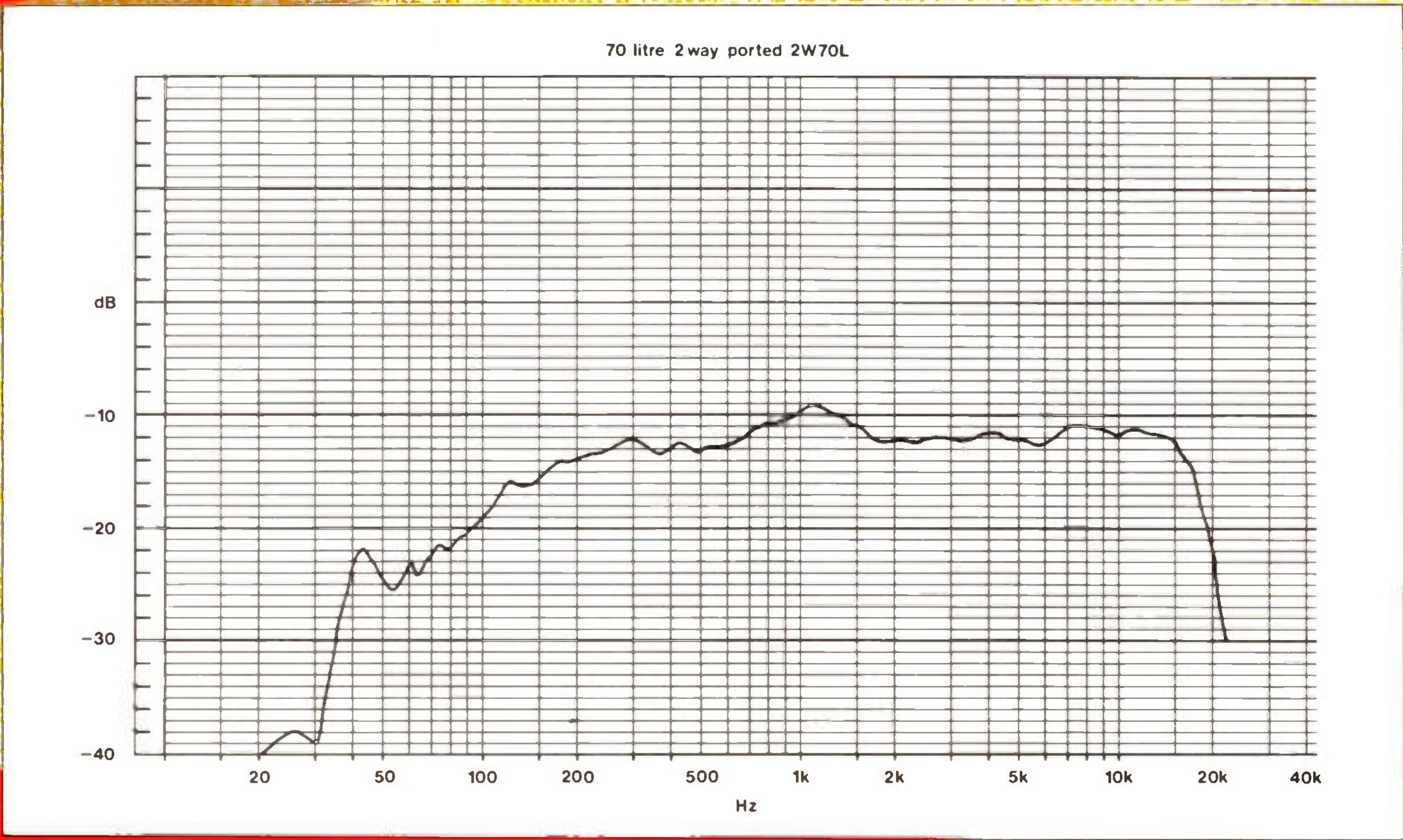


Figure 1. Total system frequency response.

referred to in diagrams and photographs.

Figure 1 shows the measured frequency response for the bass speaker XJ49D, bullet tweeter XJ54J, X-over XJ57M and the unmodified front baffle fitted into a 70 Litre cabinet. The LF performance is superb and the somewhat larger than normal cabinet volume, for a 12 inch speaker, allows for plenty of headroom when winding up the bass control. This particular speaker is ideal for continuous high power disco use (150 to 200 Watts) although the bullet tweeter will need to be connected to the reduced output pad on the X-over module.

Twelve inch, twin cone (TC) models are much lower in price than the bass model and very suitable for Hi-Fi, PA, keyboard instrument and stage monitor use. The cabinet LF performance is less, being reduced from approximately 34Hz to 50Hz and the baffle porting needs to be modified as shown later on.

For club music, PA and lead guitar use, the low cost general purpose (GP) models are recommended. The LF response will not be quite as good as the previous bass and TC versions and again, the baffle will need to be slightly modified.

Construction

Without doubt, the most difficult task to perform on any speaker cabinet assembly, is to cut out holes for the mounting of loudspeakers. If your carpentry skills allow, then the dimensions for making your own baffle board are given in Figure 2; this should preferably be made from 18mm MDF board and not chip board. Alternatively, a baffle is

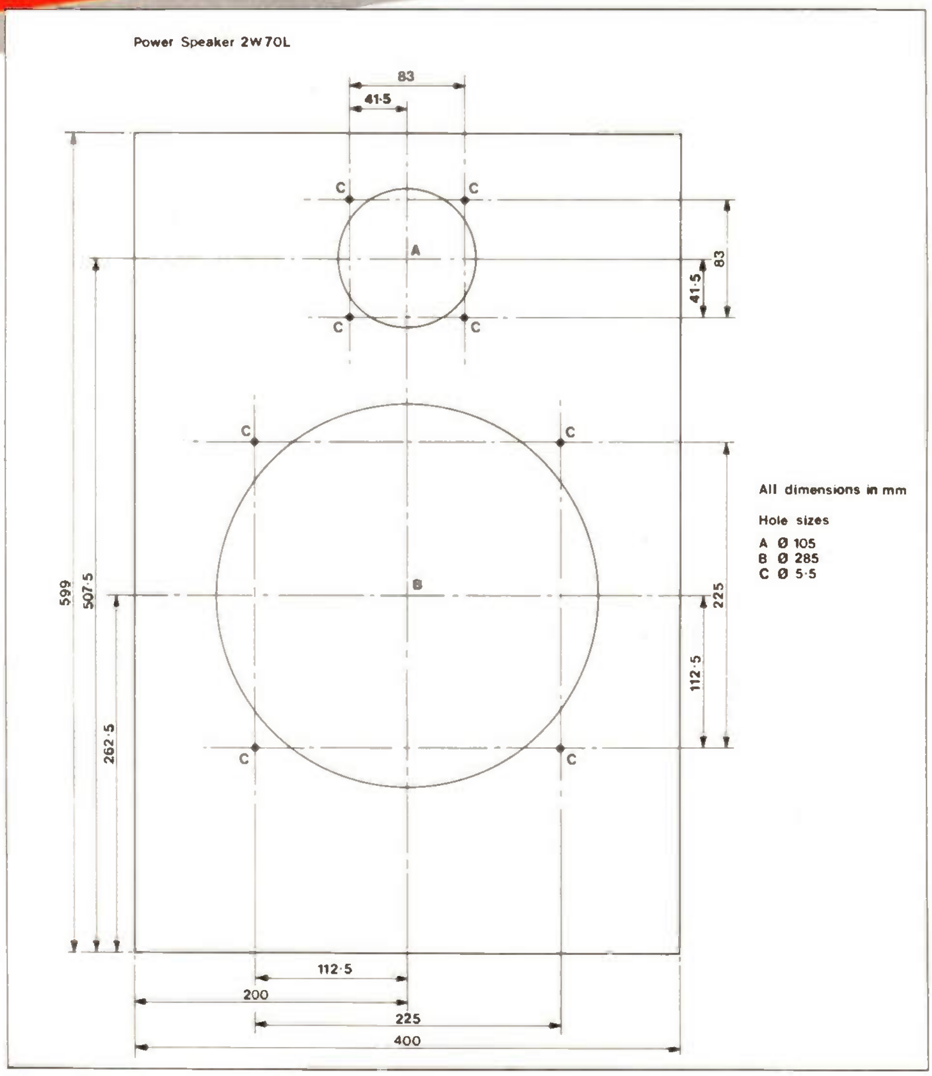


Figure 2. Baffle cut-out details.

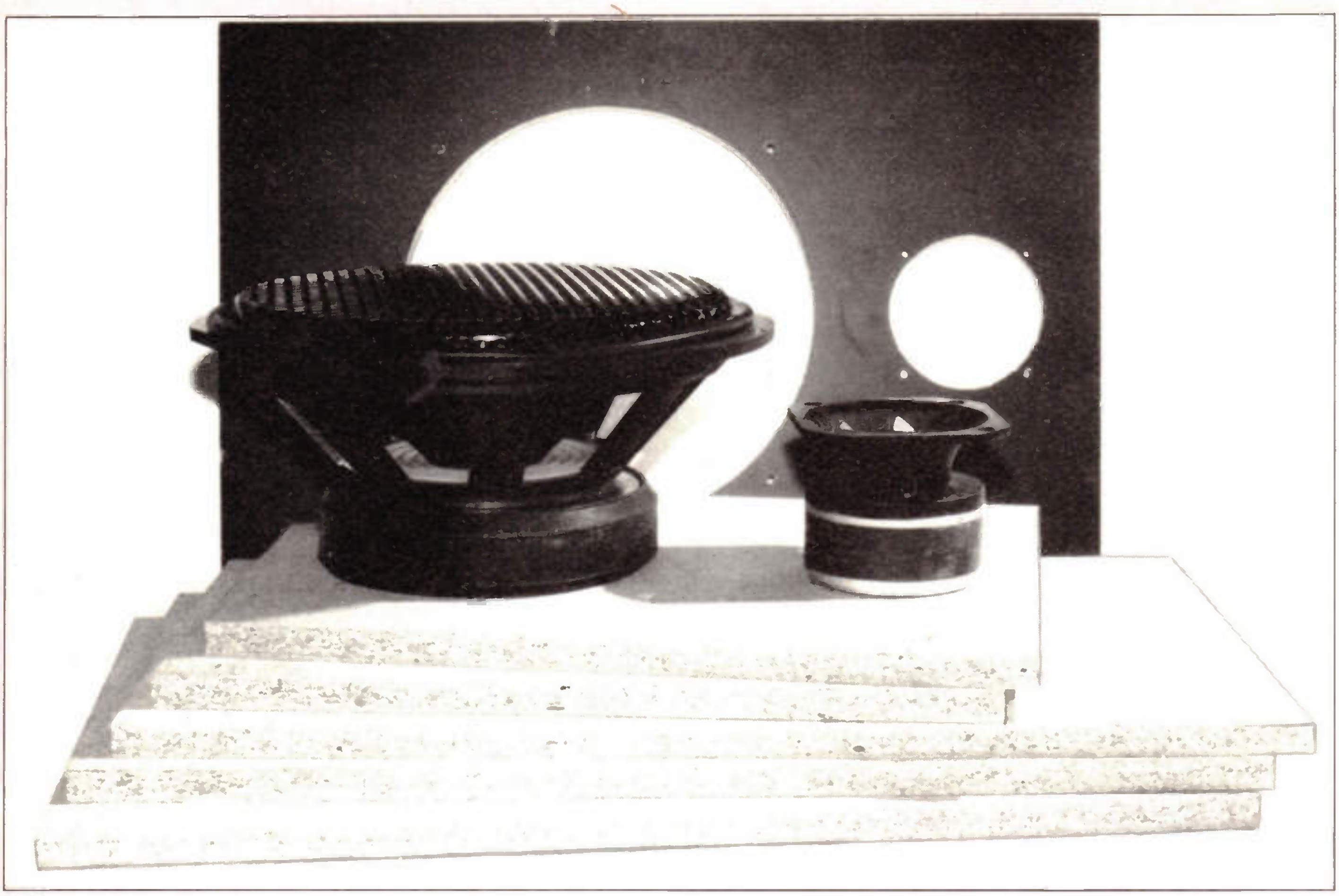


Photo 1. Basic materials.

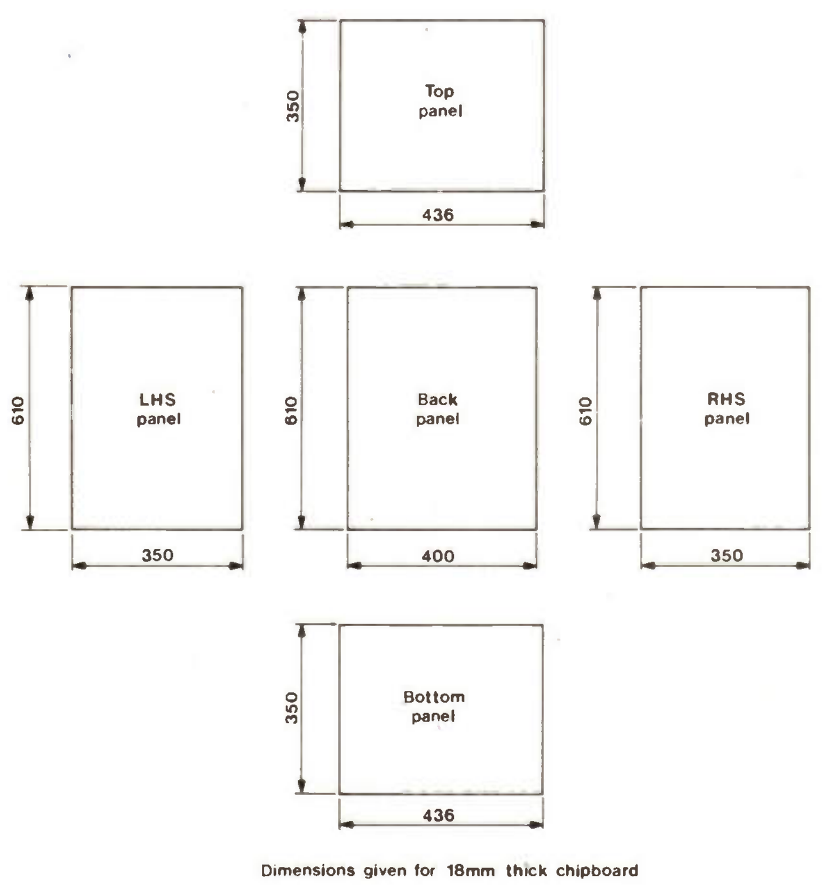


Figure 3. Panel dimensions.

available pre-cut and drilled (XM09K) which has been finished in semi-matt black on one side only, but you will need to obtain the five cabinet side panels for yourself. The cutting list shows the materials required and most wood yards should be able to cut the panels for you. In Figure 3, all of the dimensions given assume that 18mm thick chipboard will be used; any variations from this thickness will alter the top and bottom panel width dimension of 436mm, i.e. 400 + 18 + 18mm. Photograph 1 shows the basic requirements of the cabinet.

Now, from Table 1, determine which one of the six loudspeakers is to be used and cut the front baffle board to the appropriate length, as shown in Figure 4.

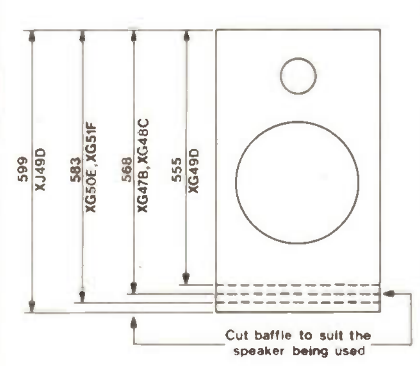


Figure 4. Cutting baffle to size.

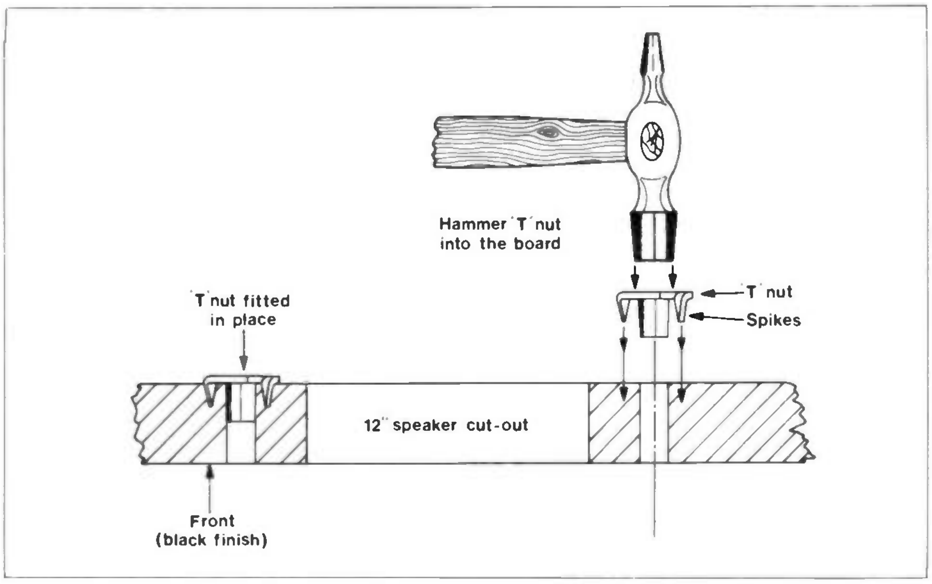


Figure 5. Fitting T nuts.

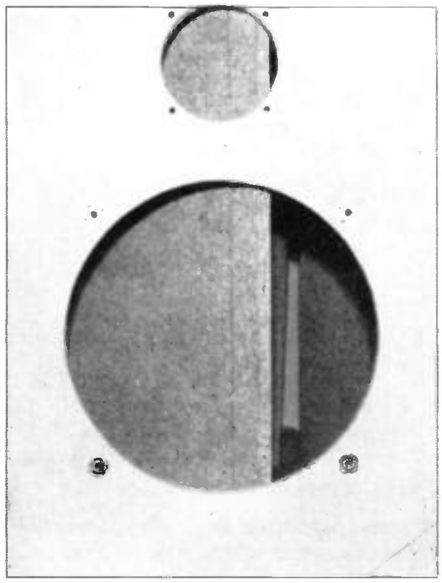


Photo 2. T nuts fitted to the baffle board.

You may note that for bass speaker XJ49D, the length is already correct at 599mm. Four T nuts are used for the 12 inch speaker mounting brackets and they are fitted into one of the bolt holes in the baffle as shown in Figure 5 and Photograph 2. Each nut is hammered home on the inside face of the baffle, therefore choose whether the plain or black finished side is to point outward, beforehand. Place the baffle to one side and proceed with the assembly of the basic shell, made up from the top, bottom and two side panels. Photograph 3 shows the basic structure with the back panel temporarily propped in position; also see Figures 6 to 9. As you will see, the only differences between the four figures relate to baffle length and the port aperture panel - when fitted. General purpose speakers do not require an aperture panel at all, but the other two speaker versions do as they have a much lower frequency response and need a tuned, ducted port. Figure 10 shows the aperture panels, one of which should be chosen to suit the loudspeaker being used.

On the Panel

To fit the panels together, I found the easiest method was to use butt joints with wood glue and 38mm (1.5") counter-sunk

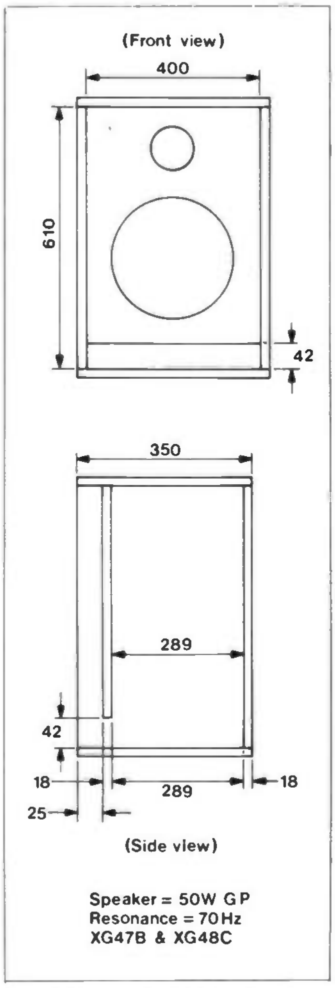


Figure 6. Cabinet for 50W GP speaker.

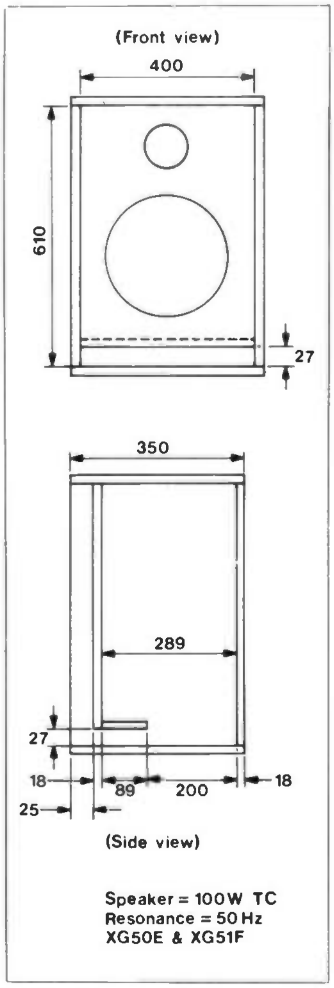


Figure 7. Cabinet for 100W TC speaker.

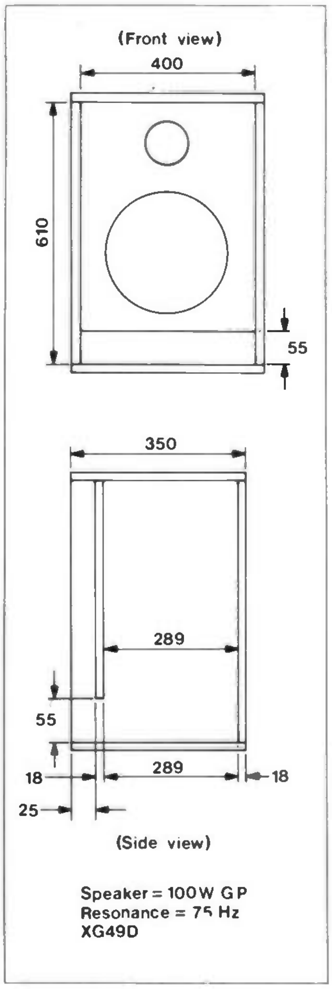


Figure 8. Cabinet for 100W GP speaker.

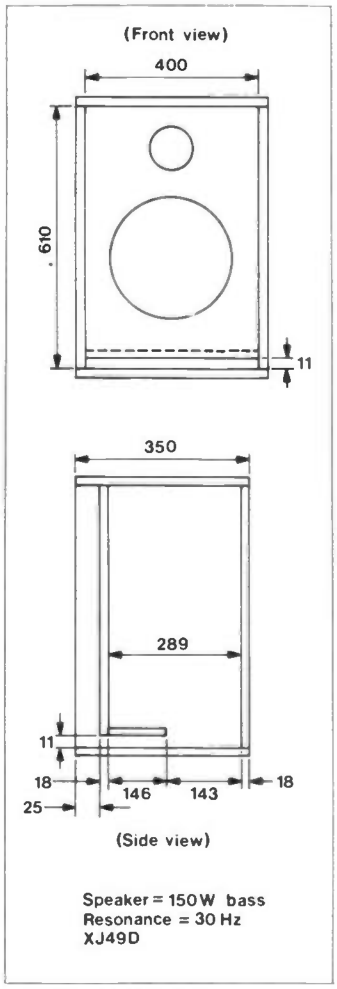


Figure 9. Cabinet for 150W Bass speaker.

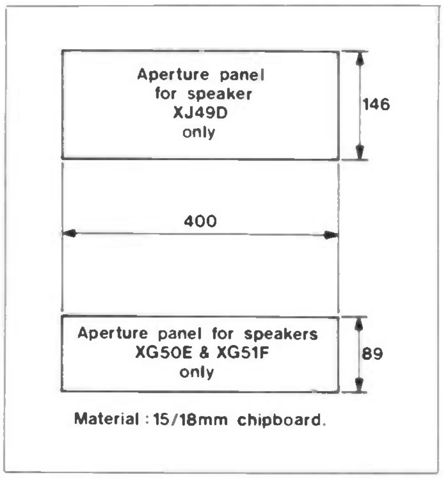


Figure 10. Aperture panel details.

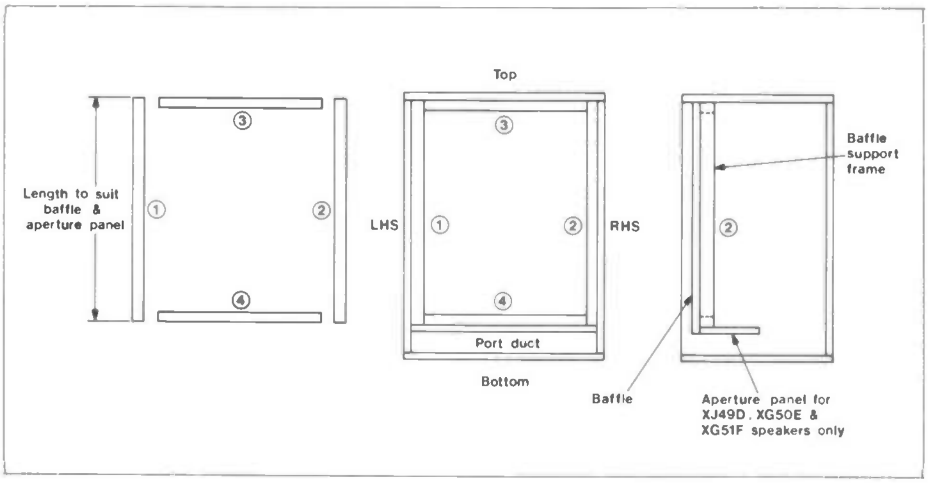


Figure 11. Making a framework.

chipboard screws. Before applying any glue to the panel edges, drill appropriately placed holes along the outside edges of both top and bottom panels; counter bore each hole for flush mounting the screw heads, on the outside faces of course! Apply a liberal amount of glue to the end of a side panel, position the previously drilled top panel over the glued end and insert the screws. Take care to keep the outside edges accurately aligned with one another while the screws are tightened up and repeat the procedure on the other side and bottom panel to complete the shell. Do ensure that all screws are kept straight and at right angles to the board, otherwise they are liable to exit through the panel sides! Wipe off the excess glue that has inevitably squeezed out from the four butt joints and fit the baffle board.

Baffled!

Photograph 4 shows the outer shell with the baffle set back from the front edge by 25mm. The top edge of the baffle (the end above the tweeter cut-out) is glued and screwed to the top panel and both long sides of the baffle are fixed to the side panels in the same way. Note that there should be a gap between the bottom edge of the baffle and the inside of the bottom panel. The amount of opening varies according to the speaker chosen and for the XJ49D, the 11mm opening is just visible at the right of the photograph. Next, fit the aperture panel (if required) and baffle support framework; glue one long edge and both short edges of this panel and place in position on the inside edge of the baffle as shown in Figure 11. Insert screws through the baffle and both side panels, to secure the aperture before mounting the support frame.

Framed!

Cut the 2" x 1" timber to fit as shown in Figures 11 & 12. Final dimensions have not been given as they can vary considerably, according to the thickness of the wood being used, whether an aperture panel has been fitted and any modifications made to the baffle length. These measurements are best left to the

Photo 3. Panel assembly.

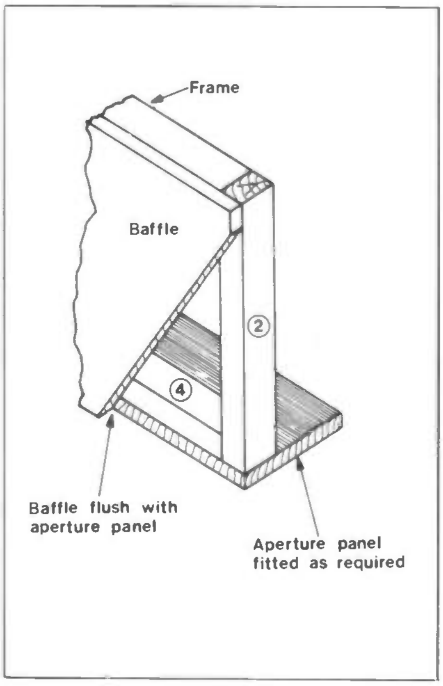


Figure 12. Fitting framework to baffle.

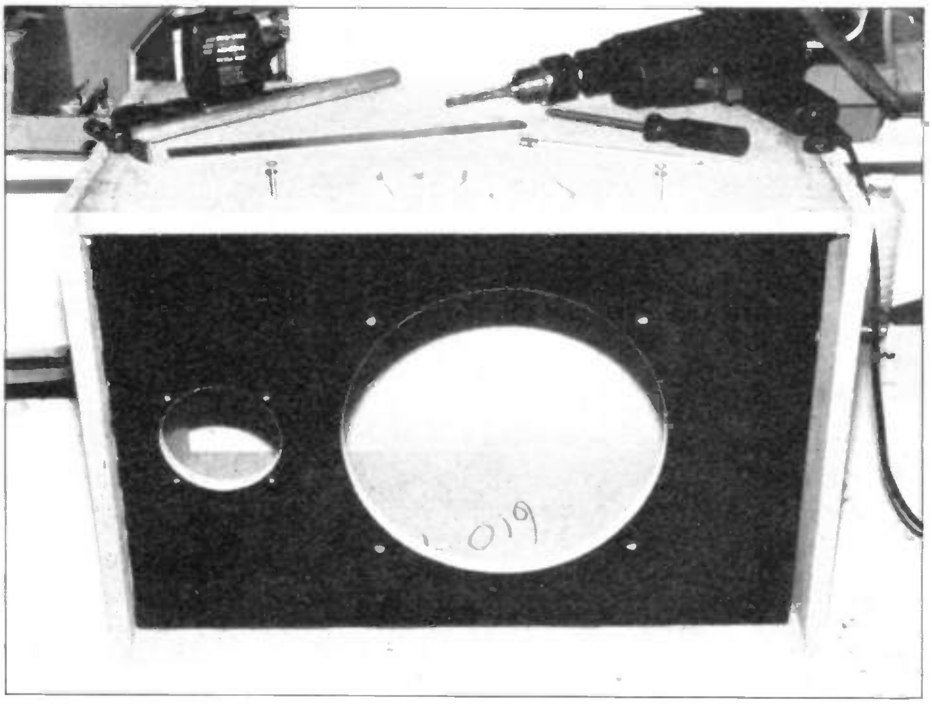


Photo 4. Fitting the baffle in position.

constructor to determine. As much as possible round off the long edges of the framework timbers - the edges that will not be glued - to help reduce internal signal reflections that are generated from right angled surfaces in boxes of this type. For cabinet versions that do not require an aperture panel, do not fit the bottom 2" x 1" timber (No.4) as it is not required. Finally, glue and screw the framework as shown in Figure 12.

Handles - With Care?

As can often be the case when writing assembly instructions, it always takes huge amounts of text to explain in detail a relatively simple procedure, especially where carpentry is concerned. "Is the pen really mightier than the chisel", one could ask...? Not being a carpenter myself disqualifies me from offering professional advice on wood-working techniques and the handling of tools, but I can say that performing the various tasks mentioned this far did not take me very long - approximately 1 hour - and I found the assembly quite easy going. However, the next stage of construction requires a bit more effort!

Refer to Figures 13 to 16 for fitting the heavy-duty strap handle and begin by marking out a 212 x 88mm rectangle on the top panel as shown, then cut out this area of chipboard - you can see the result of my efforts in Photograph 5. I used an electric drill to make as many holes as I could around the inside perimeter of the rectangle and then knocked out the centre with a hammer. The rough edges remaining need to be smoothed down with a rasp or suitable tool. The small 250 x 150mm panel shown in Figure 14 is necessary for mounting the handle assembly and should be made from 10mm material. If thicker material is used for the panel, then the 40mm screws may not quite protrude enough for a nut and washer to be fitted. In this case, counter-bore the 5mm hole just enough to allow the nut and washer to be fitted into the recess.

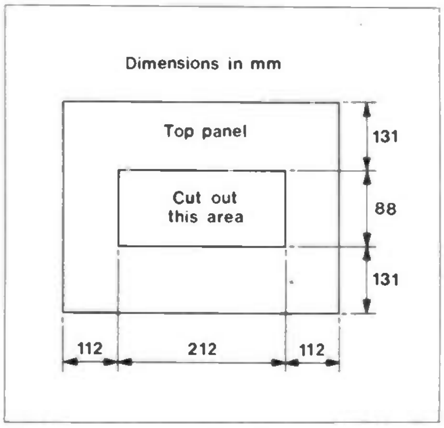


Figure 13. Cut-out for handle.

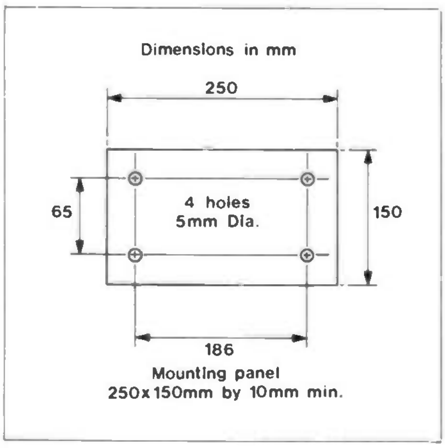


Figure 14. Detail of handle mounting panel.

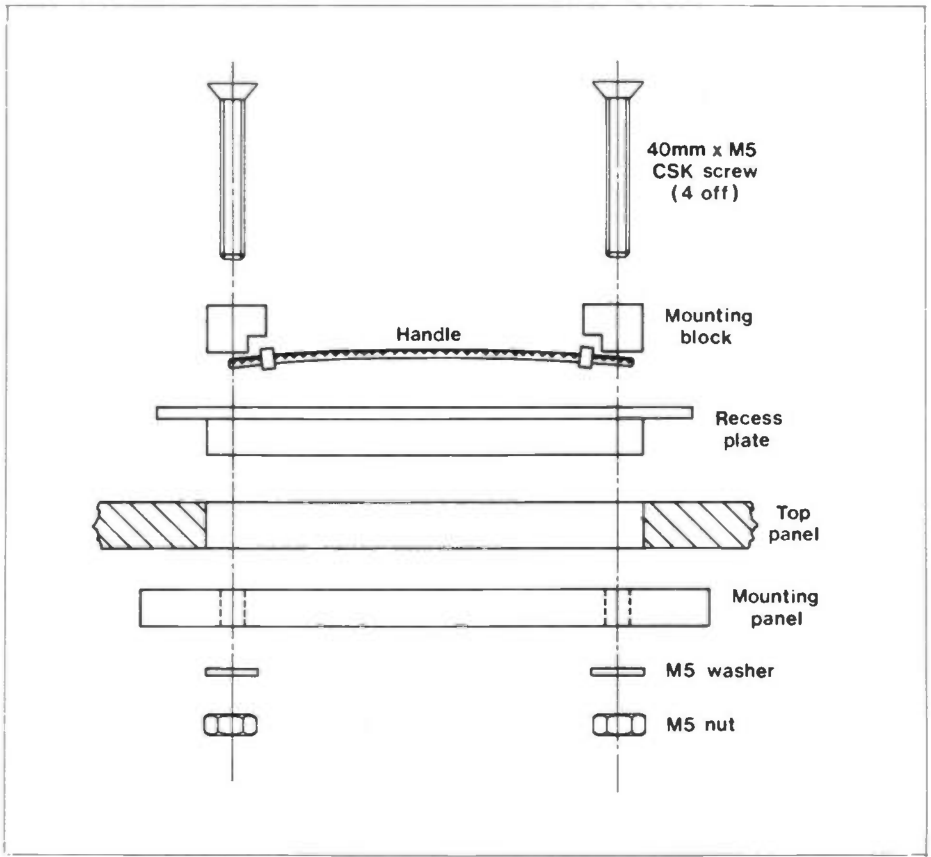


Figure 15. Fitting the handle.

Now glue the mounting panel onto the inside face of the top panel (see Figure 15) and place the plastic recess plate over the top - from the outside - with the handle and both mounting blocks. Insert 40mm countersunk screws through both the block and plate, and fit nuts and washers. Tighten the assembly, while the glue dries, but only temporarily as the plate will have to be removed later on during the covering stages. Figure 16 shows the finished handle assembly.

In addition to having the top handle, you may also wish to fit side recessed handles; details for doing this are given in Figure 17. Unlike the HD handle, the side handles are optional and as they are not supplied in the kit, they will have to be purchased separately (see Optional in Parts List).

Final Construction

The last remaining panel - the back one - can now be fitted, using glue and screws as before. Ensure the panel fits correctly before applying glue and file down any proud areas first, then after fitting, check along the joints for any gaps where air can escape through. Mix some sawdust and wood glue together until a stiff paste is formed and work it into the gaps, you can also treat the screw heads in the same way, to keep the surfaces flat and even.

Being as the back panel has such a large surface area, it is prone to resonate at low frequencies. I would advise that one or two spare lengths of 2" x 1" (or chipboard) are glued and screwed to the back panel, horizontally between the left and right side panels, to reduce this effect. While you are working on the

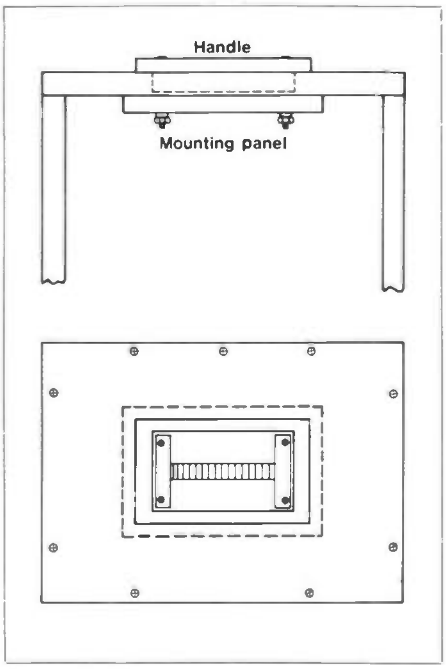


Figure 16. Mounted handle.

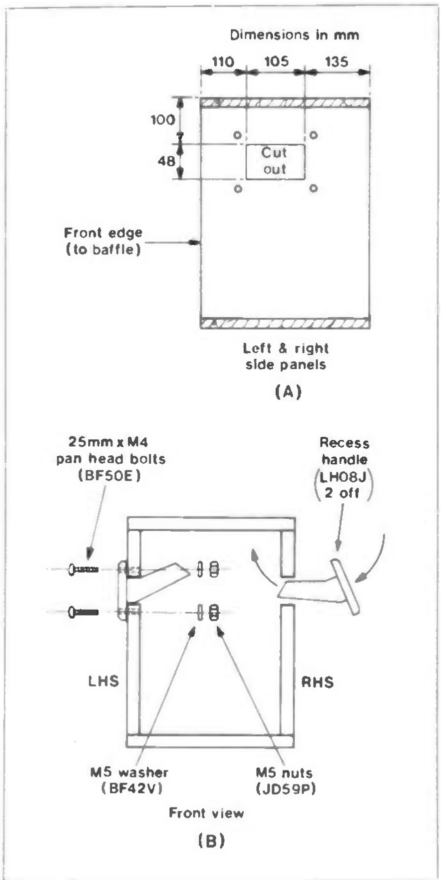


Figure 17. (a) Cut-out, (b) Mounting side handles.

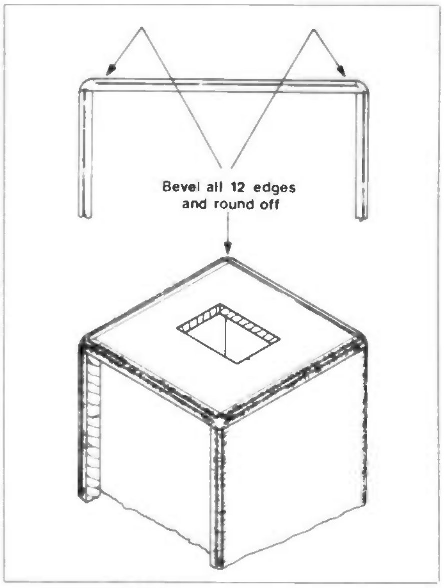


Figure 18. Rounding the edges.

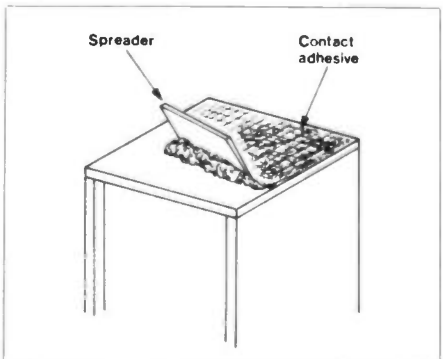


Figure 19. Spread on the glue.

Photo 5. The heavy-duty handle and its recess cut-out.

back panel, don't forget to drill or file out a hole large enough to take the jack socket and recess plate. The hole size needs to be 25mm or so and is best placed at the bottom of the cabinet.

The completed cabinet has twelve right-angled out-side edges and these should be rounded off to facilitate covering with vinyl cloth later on; this also improves the final 'look' of the cabinet as well (see Figure 18). Smooth down the outside surface of the panels with coarse sand paper and remove any lumps or bumps that are likely to show through the vinyl covering.

It's a Cover Up

The final appearance of the cabinet is determined by how well the covering cloth is applied and makes either a professional or a yukky finish. Figures 19 to 21 show the basic stages of applying contact adhesive and gently stretching and smoothing the cloth over the panels, one at a time. Allow enough cloth to hang over the front edges, so that it can be glued and stapled neatly up to the baffle board and the excess cut off. Glue the cloth to the three sides as shown, before turning the cabinet upside down and gluing the bottom area. I used an ordinary staple gun, the sort used for stapling the corners of papers together etc., but an industrial stapler is much better if you have access to one. The back covering can be cut, glued and stapled as before, but do remember to allow enough material to cover the bottom panel aperture opening. Figure 22 shows the edge trim fittings. From the 1 metre length of FP03D extrusion supplied, cut four pieces approximately 183mm long (check this measurement first!), place the extrusion centrally on one edge of the cabinet and fit two corner trims using 4 x No.6 self tappers on each trim. Fit trims and extrusions to the other three edges in similar fashion and the four rubber feet. Finally, cut the cloth diagonally from corner to corner across the handle cut out and glue the edges before re-fitting the HD recess handle plate in position.

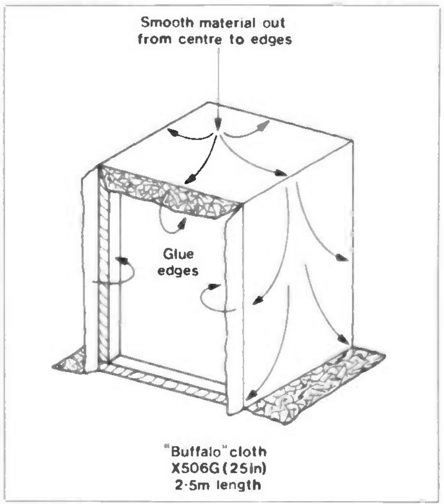


Figure 20. Put on the cloth.

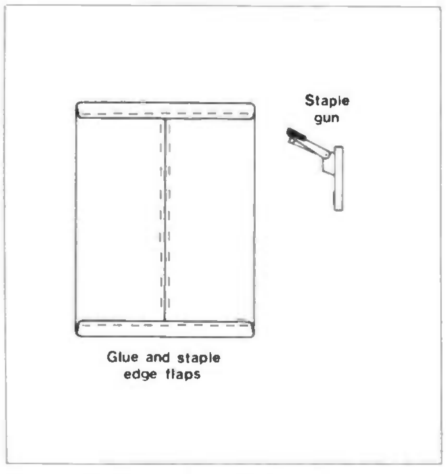


Figure 21. Glue and staple the edges.

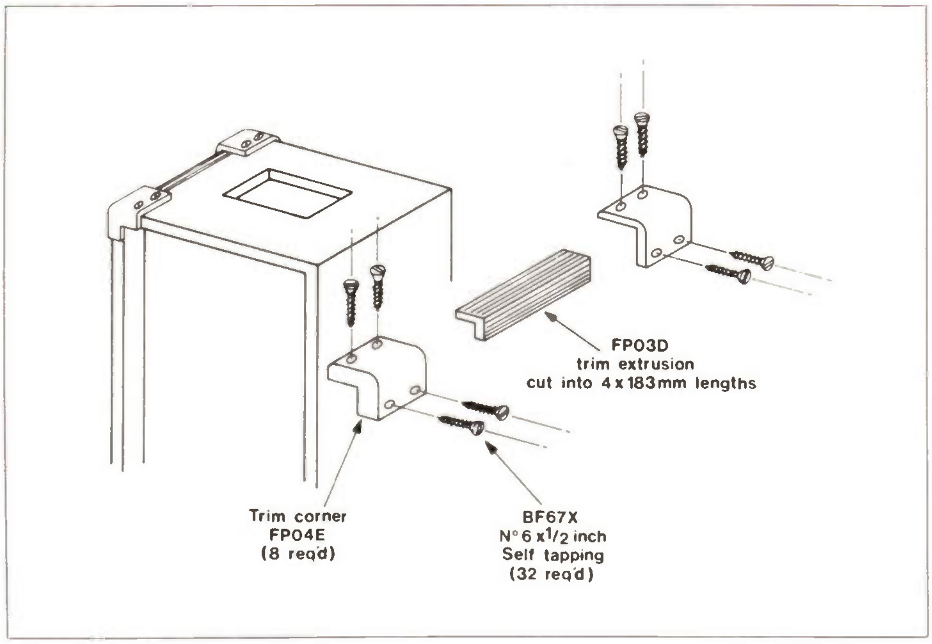


Figure 22. Fit the trim.

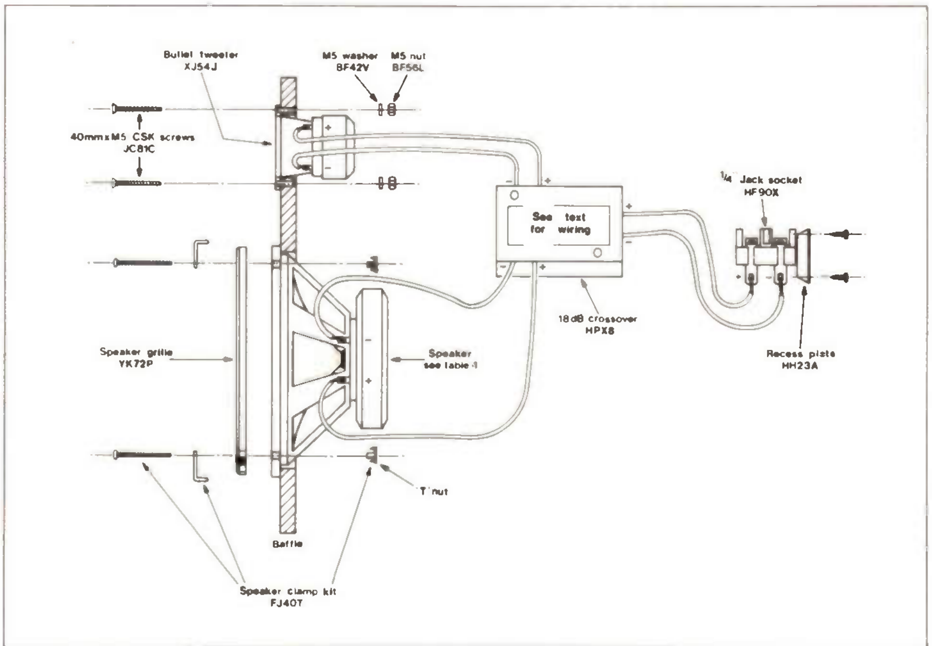


Figure 23. Wiring the speakers.

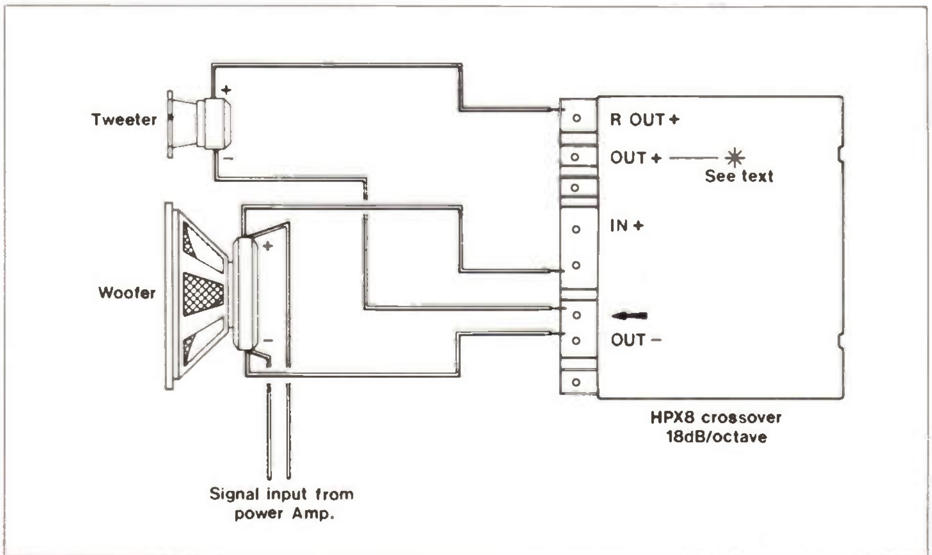


Figure 24. Wiring the X-over.

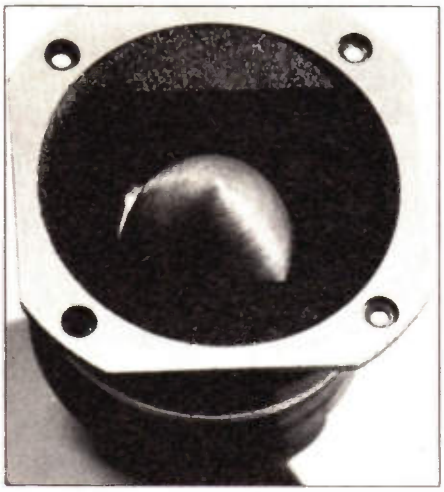


Photo 6. The bullet tweeter.

Speakers and Wiring

The assembly and wiring diagrams in Figures 23 and 24 should be followed carefully so that speaker phasing and X-over connections are made correctly. Wires must be attached to the speakers and to the jack socket before they are mounted into the cabinet - and you may find it much easier to solder the wires to the X-over module before it is mounted as well! Connect the tweeter to the R OUT+ (resistive attenuator) terminal on the X-over module if you intend to run the system at continuous high power levels of 100 Watts and above, otherwise for lower power use the OUT+ terminal. The main input wiring from the jack socket can be connected either directly to the woofer or indirectly via the IN+ and OUT- terminals on the X-over module. OUT- is the common 0V terminal.

Mount the bullet tweeter (Photograph 6) into the baffle and with the four bolt holes aligned, insert a 40mm x M5 screw into each hole. Place a washer and nut onto each bolt, on the inside, and add a second M5 as a lock nut. These nuts must be well tightened to prevent them from shaking loose in use. It is an idea to spread a small layer of glue over the nut and screw thread to lock them together.

Fit the bass speaker with the four fixing holes aligned as before, and position the grille centrally over the cone area. Use steel speaker clamp brackets to hold the grille as shown and fit the round headed bolts from the clamp kit, through both the clamp and speaker frame.

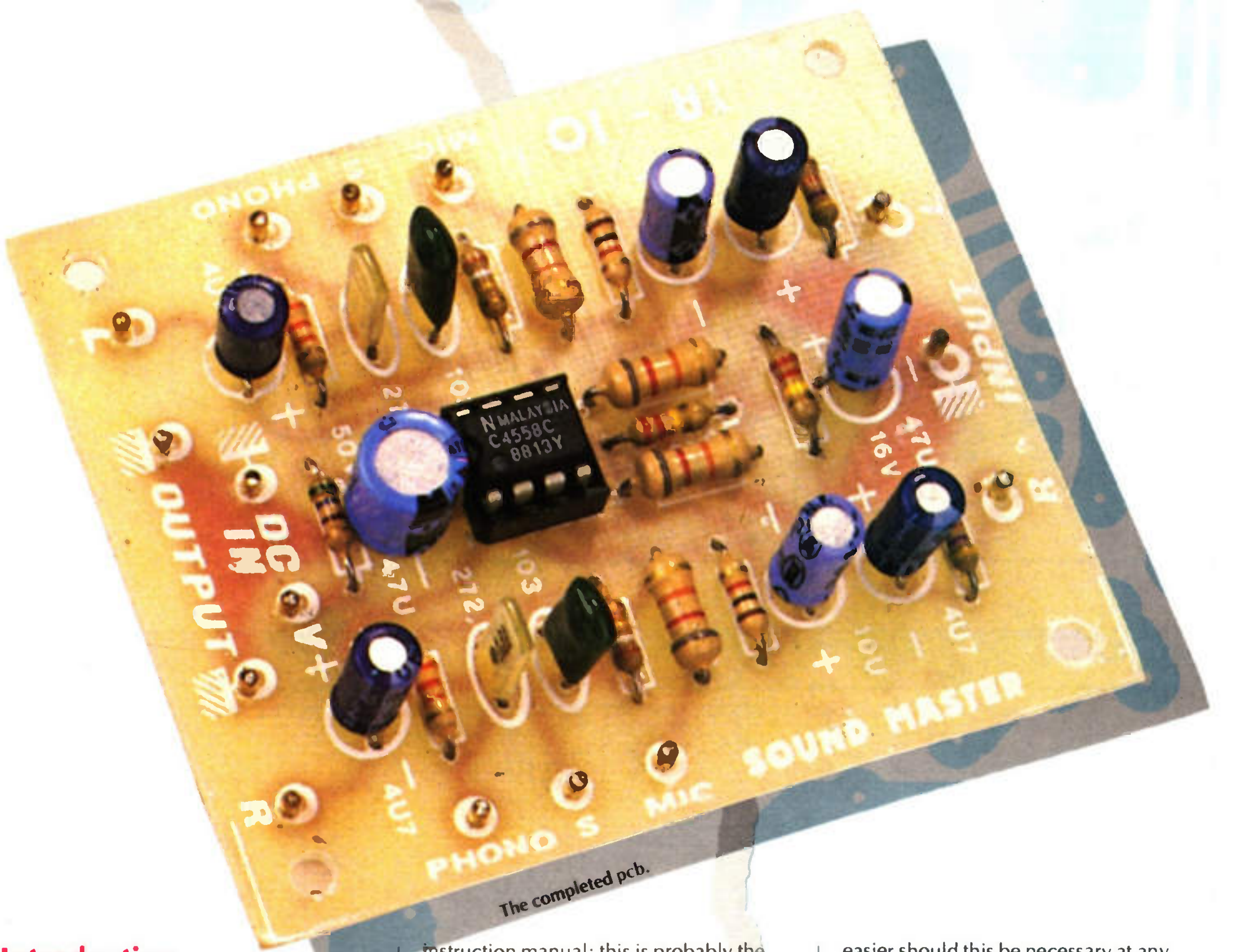
Finally, fit the previously wired jack socket and recess plate using two No.6 self tappers to fix the plate to the cabinet. Your cabinet should now be ready for use and should offer good service - providing it has been built well enough of course! Do not be tempted to overdrive the loudspeakers: if music or instrument sources produce distorted sounds, then investigate the cause, could the amplifier be faulty or is the input signal level too high, for instance? Driving an amplifier into 'clipping' will destroy the tweeter very quickly - even at relatively low power levels - and should be avoided.

Continued on page 69.

Stereo Pre-Amplifier

This pre-amp has been fitted into a metal box for screening purposes.

Review by
Gavin Cheeseman



The completed pcb.

Introduction

This is a review of the TA-10 Stereo Pre-amplifier, one of the new kits from Sound Master Electronics, marketed in the UK by Maplin Electronics. The TA-10 is an 'open ended' module that can be used in many applications where an audio frequency pre-amplifier is required; it has two separate inputs and outputs and is ideal for stereo operation. My first impression of the kit was that of a relatively simple but good quality product which consists of a few components and a fibre-glass PCB. A 4558 operational amplifier IC forms the heart of the pre-amplifier and is in fact, to my surprise, the only semiconductor in the kit. A comprehensive instruction manual is included with the TA-10 giving full details of how to build and test the finished module. The PCB layout (Figure 1) and circuit diagram (Figure 2) have been repeated in this review for reference purposes. Note that in Figure 1 the polarity symbol for C2 is shown correctly (in Figure 1 of the manual it is shown the wrong way round).

Building the Kit

The kit can be built and tested using the minimum of equipment. In addition to the parts supplied a few simple tools, some solder, and a metal box in which to house the module are needed. I think the best way to start, as with any kit, is to lay the components out on a table and check them against the parts list. I have found that it is always good practice to fit the parts in the order suggested in the instruction manual; this is probably the easiest method because the sizes and positions of the various components have usually been taken into consideration. I found the construction of the kit fairly straight forward and as long as you follow the information in the instruction manual I don't see why you should have any problem with producing a finished and working pre-amplifier module. I was pleased to see that an IC socket is included in the kit because this eliminates any risk of overheating the IC during soldering and makes its removal much easier should this be necessary at any time. When fitting the IC, please make sure that all of the pins are properly inserted into the socket; I have found that it is all too easy to bend the pins under the IC by mistake and it is often quite hard to bend these back without breaking them. As always, once all of the components have been fitted, I recommend that you check your work thoroughly to make sure that everything is as it should be; in particular, I suggest that you double check that the electrolytic capacitors and IC are fitted the right way round!

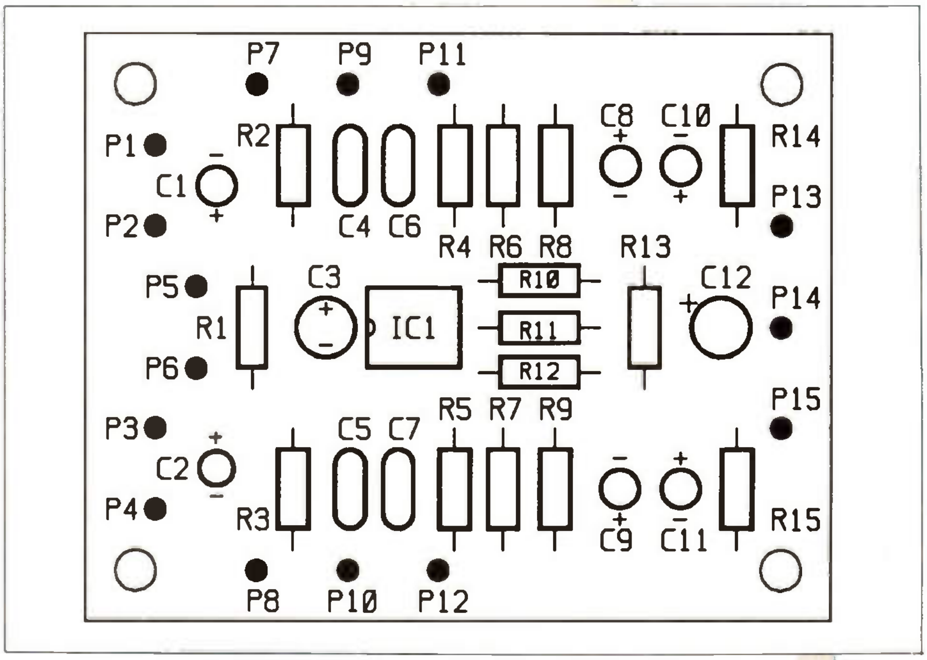


Figure 1. Overlay of the PCB.

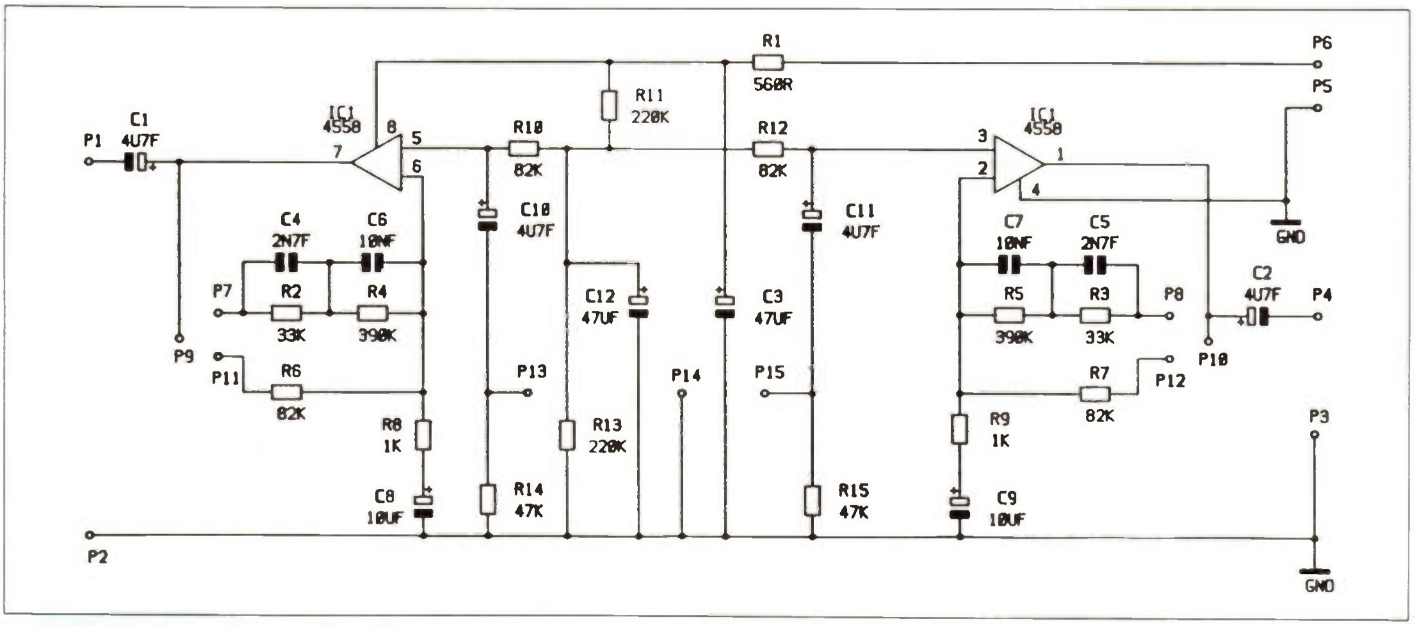


Figure 2. Circuit.

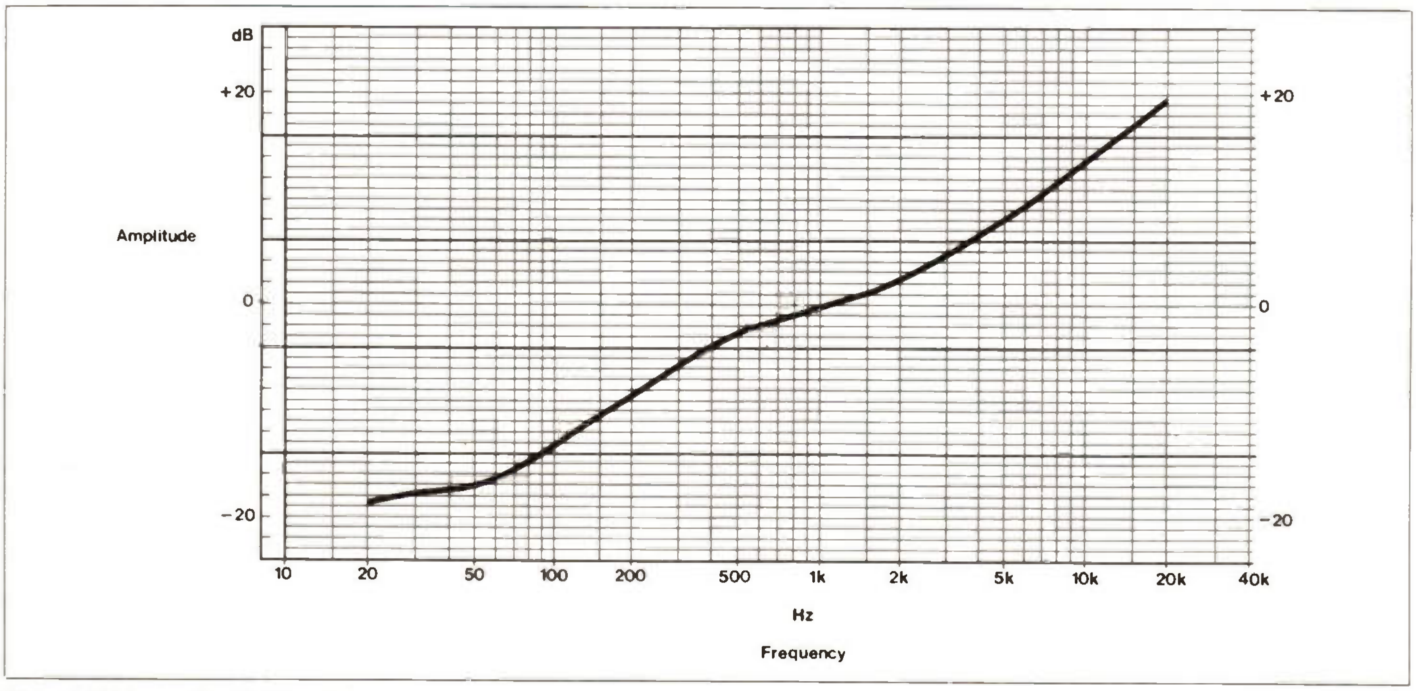


Figure 3. RIAA recording characteristic.

Testing the Module

I must stress that before any proper audio frequency tests can be carried out it is essential that the pre-amplifier is screened in a metal box (for example Maplin stock code LF10L). In addition, I found that it was important to use screened lead for the input and output wiring, otherwise the external noise pick-up can be excessive. When installing the finished module into its screened enclosure, I recommend the use of spacers at the four fixing points on the track side of the PCB in order to prevent any short circuits; these should be at least 5mm high. It is a wise precaution to measure the resistance between P5 and P6 (the power supply pins) on the module before it is installed, to make sure that these are not short circuit. I noticed that in the instruction manual it suggests that you measure the resistance between P1 and P2; I presume that this is a mistake and that it in fact means P5 and P6. The module does not require any setting up and so it is basically ready for operation as soon as construction is complete. If no test gear is available, probably the best way to test the finished PCB is to install it and check that it operates satisfactorily when in place; however, I decided to test the pre-amplifier more thoroughly in order to obtain an idea of its various parameters. The module can be operated in two different modes, namely 'PHONO' and 'MIC', each providing a different frequency response. One of the main facilities offered by the TA-10 is that of RIAA equalisation for magnetic pick-ups and when used for this purpose the 'PHONO' mode should be selected. The frequency response of record making equipment is tailored to prevent groove collapse during recording and also to reduce hiss when the record is played; this response is often known as the RIAA (Record Industry Association of America) recording characteristic (see Figure 3). Any equipment that you use to play the record should have a frequency response which is complementary to the recording characteristic and this is known as the RIAA replay characteristic. I tested the frequency response of the TA-10 in its 'PHONO' mode and the results I obtained are shown in Figure 4; this response curve is very close to the standard RIAA replay curve. In addition to equalisation the module also provides the high input sensitivity that a magnetic pick-up requires. In the 'MIC' mode the frequency response of the pre-amplifier is for all practical purposes flat, making it ideal for microphones or for general purpose use. The results I obtained from frequency response tests with the TA-10 in the 'MIC' mode are shown in Figure 5.

Output Load

As regards output load, I found that the TA-10 would operate happily into any

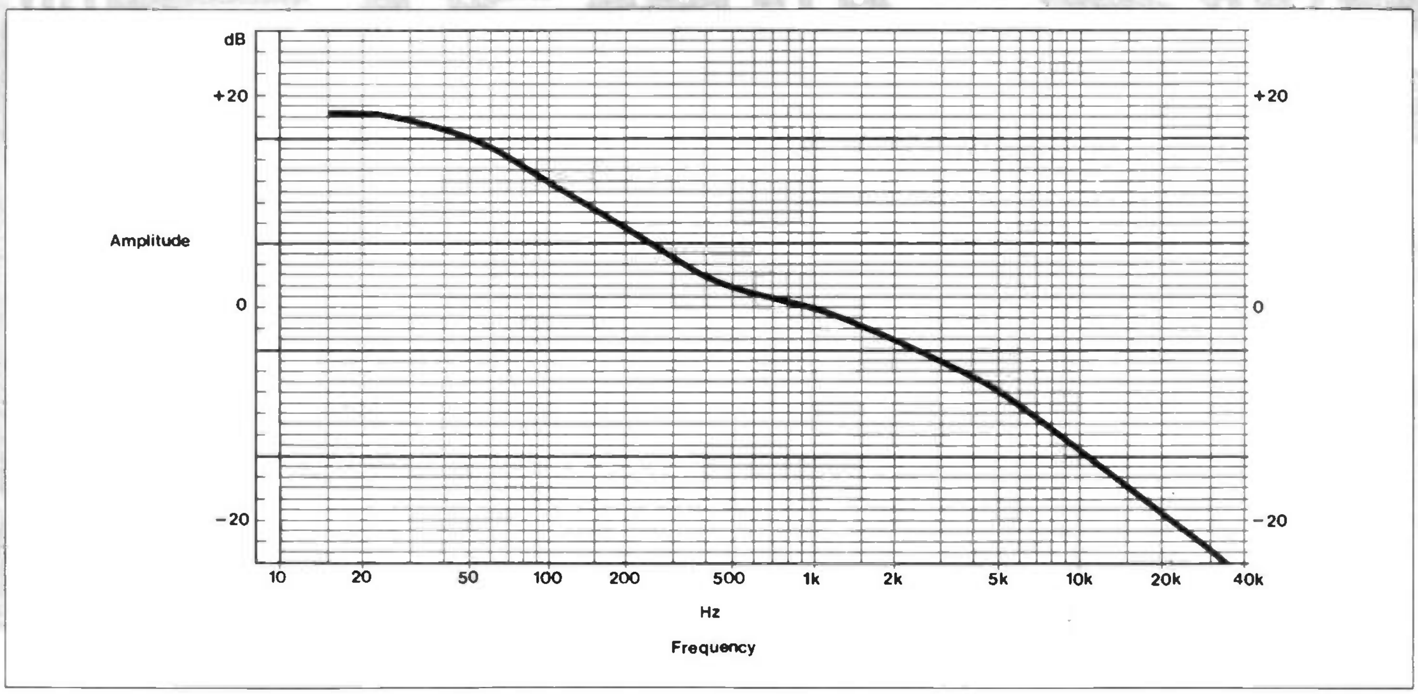


Figure 4. Frequency response in 'PHONO' mode (replay characteristic).

load impedance above 4 or 5kΩ. As I reduced the load impedance significantly below 4kΩ the frequency response of the module changed quite drastically especially at the low frequency end, which became increasingly attenuated; however the output impedance of the TA-10 is suitable for most purposes and there is unlikely to be any major problems in practice.

Power Supply Requirements

To power the TA-10, you will need a 30V power supply that is capable of delivering at least 30mA. I consider that it is of great importance that the output of the power supply is adequately smoothed to minimise the likelihood of introducing mains hum into the pre-amplifier.

Using the Module

The TA-10 is really a building block and can be used in many different applications. For example, in its 'PHONO' mode the module could form part of a record player, providing the necessary equalisation when using a magnetic pick-up. When used for this purpose the magnetic pick-up is connected to the input of the TA-10, the output being connected to the power amplifier via any extra pre-amplification or tone control circuitry that may be required. Of course, pre-amplifiers such as the TA-10 are intended for use with magnetic pick-ups only and are not suitable for use in cassette players or with other types of pick-up. I think a useful facility that the module offers is the possibility of fitting a switch allowing you to select either the 'RIAA' or 'MIC' mode as and when you need to. For example, you could arrange the switching to enable you to select either a record deck or a microphone and also simultaneously switch the module into the appropriate mode for the required frequency response. In addition to the above applications, I think the TA-10 could also be of use in many other situations where high sensitivity and gain are required.

Conclusions

I think that the TA-10 is a good quality, low cost and versatile product that can be used in all sorts of different applications where a sensitive audio frequency pre-amplifier is needed. It was a pleasure to construct and use the module and, bearing in mind that it is relatively simple, I think it performs surprisingly well. Finally, I would like to thank Maplin Electronics for the use of the review sample.

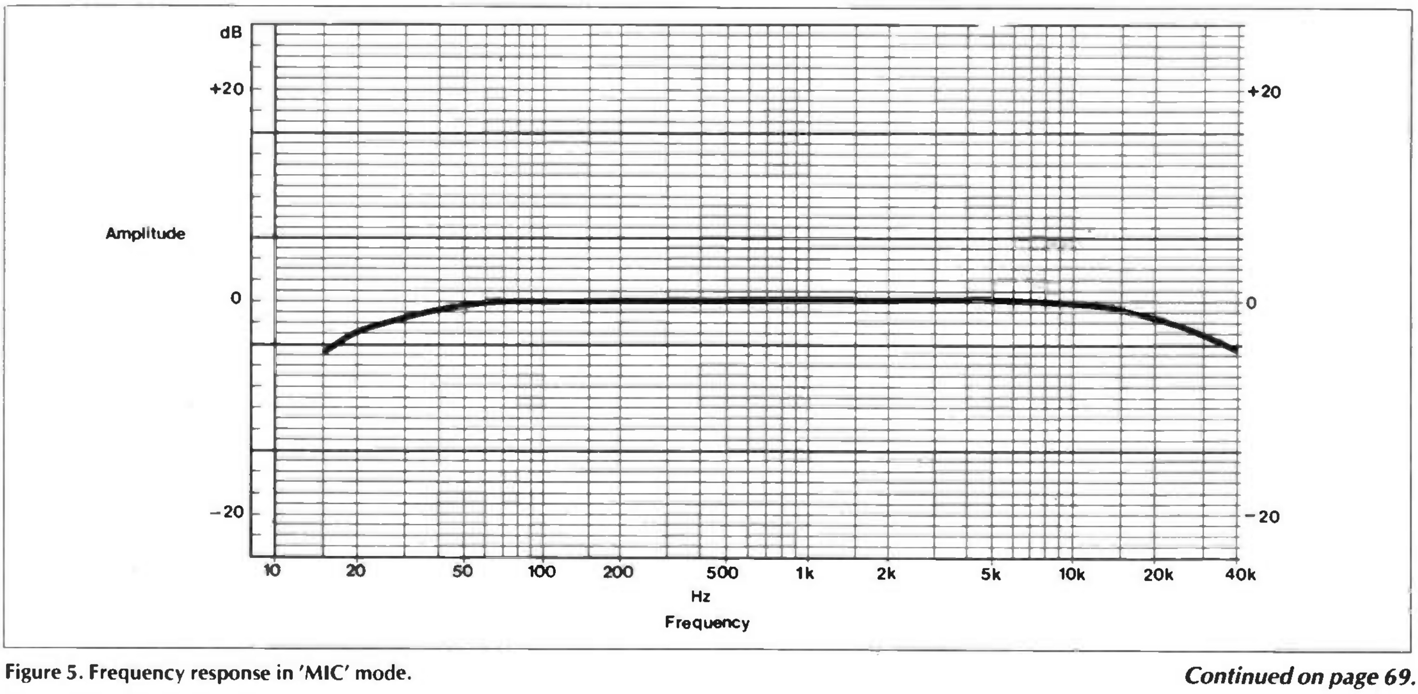


Figure 5. Frequency response in 'MIC' mode.

Continued on page 69.

COMPUTERS IN THE REAL WORLD

Part 1 By Graham Dixey C.Eng., M.I.E.R.E.

Introduction

The power of the microcomputer is evident to us all. Those who use computers a great deal, whether at work or at home, have accepted readily the interaction that takes place between human and machine. This interaction is performed through the medium of an 'interface', which is the term for any piece of hardware that makes possible the communication (in either direction) between the computer itself and its 'peripherals' and, of course, a human operator. The word peripheral is also a general one used to describe anything that is connected to the computer but lies outside its 'periphery' and so, although being essential for certain operations, is not usually an integral part of the computer itself. Figure 1 is a schematic diagram of a computer connected to a number of peripherals, in a context which most people should find familiar.

The peripherals shown in this figure are: a Visual Display Unit, or VDU, (also known as a monitor); a keyboard; disk drive unit (hard or floppy); a printer and a mouse. Figure 1 merely shows, in a very general way, how the computer is central to its peripherals. It does not show the interfaces mentioned previously, nor does it indicate what the 'microcomputer' actually comprises. To illustrate just how general the scheme of Figure 1 is, take a look at the two work stations shown in Photos 1 and 2. These include most of the features of Figure 1, yet the ways in which they are physically arranged are quite different.

Photo 1 shows a very popular type of computer, the PC (Personal Computer), this one having both floppy and hard disk drives. These drives are housed within a large enclosure, which also contains the computer block of Figure 1 and supports the VDU. The keyboard is a separate item, quite compact in nature and connected to the computer only by an extensible, coiled lead.

By contrast Photo 2 shows the author's work station, one of the original Amstrad CPC464s, very much expanded over three years of ownership. The VDU is a separate item (though it also contains the power supplies for itself and the computer). The latter is in the keyboard moulding, which also houses the now redundant cassette recorder. Twin floppy disk drives are quite separate and connect to the computer by way of a ribbon cable, as does the dot matrix printer, the latter through a special 8-bit printer port. A mouse,used for graphics, is connected to the computer and, in this case, its special interface is seen at the left rear of the keyboard, plugged into the joystick port. Further units seen to the rear of the keyboard include a ROM box, that houses an assembler, wordprocessor, mail merge and utilities ROMs, a memory expansion pack (64k RAM) and the disk drive interface. Also included in this system is a light pen, with its own dedicated interface, though this is only connected when required and is not shown in this photograph.

Although this work station is based on a computer that most would not regard as a 'serious' (!) tool, this system has proved itself well and is an excellent example of the way in which the provision of suitable interfaces allows a high degree of expansion from a basic concept. It is also ample proof that much can be done on what these days is considered a modest amount of memory (128k of RAM).

Figure 2 gives a rather more detailed insight into the component parts of a computer and the way in which the peripherals are interfaced.

Processors

This figure shows that the microcomputer consists of the processor itself (MPU for Micro Processor Unit), which is where all of the program instructions are decoded and acted upon, where the system timing originates that actually causes the program to run in the required sequence, plus other related tasks. Well known examples of processors are the 6502, Z80, 80286, 68000, etc.

By itself the processor would achieve little if anything. To make it do something it must be given a program, which is nothing more than a list of instructions which, one by one, it obeys, like the slave that it is. This program may be stored in

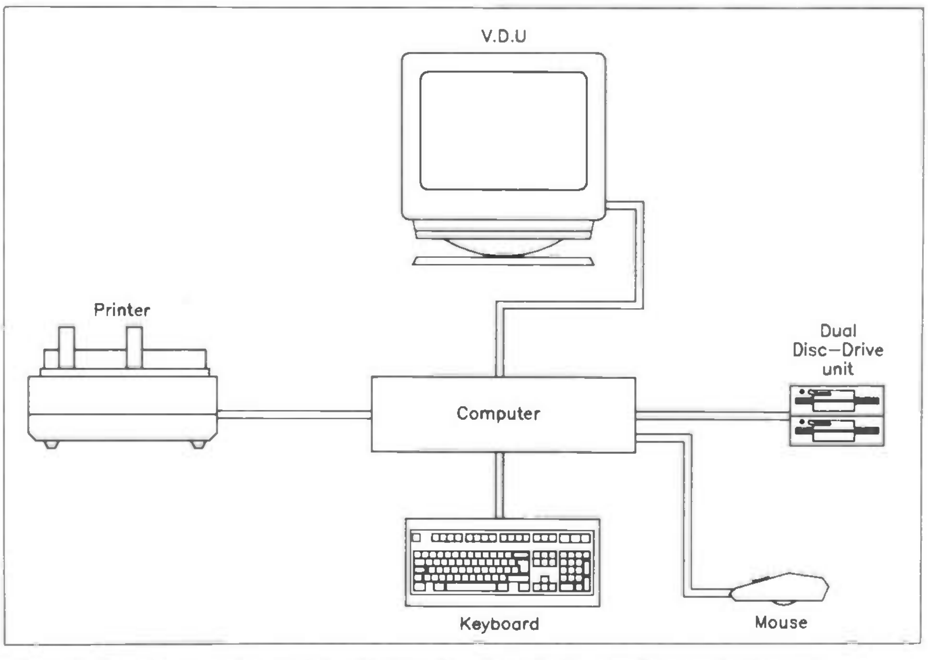


Figure 1. A computer and its peripherals. Not the only such situation but one that is easily identified. The computer is seen as the central element, common to all computing situations; the number and nature of the peripherals can change according to the requirements of the system.

ROM (Read Only Memory) or RAM (Random Access Memory, more usefully thought of as Read/Write Memory). Most computers will have programs stored in both types of memory, those in ROM either being written to allow the computer to perform a variety of mundane functions such as reading the keyboard, writing to screen, etc, or providing specific functions, such as running a high level language (BASIC, PASCAL, etc) or facilities such as word-processing, and so on. The programs in RAM will be those entered by the user, usually from an external storage device such as a disk drive, although it is, of course, possible to enter short programs into RAM directly through the keyboard. The blocks marked ROM and RAM in Figure 2 indicate the presence of both types of memory, irrespective of how much of each is actually provided.

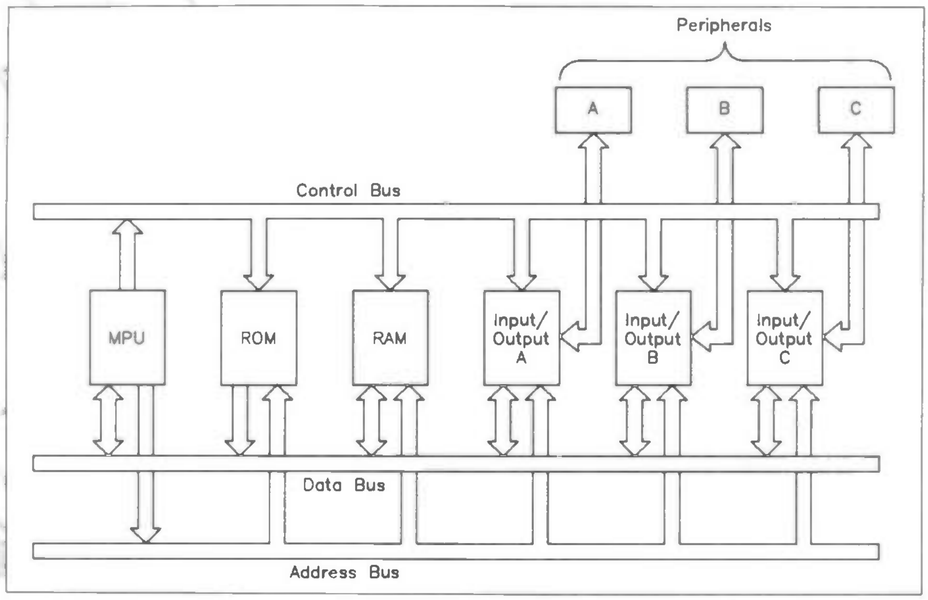


Figure 2. Essential block diagram for any computer, irrespective of its application. It's easy to see why the computer is often referred to as a 'bus-oriented system'. The input/output are quite general as shown and could refer to any of the peripherals and their interfaces shown in Figure 1 or Photos 1 and 2.

Interfaces & Buses

The final blocks in Figure 2 are the interfaces to the peripherals themselves. Sometimes they are known as the 'input/ output ports' of the computer, especially when they are provided by a general purpose interface chip, such as the 6522 VIA (Versatile Interface Adaptor) or the Z80 PIO (Parallel Input/Output). Other interfaces may have names which, by familiarity, determine their likely function. For example, the Centronics parallel port is used with a number of popular printers, whereas some printers either require, or offer the option of, the use of a serial connection such as RS232C.

Connecting all of these blocks are the 'highways' known as buses. They are the Address Bus that is used to identify and access the required area of memory at any instant, the Data Bus that is used to transfer data back and forth between processor, memory and peripherals, and the Control Bus whose functions include co-ordination of all the events during the running of a computer program.

It would be useful to define, in a general way, the function of any interface device. It is not unreasonable to ask why such a device is needed at all. To the initiated it may seem obvious; those with less experience of the ways in which computers and peripherals work may not find it so apparent.

Signal Conversion

The need for an interface arises either because the signals originating in a peripheral are in some way different from those which the computer requires, or because the signals are the same but the speeds at which the computer and peripheral handle the data are quite different. Alternatively, some conversion may be needed just to allow effective communication between the two devices. This reasoning applies in either direction of data flow. It may be that the peripheral requires a signal that is quite different

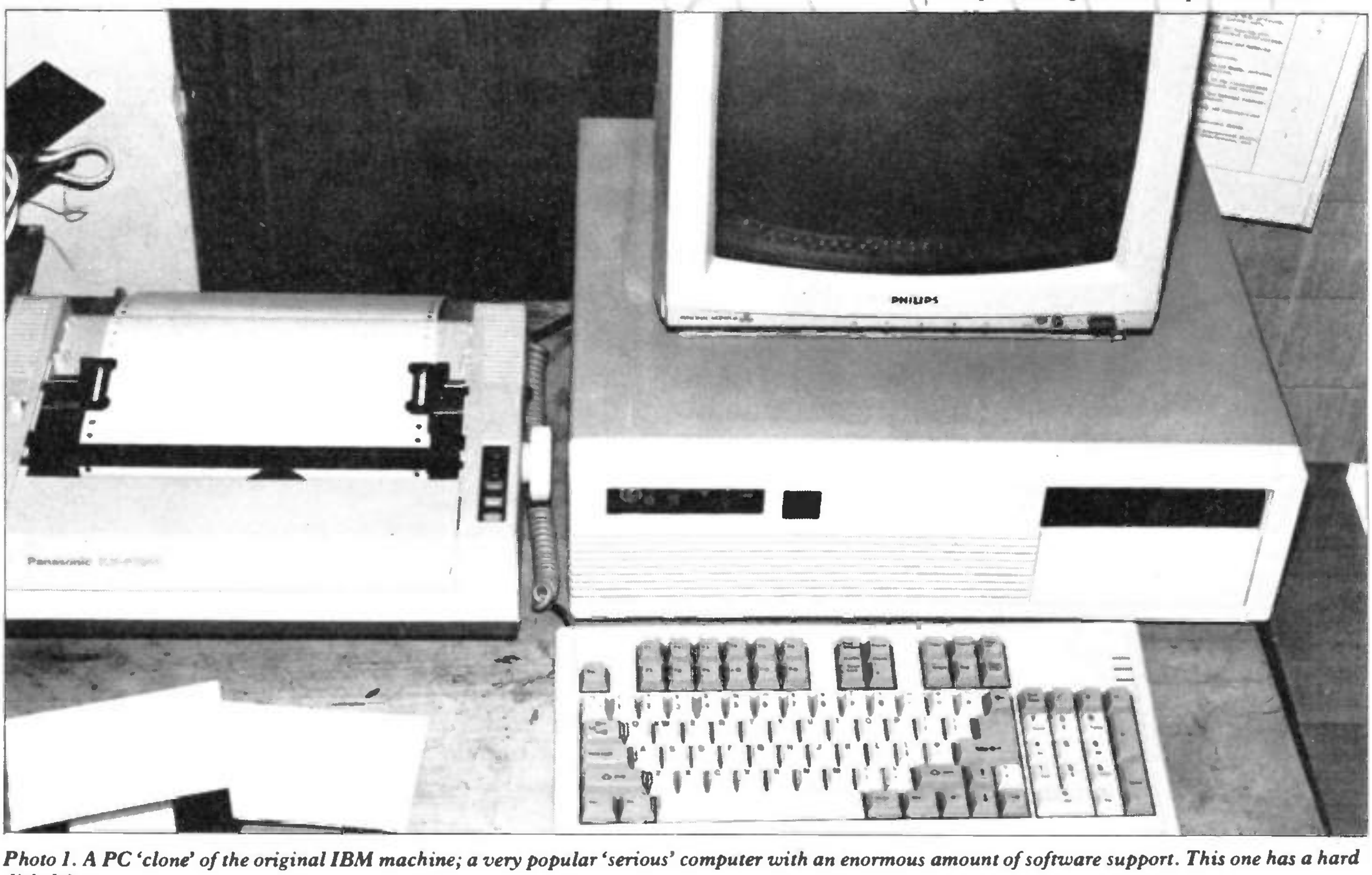


Photo 1. A PC 'clone' of the original IBM machine; a very popular 'serious' computer with an enormous amount of software support. This one has a hard disk drive.

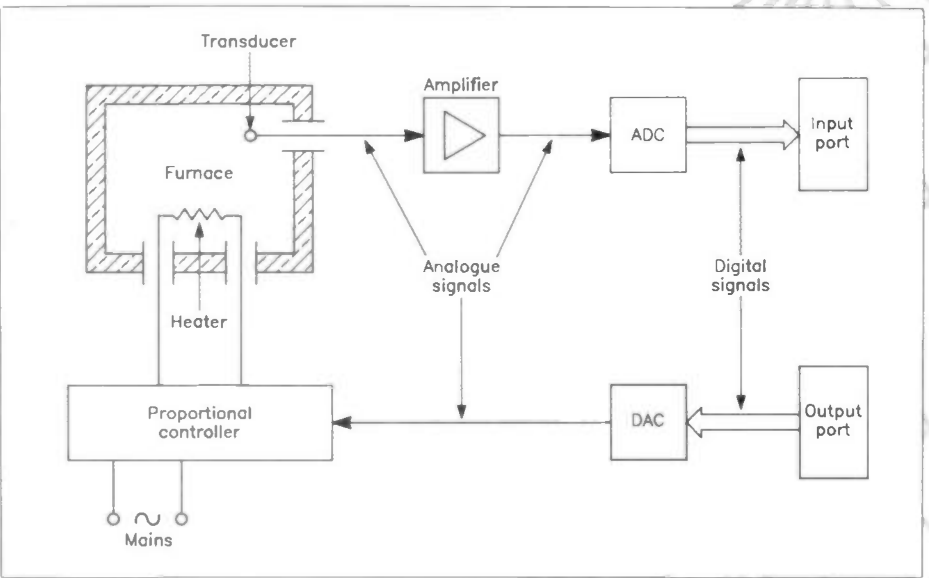


Figure 3. A practical application of a computer illustrating the need for signal conversion. Analogue output from transducer (monitoring furnace temperature) is amplified and converted to digital form before being processed by the computer. Conversely, digital output is converted to analogue form in order to control furnace power.

from the parallel digital output that the computer normally supplies.

To take each of these points further, consider the differences that may exist between signals.

All signals may be classified as being either 'analogue' or 'digital'. An analogue signal is one which can take up any of an infinite range of values and is capable of continuous variation. For example, in an audio amplifier the signal could have a value that was anything from a fraction of a millivolt to several volts; there is no one level that the signal could be assumed to have. The level at the pick-up end of the system is quite different from that at the speaker end. The same is true of any system that uses an analogue input and gives an analogue output. By contrast, a digital signal has only two values, known as 'logic 0' and 'logic 1'. A system based on these values is termed a 'binary system'; this is the system that all computers use. It is only necessary to assign nominal values of voltage to these two binary values and to design the computer circuits so that they are capable of distinguishing between them, a quite easy task for it to do. Naturally, if 0V is assigned to 'logic 0' and +5V is assigned to 'logic 1' (as is quite usual), we must expect that there will be departures from these values due, for example, to volt drops in the system, but it is quite easy to allow the two logic levels to have tolerances and still be capable of being distinguished, one from the other.

Perhaps we can now begin to see how some of the problems arise.

Suppose we have an analogue device whose output we wish to send to a digital computer for processing. The two types of signal are totally incompatible. In all probability the level of the analogue signal is far too small and furthermore the digital computer won't know what to do with it anyway. It becomes necessary to raise the level of the analogue signal (one of the processes known as conditioning) and to make an actual conversion from the analogue to the digital form. The circuit that performs this conversion is known as an 'analogue-to-digital converter' (ADC). This situation arises in many industrial control systems where a computer is used to control a process, such as the temperature of a furnace, by monitoring the variable (in this case temperature) and generating a signal that is then sent to a controller to maintain the required temperature. The latter will often also need converting because it may well be an analogue device as well, quite unable to respond directly to the digital signal produced by the computer. The device that performs this conversion is known as a 'digital-to-analogue converter' (DAC). This situation is shown in a simplified form in Figure 3.

A Question of Speed

The second case concerns two devices, the computer and a peripheral, that both handle digital signals but have quite different operating speeds. The best example is when a printer is driven from a computer. The latter is capable of working at quite incredible speed, often executing thousands of instructions in a few milliseconds. The printer, by contrast, is incredibly slow. Even the fastest printer is virtually at a standstill compared with the

Photo 2. Showing that even a so-called 'games' computer can be applied to more serious uses. This Amstrad CPC464 has been much expanded and enhanced over its three years of professional use.

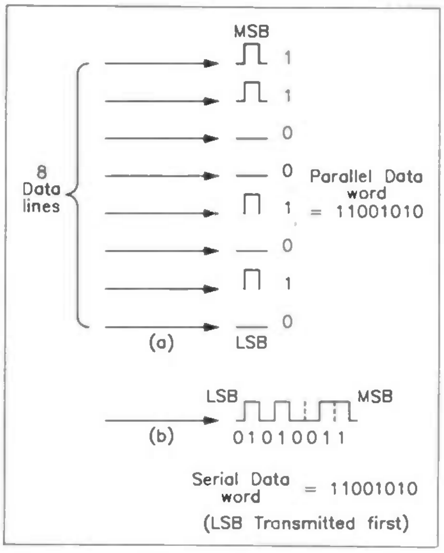


Figure 4. The difference between (a) parallel and (b) serial transmission of data. The parallel data needs one line per bit but all bits are sent at once. The serial data needs only one line, but the bits are sent one after the other.

speed of the computer. Yet somehow it is essential to synchronise the two so that the printer gets its supply of data so that it can carry out its task. An interface is needed that will keep the printer supplied with a stock of data (in what is called its 'buffer'), which it can 'top up' from the data held in the computer as required. The printer and computer will carry out what is called a 'handshaking' procedure in order to do this. In a later part, the operation of various printers will be described in detail.

The third case could also concern a printer but is equally applicable when connecting a computer into the public telephone network so that it can 'talk' to other computers. The function of the interface now is to convert the normal 'parallel' output of the computer into 'serial' form. The difference between the two types of digital signal is illustrated in Figure 4. The parallel signal needs a separate line for each bit, whereas only a single line is needed, no matter how many bits the signal has, in the case of serial data. The special advantage of the latter is evident when long distance communication is the case, although it is obviously a lot slower than parallel transmission because the bits are sent one after the other. Also, extra bits have to be sent to indicate the beginning and end of a data 'word', as well as supplying information that allows errors to be detected and corrected. Some printers accept or even need serial input. MODEMs, used where communication over telephone lines is required, also have to 'condition' the signal by using it to modulate the telephone carrier - the MO part of MODEM at the sending end - and to demodulate the telephone carrier at the receiving end - the DEM part of MODEM. Figure 5 shows two computers communicating through MODEMs. Even here there can be incompatibilities. The rate at which the data is transmitted, known as the Baud Rate, must be selected to be the same for both ends of the system, although it doesn't have to be the same in both directions. A more detailed discussion of the principles of MODEMs will follow in a later article.

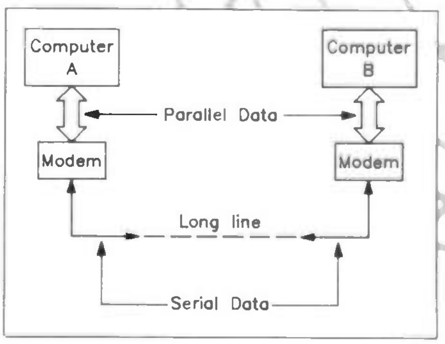


Figure 5. Two computers communicating via Modems. A conversion from parallel to serial form and vice versa is needed at both ends of the line.

Core Task

In any computer system the 'computer' is the central core. It should be evident by now that the computer consists solely of the MPU, memory, input/output chips and some additional logic. All of this can be accommodated on a single board, often of quite modest size. The VDU, keyboard, disk drive, etc, are not actually part of the computer proper but merely peripherals for it. It is quite possible to have a computer without a keyboard, without a VDU or any sophisticated display device and without any external storage device, such as a disk drive unit. As long as it can run a program and perform some useful task it is still a computer. It will be designed to run a program in ROM as soon as power is applied to it and any variations on this program will be made by an operator setting a few external switches to selected positions. A rather hackneyed, but nonetheless readily appreciated, example is an automatic washing machine. The exact wash program run can be predetermined at the start by setting switches and the inbuilt ROM program will look after operations that, in general, are concerned with establishing time durations, water temperatures, switching motors on and off for washing and spinning, and so on. It doesn't look the least bit like the PC of Photo 1 or the 'Arnold' of Photo 2 but it has exactly the same right to be called a computer. It is, for obvious reasons, usually referred to as being 'dedicated', since it never does anything else during its life than the one task. The more conventional computers are then said to be general purpose machines.

The foregoing discussions should have made it clear that, for one of several possible reasons, some form of signal conversion is often required. Hence the need for interfaces. What this series will be about is how we can make computers perform a variety of useful, and often quite different, functions for us, how the actual application of a computer is determined by the program run on it, the peripherals connected to it and the interfaces that provide the necessary degree of compatibility. Apart from the general interest that may be stimulated by discussions of the role of computers in the differing environments of the office, home, factory, hospital, etc, those readers who use a computer themselves may feel tempted to make wider use of it. To this end, where it is practicable or relevant, details will be given for building interface circuits and experimenting with them and associated hardware. In this respect some hints on how to write the controlling software will also be provided. As for who the series is for, it is for anyone interested in today's computer-orientated world. Only a modest amount of knowledge of electronics will be assumed and, hopefully, not too much will be taken for granted where the computers themselves are concerned.

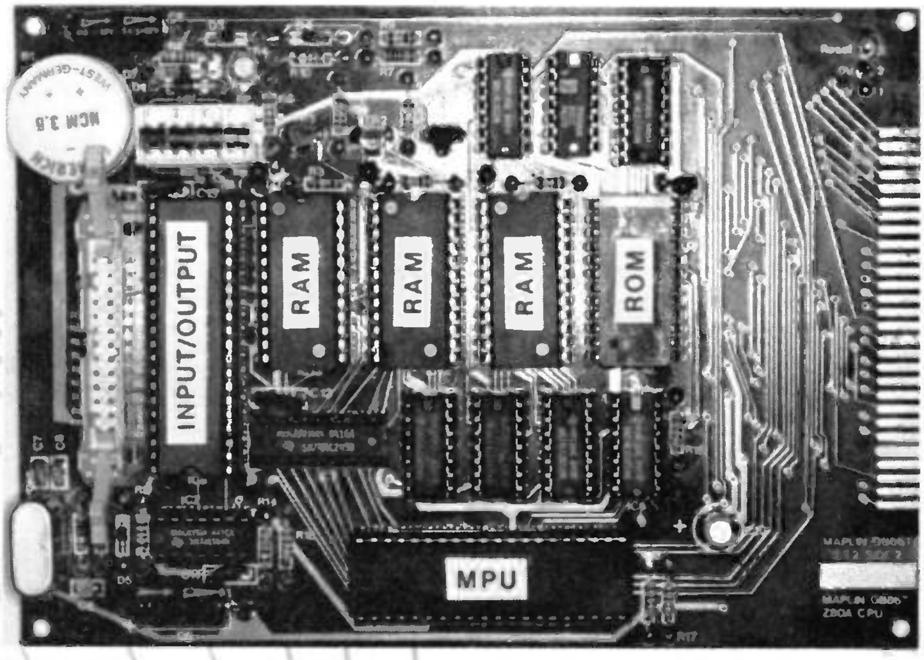
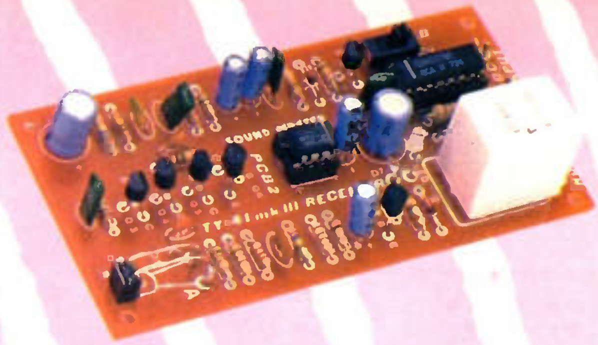


Photo 3. This is a complete 'single' board computer, only needing some peripherals to form a working system. The main blocks of the computer are clearly identified. Other, smaller, chips are the logic for decoding, etc.

INFRA-RED REMOTE CONTROL SWITCH



Introduction

The 'TY41 MKV Infra-Red Remote Control Switch' kit is one of the new products from Sound Master Electronics marketed by Maplin. The system allows remote switching of a relay with provision for either momentary or latched action and features a range in excess of 10 metres.

I was very impressed with the presentation of the kit, which comes in a clear plastic box containing all the parts necessary to produce the finished item. There is even a black plastic case for housing the finished infra-red transmitter, which I think looks quite neat. In addition to the parts supplied in the kit, you will also require a metal box to house the finished receiver PCB. An easy to follow instruction manual is included in the kit giving full information on how to build and test the finished product. The circuit diagrams (Figures 1a and 1b) and layout diagrams (Figures 2a and 2b) have been repeated in this review for reference purposes.

Building the kit

As always, before attempting any construction, I suggest that you lay the components out on a table and check them against the parts list to make sure that everything is correct. There are effectively two sections to the kit, namely, the transmitter and the receiver; the manual deals with the construction of each of these separately. In addition to the parts supplied, a soldering iron, some solder and a few simple tools are required to build the kit.

REVIEWED BY GAVIN CHEESEMAN

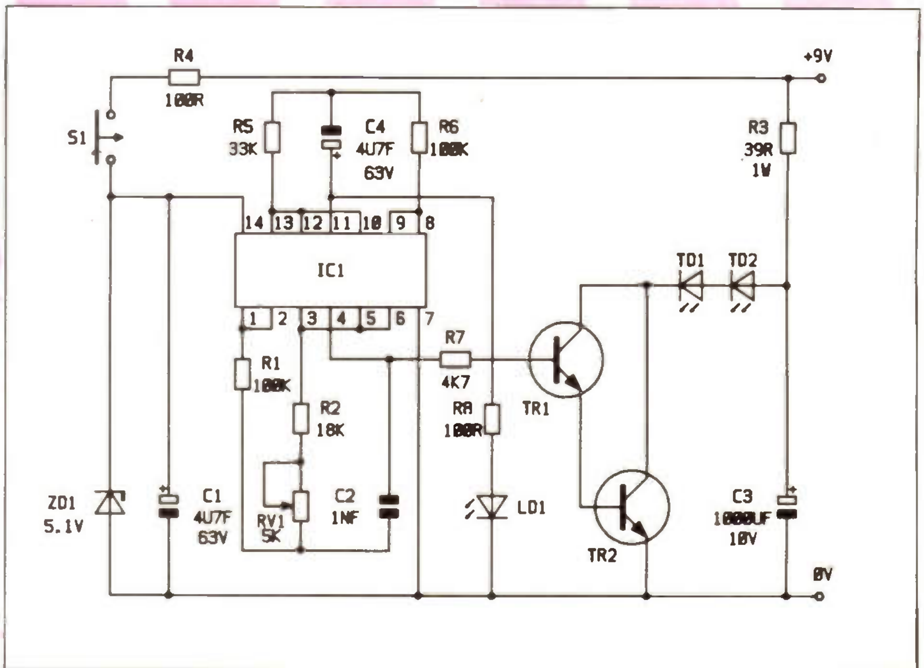


Figure 1a. Circuit Diagram of Transmitter.

Transmitter Construction

I found construction of the transmitter fairly straight-forward and you should not experience problems if you follow the information in the instruction manual. Some care is required when fitting LD1, as it is soldered to the track side of the PCB and the leads have to be cut very short, making it prone to overheating during soldering. I suggest that the soldering time is kept as short as possible to avoid damage to the LED. It is nice to see that IC sockets are included in the kit, as these help to prevent any damage that could be caused by soldering the ICs directly into the PCB and also make IC removal easy should this be necessary at any time. Make sure that all of the IC pins are inserted properly into the socket; it is all too easy to bend the pins under the IC if too much force is used or if the IC is incorrectly placed. It may be necessary to straighten the IC pins before the device is fitted, to enable the IC to be installed

SPECIFICATION

Receiver		**Transmitter**	
Supply voltage	9V – 12V	Power supply	9V battery (PP3 type alkaline)
Standby current	35mA at 12V	Operating current	see Table 1
Operating current (relay switch on)	120mA at 12V	Carrier frequency	18.5kHz – 23.5kHz (set by RV1)

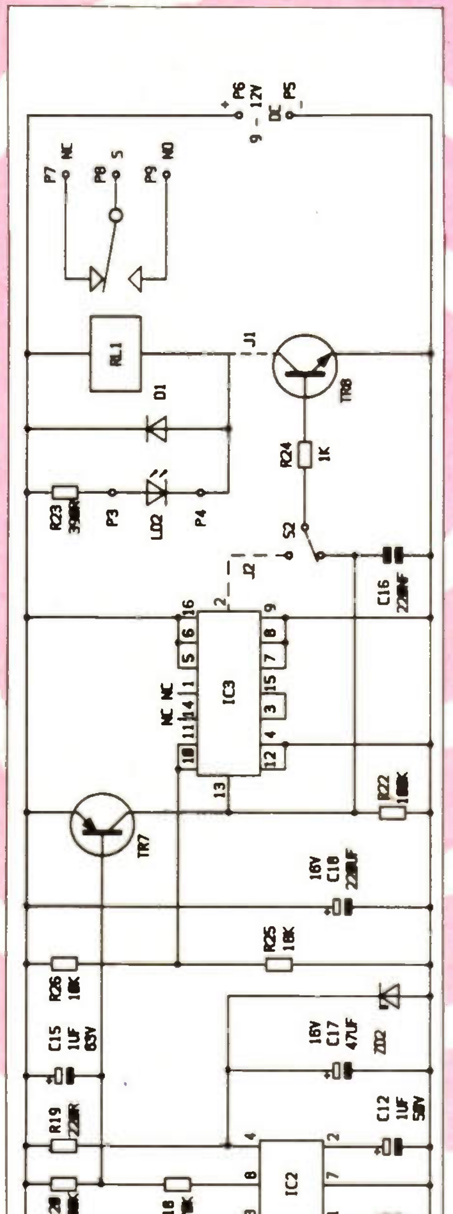
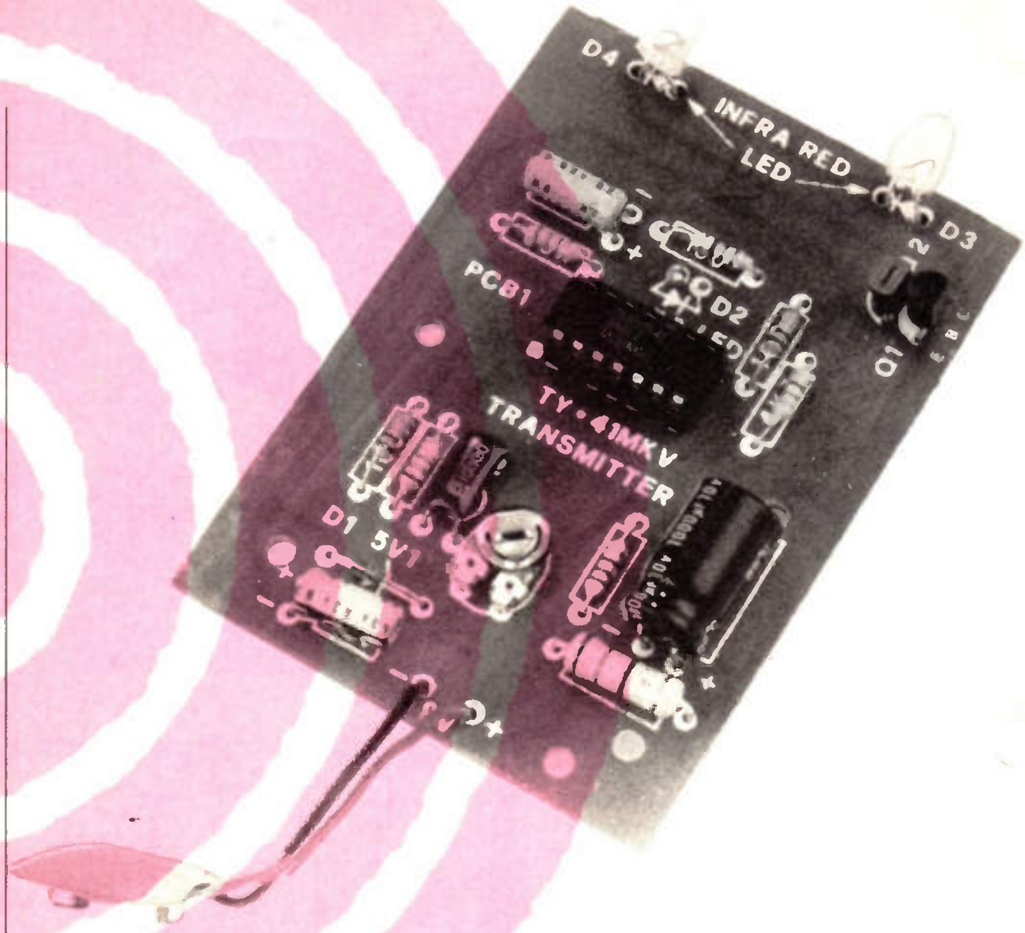


Figure 1b. Circuit Diagram of Receiver.



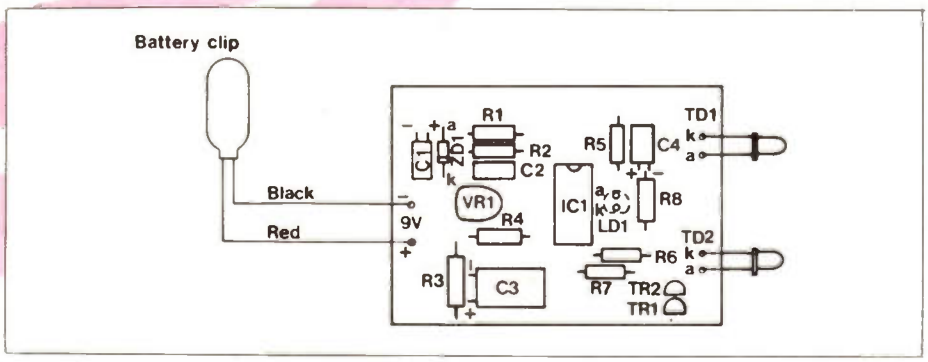


Figure 2a. Layout Diagram of Transmitter.

correctly into the socket. Take care when you fit preset resistor RV1 as it is quite fragile and easily damaged by excessive force.

The transmit switch, on the control unit is formed by a flexible metal plate which is held in the appropriate position on the track side of the PCB using a square of adhesive tape, as shown in the instruction manual. The transmitter PCB is positioned in the case such that the metal plate and associated assembly, lines up with the button on the front of the control unit; when this button is pressed the metal plate makes contact with the appropriate PCB track and switches on the transmitter. When you are installing the transmitter PCB into the plastic case, make sure that transmit diodes TD1 and TD2 are fitted correctly into the reflex cups before the board is finally fixed in place using the four small self tapping screws provided. LED indicator, LD1 should protrude through the appropriate hole in the front of the transmitter case. The 'plastic lens' is then clipped into position; it should be pointed out that this is in fact not a lens but a transparent, red, plastic filter that fits in front of the transmit LEDs. A decorative self adhesive label for the front of the transmitter is included in the kit. When you stick the label down, make sure that the holes for LD1 and the transmit button (S1) are positioned correctly. Access to the transmitter circuit board is necessary for alignment purposes, so the rear cover should not be fitted until the unit is fully tested and working.

The transmitter operates from a 9V PP3 type battery; I recommend that you use an alkaline battery, because the transmitter current drain can be fairly high. If you do not require the maximum possible range, the value of R3 may be increased in order to reduce the transmitter current consumption and thereby prolong battery life. Suitable values for R3 and corresponding current drains are given in the instruction manual. The transmitter only draws current from the battery whilst S1 is pressed, so where possible the transmit button should be held down for the minimum time required to trigger the receiver unit.

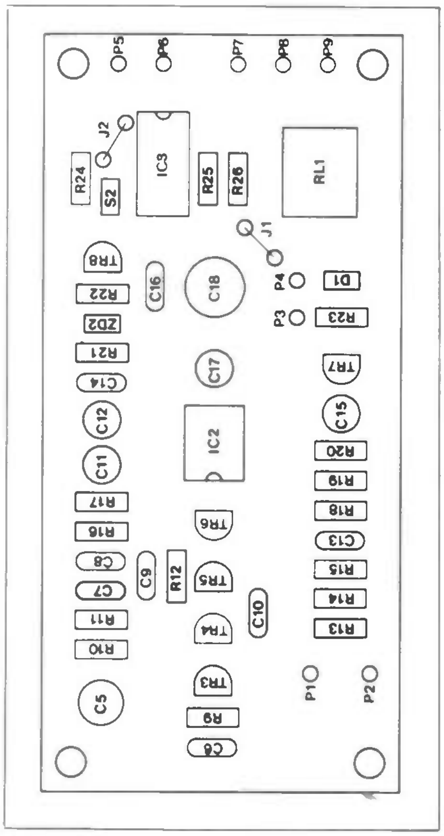


Figure 2b. Layout Diagram of Receiver.

Receiver Construction

The receiver PCB is the larger of the two (108mm x 55mm) and uses the majority of the components in the kit. One important point that should be noted regarding the receiver is the fact that a PCB mounted relay is used. I must stress that for safety reasons, the relay must not be used for voltages in excess of 50V or for currents above 1A. The relay should NOT be used to switch mains voltage under any circumstances!

False triggering due to external noise pickup by the receiver can be a problem if the unit is not properly screened. For effective screening, the receiver PCB should be housed in a metal box; a suitable enclosure for this purpose is box type AB7, available from Maplin Electronics (stock code LF08J). In addition to housing the unit in a screened enclosure, it is a good idea to use screened lead for external connections to the PCB. I noticed that Figures 4 and 9 in the instruction manual show different types of receive diode (RD1). To avoid confusion the anode and cathode connections for both types of diode are shown in Figure 3 of this review; the cathode is connected to P1 and the anode to P2.

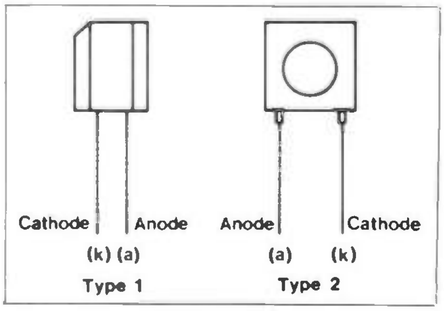
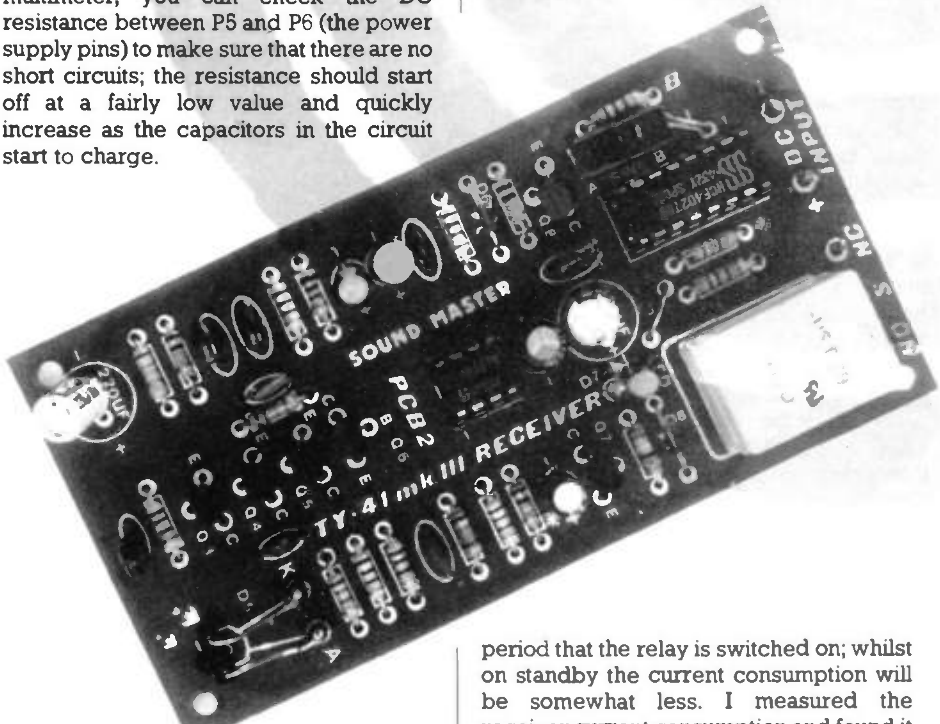


Figure 3. Receive Diode (RD1) Anode and Cathode Connections

Before carrying out any tests, it is a good idea to double check that everything is correct; in particular, make sure that the polarised components (transistors, ICs, diodes and electrolytic capacitors) are the right way round. Check that all component leads are cut as short as possible so that they do not protrude excessively from the track side of the PCB. If you have a multimeter, you can check the DC resistance between P5 and P6 (the power supply pins) to make sure that there are no short circuits; the resistance should start off at a fairly low value and quickly increase as the capacitors in the circuit start to charge.



When you install the receiver PCB in the screened enclosure, to eliminate any risk of a short circuit, please ensure that you allow enough clearance between the track side of the PCB and the metal chassis; I found that 5mm high spacers provide adequate clearance if the component leads are kept short. Receive diode RD1 is best positioned such that the flat unmarked side of the diode is facing in the direction of the infra-red transmitter. A small hole should be drilled in the metal housing to provide a clear (line of sight) path between the transmitter and the receive diode (RD1). You may have to extend the diode leads to enable it to be placed in the optimum position for the particular housing that you have chosen; if the leads have to be extended any more than a couple of centimetres, remember to use screened cable. The state of the relay is indicated by LD2; this feature is especially useful when aligning the system, as it gives you a simple visual indication of whether or not the infra-red transmission is being received. It will probably be necessary to extend the leads of LD2 to allow the diode to be placed in a position where it can be easily seen when operating the system.

Receiver Power Supply

A 9V to 12V, regulated power supply, that is capable of delivering at least 150mA is required to power the receiver. I must stress the importance of adequate power supply decoupling as the infra-red receiver is prone to false triggering if mains derived noise is introduced onto the supply rail. It should be borne in mind that maximum current drain occurs during the period that the relay is switched on; whilst on standby the current consumption will be somewhat less. I measured the receiver current consumption and found it to be around 120mA with the relay switched on and 35mA in the quiescent mode when using a 12V power supply.

Testing and Alignment

In order to test the TY41 MK V, you will need to set the system up in an area where you can attain a reasonable distance between the transmitter and receiver, without any degree of obstruction. The receiver may be used in one of two modes, providing either momentary or latched switching action, the desired mode being selected by S2. With S2 set to position 'A' the action is momentary and when the button on the transmitter (S1) is pressed, the relay switches on until the button is released. In position 'B' latched action is provided: When S1 is pressed once and then released, the relay switches on and latches; if S1 is then pressed and released a second time the relay will return to the off state. While testing the system, I found it was best to set S2 to position 'A' because in this mode, LED indicator LD2 is only lit during the period that a signal is being received; this makes it easy to see when the transmitter is in range.

To align the transmitter, point the controller towards RD1, press the transmit button and adjust preset resistor RV1 until LD2 lights, accompanied by a click from the relay. If everything is working correctly, increase the distance between the transmitter and receiver and adjust preset resistor RV1 until the range is optimised. Once aligned, the back cover of the transmitter may then be fixed in position using the self-tapping screw provided. The relay is a single pole, double throw type and provides both normally open and normally closed contacts. For normally closed contact operation, make connection to P7 and P8, if however, you require normally open contact operation, make connection to P8 and P9.

Control Distance (Range)

During tests on the TY41 MK V, I found the range to be very good. The maximum distance obtainable depends on several factors; in particular a clear path between the transmitter and receiver is important and greatly increases the maximum distance over which control can be maintained. Under some circumstances control may be achieved by reflecting the infra-red signal from a solid object such as a wall; this is especially the case when the distance between the transmitter and receiver is short. It is interesting to note that the infra-red transmission will also travel short distances through some types of glass.

Using the System

Before deciding whether the TY41 MK V is suitable for a particular purpose, it is useful to have an idea of the limitations of the system and how some of the problems can be overcome. One thing that you should always remember is that infra-red is very similar in nature to visible light and therefore in most cases does not propagate through solid objects. In order for the system to operate there must be a direct (or at least reflected) path for the infra-red transmission between the transmitter and receiver; if this is not available then the system will not work. In practice, it is surprising just how well the TY41 MK V works and even under quite adverse conditions it is often possible to obtain enough reflection to operate the unit.

Under some circumstances the performance of the system may be impaired if the receive diode, RD1, is exposed to direct sunlight and this should be borne in mind when choosing a location for the unit.

The system could be used in many applications requiring remote operation of a switch; it could form the basis of a remotely operated garage door opener or remote control light switch for example.

Conclusions

The TY41 MK V infrared remote control switch can find uses in all sorts of situations where manual operation of a switch is either not possible or is simply not practical. I was particularly impressed by the range obtainable. If you require a short range 'line of sight' remote control switching system, then the TY41 MK V is for you.

The Sound Master 'Infra-Red Remote Control Switch-TY41 MK V' kit, is available from Maplin Electronics, order code: LM69A price £17.95

TRANSMITTER PARTS LIST

Resistors: (all 5% tolerance)	
R1	100k
R2	18k
R3	39Ω 1 Watt
R4,6,8	100Ω
R5	33k
R7	4k7
RV1	5k Preset
Capacitors	
C1,4	4μ7F 63V PC Electrolytic
C2	1nF Mylar Film
C3	1000μF 10V PC Electrolytic
Semiconductors	
TR1,2	9011 or 9013 or 9014
ZD1	5.1V Zener Diode
LD1	Red LED (3mm)
TD1,2	Infra-red LED
IC1	4011
Miscellaneous	
S1	Skeleton Click Switch
PCB	Marked 'transmitter'
Case	(2 parts)
Lens	
Reflex Cup	
Screws	6mm
Screws	12mm
Push Button	
IC Socket	(14 pin)
Adhesive Pad	
Nut	(M2.5)
Front Panel Label	
9V Battery Clip	

RECEIVER PARTS LIST

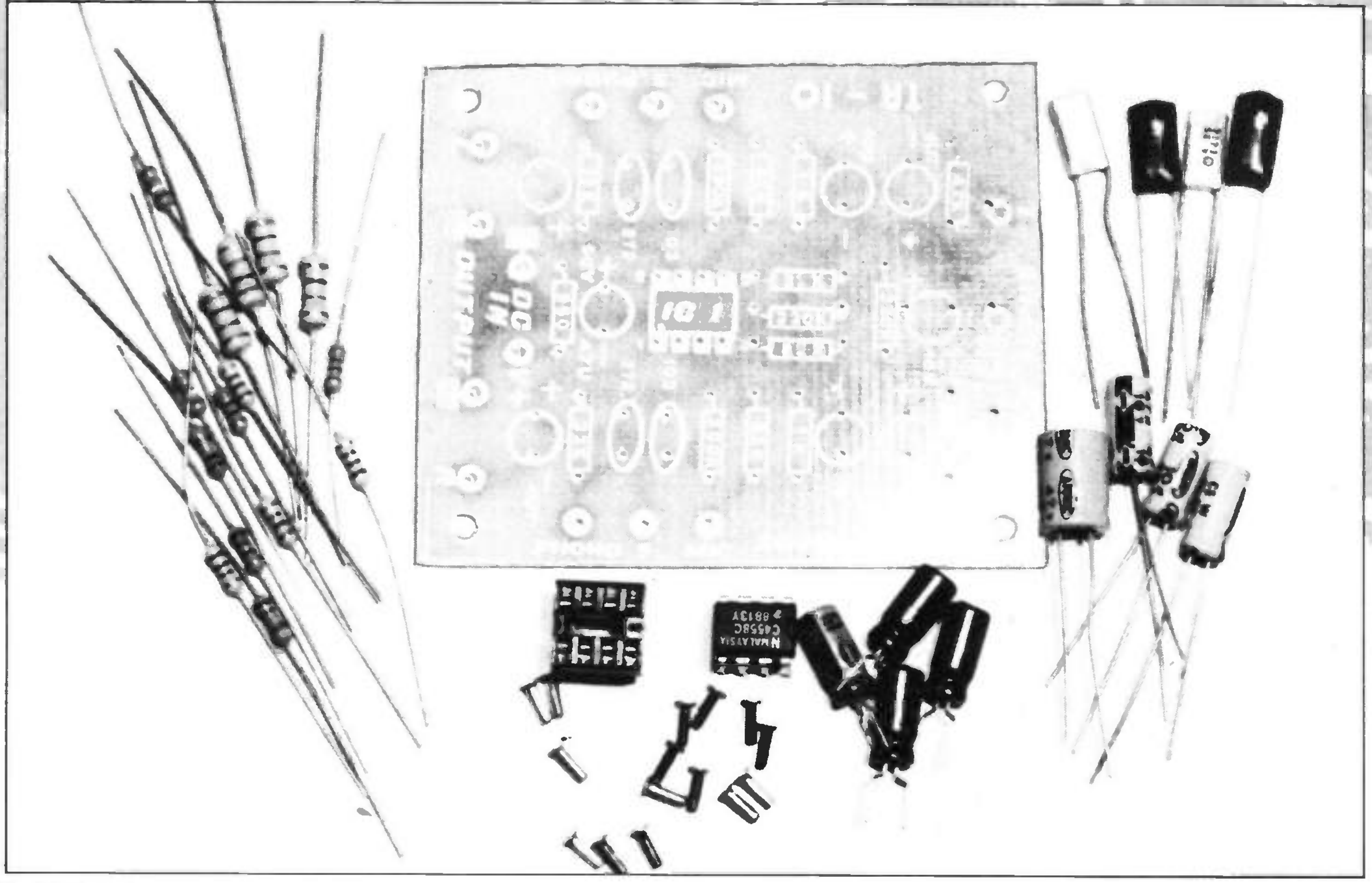
Resistors: (all 5% tolerance)	
R9	1M
R10	560k
R11,20,22	100k
R12	150k
R13	15k
R14,24	1k
R15,16	2k2
R17	1k5
R18	270k
R19	220Ω
R21,26	10k
R23	390Ω
R25	18k
Capacitors	
C5,18	220μF 16V PC Electrolytic
C6	1nF Mylar
C7	10nF Mylar
C8,16	22nF Mylar
C9	33pF Disc Ceramic
C10	5pF Disc Ceramic
C11,12,15	1μF 50V PC Electrolytic
C13	100nF Disc Ceramic
C14	4n7F Mylar
C17	47μF 16V PC Electrolytic
Semiconductors	
TR3,4,5	9014
TR6,7	9015
TR8	9011 or 9014
RD1	Infra-red Receiving Diode
ZD2	5.1V Zener Diode
D1	1N4148
IC2	NE567N
IC3	4027BE
LD2	Red LED (3mm)
Miscellaneous	
RL1	Relay
S2	Slide Switch
P1 to P9	PCB pins
IC socket	(16 pin)
IC socket	(8 pin)
PCB	Marked 'receiver'

Optional (not supplied)

Metal box	(Maplin stock code LF08J)
Screened lead	(Maplin stock code XR13P)

The TY41 Infrared Remote Control Switch is available from Maplin Electronics:
Order As I/R Switch LM69A Price £17.95

Stereo Pre-Amplifier continued from page 59.



The Kit of parts.

The TA-10 Stereo Pre-Amplifier Kit is available from Maplin:
Order As LM68Y (Stereo Pre-Amp Kit) Price £4.95

High Power Speaker Cabinet continued from page 55.

Material: 18mm HD Chipboard.	
1 Back panel	610 x 400mm
2 Side panels	610 x 350mm
2 End panels	350 x 436mm
1 Aperture panel	400 x 146mm
or	400 x 89mm
Material: 10-15mm Chipboard.	
1 Mounting panel	250 x 150mm
Material: 2in x 1in prepared.	
2 Horizontals (3&4)	400mm
2 Verticals (1&2)	600mm

Wood cutting list.

2W70L CABINET PARTS LIST

Baffle 2W70L	1	(XM09K)
250W Bullet Tweeter	1	(XJ54J)
X-over 5kHz 250W	1	(XJ57M)
Buffalo Cloth 23.5in	2.5 Mtrs	(XS06G)
Speaker Clamp Kit	1	(FJ40T)
12in Speaker Grille	1	(YK72P)
Jack Socket Brk	1	(HF90X)
Recess Plate	1	(HH23A)
HD Strap + Recess	1	(BK29G)
Trim Extrusion	1	(FP03D)
Trim Corner	4	(FP04E)
Self Tapper No.6 × ½in	4 Pkts	(BF67X)
Pozi Screw M5 40mm	1 Pkt	(JC81C)
Isoshake M5	1 Pkt	(BF42V)
Isonut M5	2 Pkt	(BF56L)
HC Wire Black	2 Mtrs	(XR57M)
HC Wire Red	2 Mtrs	(XR59P)
Optional		
Large Rubber Foot	4	(FP02C)
Castors (pair)	1	(FX96E)
Recess Handle (side)	1	(LH08J)
Spkr 12in 50W GP 8R	1	(XG47B)
Spkr 12in 50W GP 16R	1	(XG48C)
Spkr 12in 100W GP 8R	1	(XG49D)
Spkr 12in 100W TC 8R	1	(XG50E)
Spkr 12in 100W TC 16R	1	(XG51F)
150W 12in Bass	1	(XJ49D)

Also required
38mm Chipboard Screws
Resin 'W' Adhesive
Contact Adhesive
Staple Gun

A kit of parts, excluding Optional, is available:
Order As LM81C (2W70L Cabinet Kit) Price £89.95

Also available separately, but not shown in our 1989 catalogue:
2W70L Baffle **Order As XM09K Price £4.95**

Air your views!

A readers forum for your views and comments. If you want to contribute, write to the Editor, 'Electronics - The Maplin Magazine', P.O. Box 3, Rayleigh, Essex, SS6 8LR.

New Look

Dear Sir,
You seem very pleased with your 'new look' magazine. You seem though to agree that colour circuit diagrams don't agree. May I say the same of print? It may be technologically clever to mix colour, even pictures, with text, but at the end of the day, one wishes to read it. Pages 9 (Telecommuting) an 17 (RTTY Demodulator) in the June/July issue are gruesome. Pages 8 & 9 together are surely being clever for the sake of it. All the useful information i.e. text and title will fit just half a page. I can think of much better uses for 1½ pages, along with another page from pages 2 & 3. If you wish to sell your products, publish a genuine review not a crib from the instruction leaflet. I would hope that before you market such products you either rigourously test them for performance or commision a laboratory to do so. An article based on that to show true performance and how it compares with the opposition is what I require as a potential purchaser. How the performance is achieved i.e. details of circuitry can be interesting. True performance embraces such things as linearity, and variations in any of this or amplitude over the full frequency range. With amplifiers distortion and maximum output are of similar interest. 99% of the article is just what one would expect in the advertisements and instruction leaflet. A reviewers job is to cut out the 'puff' whereas this one seems to be eating out of your hand.
C. Stealfield, Dorset.

Yes, we are pleased with the 'new look' magazine, and so are most of our readers! It really does come down to what you like personally, we can't please everybody all of the time. If we were to adopt the policy of just printing the facts and figures, the magazine would consist of word processed text and line drawings, the result being something like a manufacturer's data sheet on an IC. Most people enjoy a well presented colourful magazine that is a 'good read' as well as being factual and informative. On the subject of reviews, we do not re-print advertising or instruction leaflets. The reviews are the result of many days (sometimes weeks) of evaluation, testing and research. As an example, the SA-128 'Intelligent Keypad' took some TWO weeks of work to find out how all of the different functions and modes operated. What about the instruction leaflet you may ask? Well as with most of our readership, we can't read Taiwanese and the translation was about as clear as the proverbial mud! The result of the time we spent is all the information you need know. From this you can decide whether the item is suitable for your use and if it is, understandable instructions on how to use it. With regard to test results, the parameters you mention are included in articles, where they are applicable. With amplifiers and the like, the specifications printed are as measured in our laboratory.

Give us a Sign

Dear Sir,
The Maplin catalogue features a wide range of radio/TV aerials and associated brackets, lashings, masts and amps, etc. that go with them. It also features a useful section giving information and data on transmitter sites, frequencies and power outputs. This is all very useful for the amateur aerial installer. To complement this, would it be possible to feature, possibly as a project, some kind of field strength meter to assist in the proper alignment of an aerial? Waddya think? Thoroughly enjoy the magazine by the way!!
M. Ashby, Luton.

Who knows what incredulous creations will come out of the mad scientists laboratory next? (we don't!) Seriously though, the idea will be passed on to the lab engineers.

Monitoring RTTY

Dear Sir,
I am writing to you, for the first time, regarding the RTTY Demodulator in Issue 32 of 'Electronics'. Why does the output for receiving (my interest), have to be fed into a computer?
Can you please give us a circuit that will enable the output to be fed into a monitor as composite video!
Regarding the magazine as a whole I must congratulate you on a really first class publication that has been high on my MUST read list for many years, as it always contains something of interest.
W. Gates, N. Yorkshire.

The RTTY demodulator recovers the binary serial data from the audio tones received, the computer is necessary to translate the BAUDOT coded serial data into alpha-numeric characters and display them on the monitor screen. Using a computer to perform this task is the easiest way to decode the data. Quite a lot of people already have a computer which is suitable for use and in this way the cost of the project is kept down. Commercial RTTY demodulators and decoders are available for around £400. It would be possible to pick up a second hand computer that would be suitable for use with the RTTY demodulator, try our Classified Adverts section. A dedicated circuit to perform the task would need to be processor based, have a video character generator and other hardware that would be found in a computer.

Coloured Padding

Dear Sir,
Having received and read two issues, I must say that, as a general electronics magazine, I feel it falls short of the general standards set by others such as 'Elektor'. If I may make a few points.
Is full colour really necessary? Articles which pourport, or at least appear, to be constructional projects, turn out to be reviews of Maplin kits, without comprehensive circuit diagrams! (e.g. Digital Panel Meter in issue 31, Logic IC Tester in issue 32). I do not buy kits, as I have good stocks of the more popular components and can make my own boards. The magazine in general seems to be very 'padded'. How many of your readers want a 2½ page full colour article on the town of Nottingham? (issue 31). How many oscilloscope users need 18cm² of print to tell them to put a mains plug on the lead? (page 6, issue 32).
T. Groves, Ireland.

The response we have had from our readers has been overwhelmingly in favour of the new colour format, we had a few niggles with certain combinations of colour backgrounds but that has been resolved. I can't really understand why you don't like colour. We changed from quarterly to bi-monthly, with the addition of colour and the cover price is still £1.00, so it can't be on the pretext of increased cost. After all, would you buy a gardening magazine in black and white? The projects that you mention do have full circuit diagrams (if you don't believe me look them up!). As they are only available as kits, we have not printed parts lists, due to the fact there are some non-standard items which are not available separately. Is a project any less a constructional project if it is only available as a kit? You are very fortunate to have a good stock of components and facilities for making PCBs, but many people would not be able to produce a double-sided through hole plated PCB (as used with the IC Tester). 'Electronics' is around 5 to 15 pages longer than most electronics magazines, and doesn't contain 16 pages of advertising, so if any magazine is 'padded' it's certainly not 'Electronics'! I am sure that most of our readers in the Midlands and elsewhere found the article on Nottingham and Maplin interesting. The feature on the oscilloscopes stated that a mains plug was not supplied and gave the order codes for a plug and the correct value fuse, so they could be ordered at the same time as the 'scope. You can imagine the frustration that someone might feel after ordering an oscilloscope only to discover that they didn't have a mains plug to fit on the lead! P.S. It actually took 16.5cm² of text to explain about the plug and 4,000cm² to reply to this letter.

A Timely Problem

Dear Sir,
I recently purchased two kits of parts from one of your competitors in the electronics field to make up an M.S.F. clock with digital display. The problems I had with these included incorrectly printed PCBs for both the receiver and the logic boards, shortage of components, component values which did not agree with the theoretical diagrams, while the diagrams themselves were very poor photostat reproductions deficient in detail and lacking in information as to exactly how certain displays could be achieved, while no arrangements for mounting the display had been allowed for with the digits and their associated components on the same side of the board.
Added to this the receiver was unstable in a manner which the suppliers could not explain and the episode ended with the whole lot being sent back from whence it came.
Now I am sure Maplin could make a much better job and I would like to suggest such a project for some future issue of your excellent magazine. I have just one criticism of the new 'Electronics' colour presentation and it is this; I do wish you would avoid printing on a blue background, as for example, on pages 16 and 17 of the April/May issue. Black on blue doesn't make the best example for clarity and is very difficult to read in artificial light.
E. Brock, Yorkshire.

Your idea for the M.S.F. clock has been passed into the lab 'Think Tank'. As far as possible we always try and ensure that text and diagrams are clearly legible, i.e. on light coloured or white backgrounds. Because of the production process involved with colour, sometimes a background may come out a bit darker than initially forseen, by then the 'films' have been made and it's too late.

CPU Revisited

Dear Sir,
May I take this opportunity to say how much I like 'Electronics' magazine. I look forward to buying it every month, even though it is a bi-monthly magazine. In fact I pester my local newsagent if I haven't seen it on display. I have now taken out a subscription, and hopefully this solves the problem of searching all the newsagents for a copy.
There is one small annoying problem with electronics magazines, including yours. The fact that sometimes published projects leave quite a lot to be desired. A case in point is the Z80 CPU as published in 1985.
I purchased two of those Z80 CPUs and was hoping that in time there would be a memory expansion board with parallel and serial input/output. However to date, there is nothing. In 1982 Elektor Magazine did the same thing. I have two Elektor Z80 CPUs too.
I would like to know if you will ever have a memory upgrade plus input/output for the CPU module or should I bin them!
E. De Terville, London.

Thank you for your comments on the magazine, and I hope you will enjoy the benefits that subscription brings. The Z80 CPU card was intended as a general purpose processor card to be used for control or other similar purposes. For this reason the project was aimed at the constructor who had sufficient knowledge to design/build hardware and write machine code software for the CPU module, to suit an individual application. However a keypad/display module was presented to make things easier. There was no intention at any stage to produce a complete hardware system. As with all of our projects, please read the accompanying text thoroughly and decide whether the project is suitable for the required application, BEFORE purchasing a kit or components. If you are still wondering what to do with the modules, don't bin them! Why not advertise them in our Classified Adverts section.

Separating Stereo

Dear Sir,
People wanting to adjust the stereo separation on the stereo decoder discussed in your Feb/March issue might take advantage of the special test transmissions made on BBC Radio 3 after the midnight news on monday and saturday nights. These tests can be used for quite elaborate adjustments, but several of them make adjusting stereo separation much easier than trying to do it with a music signal. An information sheet listing the sequence is available from the Engineering Information Dept. at Broadcasting House (01-927-5040).
P. Draper, Borehamwood, Herts.

Mis-LED

Dear Editor,
As a recent subscriber to your magazine and a beginner to electronics, I liked the idea of the Electronic Die circuit in the Feb/Mar issue and decided to have a go. My struggle to understand what was going on was not helped much by the LEDs being referred to in diagram 1 as D1-D7, only to change without warning to LD1-LD7 in diagram 2. Then the 'D's reappeared as signal diodes and were joined by four more. Now moving to the parts list the 'LD's disappear again but the 'D's now go up to 18! Confused?
Some time later I think I sorted that lot out but couldn't follow why R7 is higher than R5 & R6 since they seem to do the same job. Could it be that R4 and R7 are the wrong way round?
Please have a thought for us learners, many more of these 'deliberate' mistakes and I might have to go back to knitting!
S. Hurt, Norfolk.

Our apologies to you and anyone else who was confused! We do make mistakes from time to time. Bob's mini circuit prototypes are checked by our lab engineers and they do work. But don't forget they are circuit ideas and not full blown projects.

Digital Apples

Dear Sir,
Your article 'Digital Record and Playback Module', finishes with a request for further ideas on how to use the project. I wonder if it would be possible to take the output of the UM5100 directly into a computer. If this could be achieved, the digital data would be available for graphic display – with extended and partial axes and for mathematical analysis (Fourier Transform?). This would enable detailed comparison of the structure of words, phrases and short sentences, hopefully by using the full frequency limits of the UM5100 for some musical phrases. I would like to transfer the signal directly to the 50 way connector on my Apple II plus, but I can imagine others preferring to use an RS232 port. If this is feasible, I would also like to provide an alternative matched input from a tape recorder. As yet I have not looked at the detailed requirements.
F. Bowerman, Cheshire.

As with a number of other letters in past issues, regarding a similar idea, it would be possible to connect the Rec/Playback Module to a computer, but would require some extra hardware to perform the data transfer, a parallel system rather than serial, would be best to use, as less hardware would be needed and could also transfer the data much faster. We do not have at present any plans to produce a computer interface, mainly because of hardware differences between computers and also due to the heavy reliance on software.

Sound In Time

Dear Sir,
Congratulations on your local (Nottingham) shop – I have saved pounds on postage etc! Can you tell me if there exists a kit or conversion kit or project marketed by you, in order to either build or preferably convert a pocket size radio to receive TV sound. I am no great expert in electronics. Can this be done? It seems difficult to find anything to do this job – I do have other equipment to receive the frequencies but they are hardly pocket size! – in any case they are distorted because the mode is wrong.
A. Sheldon, Nottingham.

We do not currently market a TV sound tuner or conversion kit, but something may be in the pipeline . . .

Delayed Recordings

Dear Sir,
Having just read the article in the Feb/March '89 issue of 'Electronics', about the record/playback module, I have some queries. Firstly, it is not clear whether the module will simultaneously record and playback. In other words, will the recording ripple through the memory with a 5 to 20 second delay, if desired? You may have seen Tomorrow's World when they demonstrated a cassette tape recorder which incorporated a digital input circuit which delayed the recording. The idea was that you only switched on the tape drive when you heard something that you wanted to keep. Can your module be used in this way?
Second question: what quality of recording does the module provide at best? Is it good enough for music? Thanks for a good magazine. I like the loudspeaker articles and the telephones and am trying each of the Exploring Radio ideas in turn. I also suggest that a pulse monitor would prove popular with the general public.
B. Castle, Sevenoaks, Kent.

The module has been designed so that the record and playback processes are separate, i.e. one switch starts the record process, after the elapsed recording time, recording stops and then the phrase may be played back by operating the other switch, or the phrase may be re-recorded by operating the record switch again. The recording may be replayed as many times as is desired. Note, if speech is required to be permanently stored the EPROM add on card will be required. The module has been primarily designed for speech use, and to this end the frequency response is tailored accordingly. This gives very intelligible and recognizable speech – it sounds like the person who spoke and not like a computer! For this reason the module is not intended to record music.

Testing Circuits

Dear Sir,
I would like to congratulate you on your new book or should I say magazine. Is there any chance of you putting some test circuits in the magazine; i.e. test circuits for FETs, SCRs, 555 ICs, 741 ICs etc, I ask this because I don't know how to do this, electronics is only a hobby to me.
K. Hall, Coventry.

For circuits on the range of devices mentioned, may I suggest that you refer to the Books section in the current Maplin catalogue, there are many suitable titles which will be of interest, my personal favourite is IC 555 Projects by E. A. Parr. This can be found on page 86 of the catalogue. Order Code LY04E price £2.95 NV.

Frustrating Amstrad

Dear Editor,
I am feeling rather frustrated at the moment as I am unable to find out what I/O lines are free to use on the Amstrad PCW8256 computer. These details seem to be governed by the Official Secrets Act! I have written to Amstrad Consumer Electronics PLC and all they would let me know was how to connect 5¼ inch disk drives! I am desperate to know what lines are free as I am hoping to use this computer as part of my degree project. I am sure I am not the only one who would be interested in this information and if you could possibly help in any way I will be very grateful. By the way, the new look magazine is one of the best. How about running a series of 'matching' test gear projects. At the moment, the range of test gear projects offered by Maplin, although of good quality, is not very comprehensive. If you were to design a series of 'matching' instruments, such as: a signal generator, power supply, pulse generator, transistor tester, etc, I am sure they would prove very popular. I have constructed my own test gear in this fashion, using the same style case for all the instruments and they look a great deal better than a collection of oddments, as well as performing equally well.
S. Plumridge, Greenhithe, Kent.

If any readers have any information on the PCW8256 that would help Mr Plumridge, please send it in and we will pass it on. The suggestions on 'matching' test gear have been passed onto the Lab engineers.

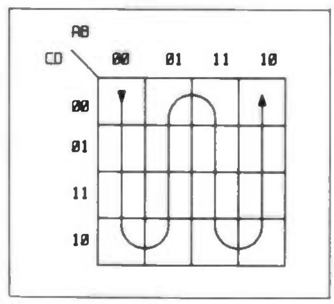
Scout Radio

Dear Sir,
I refer to the 'Scouts' article in the Dec 88/Jan 89 issue of the Maplin Magazine. The report of the activity on the Scout stand at the RSGB convention was excellent. It gave the general public a good insight into the type of training that the Scout Association has to offer in the radio and electronics field. There were, however, a number of errors in the paragraph headed 'Maplin to the Fore!' and I hope you don't mind me putting the record straight. Andrew Jeffs is a Venture Scout from the Northampton West District (not East Birmingham as printed), the correct title of the Group is 'Northampton Scout Amateur Radio Group' (not Northants as printed) and the Group is headed by myself, Ian Rivett (not Dr. Roger Hancock, who is the Leader with the Birmingham Scouts). Once again, congratulations on a great article. Keep up the good work.
I. Rivett, Group Leader Northampton Scout ARG.

Our apologies to those in question!

Extending Gray

Dear Editor,
Flushed with success from the Feb/March edition's Boolean Boob, might I say that I find the third article by Jeff Scott on number systems to be excellent in content, and extremely informative; might I also say that the Gray Chart Code, Figure 4, can be extended beyond decimal value 9 to decimal value 15, (a base of 16). This can be shown more easily with a Karnaugh Map using the cyclic code as follows, following the arrow, and is easily recalled.



Decimal Value	Gray
0	0000
1	0001
2	0011
3	0010
4	0110
5	0111
6	0101
7	0100
8	1100
9	1101
10	1111
11	1110
12	1010
13	1011
14	1001
15	1000

F. W. Mills, Fullwood, Preston.

Late Arrivals

Dear Roy Smith,
This week I received your reminder of my subscription renewal which I would confirm that I do indeed wish to renew as I find the magazine first class in many respects. However I feel I must take you to task about your claim that I will receive my magazine 'the minute they're printed'. The Feb/Mar edition had been on sale in my local newsagent for a full seven days before I received my copy by post. In fact I have not yet received a copy before it has been available elsewhere for the last couple of years. While my method of renewal suits me at the moment, I would ask you to consider my view that now the magazine is so widely available (not the case when I took out my subscription some years ago) people like myself may decide to be more selective about which issues to buy rather than contract to take them all. We would also be able to have the copies we want before they are available to the regular subscribers. While I accept that you are to some extent reliant upon your delivery agent I must begin to reconsider my subscription arrangement unless you can offer me a slightly improved deal. The financial advantage of fixed cover price is not one which really sways the true enthusiast, we would prefer to have our magazine at the same time that it is available to the casual reader. It really does irritate to see one of my favourite magazines on sale, but I am unable to read it yet. In the meantime I will continue with my subscription for another year but I would appreciate an improvement or at least an explanation via your letter page. I do agree that the value for money of this magazine is unrivalled and has probably done much to popularise the hobby of electronics.
R. Seaton, Hollywood, Birmingham.

We will most certainly be looking into this problem of 'late arrival' of subscribed for magazines. It is not a satisfactory state of affairs, as you say, and if you have taken out a subscription we can see how frustrating it must be to see it on the bookshelf and be unable to buy it. We'll try to improve the situation.

All Bar None

Dear Editor,
Congratulations on the new style magazine. It is refreshing not to find it monopolised with computer matter. The serials on the history of telephones and loudspeakers are very interesting. I would like to make a suggestion. As we are now finding bar codes on most of the things we buy, how about an article on how this is read? Also a constructional project to build a reader would be most useful to read the prices of articles in the absence of a normal price label. Keep up the good work.
Victor Kennedy, St Albans, Herts.

Exchanging Phones

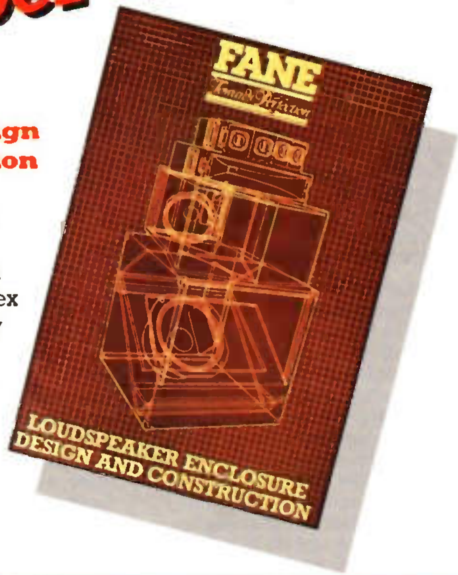
Dear Editor,
Thank you for the Feb-Mar '89 magazine; it makes good reading. I am aware that you have a sophisticated kit for multi exchange lines and lots of extensions, but with handsets now so cheap, I think you would find quite a lot of demand for a circuit that would link 3 or 4 of these phones together for domestic or small business use. These would be entirely separate from the BT system so even unauthorized handsets could be used. The kit would comprise of a power unit plus simple use of the existing ringing circuits. My guess is that there would be great potential.
P. Woffindin, Colne, Lancs.

If any readers have other thoughts, ideas, comments and suggestions, please write in!

Maplin's 20 BEST SELLING BOOKS!

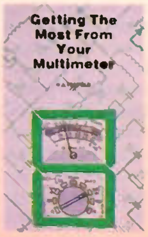
These are our top twenty best selling books based on mail order and shop sales during April and May 1989. Our own magazines and publications are not included. The Maplin order code of each book is shown together with page numbers for our 1989 catalogue. We stock over 250 different titles, covering a wide range of electronics and computing topics.

Number One



Loudspeaker Enclosure Design and Construction
by Fane Acoustics
This book contains a broad selection of cabinet designs from small-sized bass reflex cabinets to multi-way power systems. *(WM82D) Cat. P87.*
Previous Position: 1
Price £3.00

2



Getting the Most from your Multimeter, by R.A. Penfold. *(WP94C) Cat. P83.* Previous Position: 2. **Price £2.95**

3

IC555 Projects, by E.A. Parr. *(LY04E) Cat. P86.* Previous Position: 3. **Price £2.95**

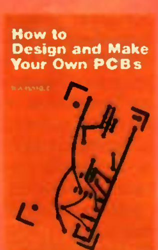
4

Power Supply Projects, by R.A. Penfold. *(XW52G) Cat. P84.* Previous Position: 4. **Price £2.50**

5

Introduction to Electronics, by Pam Beasant. *(WP50E) Cat. P83.* Previous Position: 6. **Price £3.50**

6



How to Design and Make Your Own PCB's, by R.A. Penfold. *(WK63T) Cat. P82.* Previous Position: 11. **Price £2.50**

7

MIDI Projects, by R.A. Penfold. *(WP49D) Cat. P89.* Previous Position: 5. **Price £2.95**

8

Electronic Security Devices, by R.A. Penfold. *(RL43W) Cat. P85.* Previous Position: 7. **Price £2.50**

9

More Advanced Power Supply Projects, by R.A. Penfold. *(WP92A). Cat. P84.* Previous Position: 10. **Price £2.95**

10

Mastering Electronics, by John Watson *(WM60Q). Cat. P83.* Previous Position: 12. **Price £4.50**

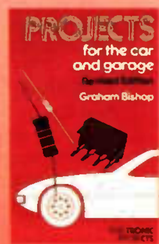
11

How to Use Op-Amps, by E.A. Parr. *(WA29G) Cat. P81.* Previous Position: 17. **Price £2.95**

12

Practical MIDI Handbook, by R.A. Penfold. *(WP96E) Cat. P89.* Previous Position: 8. **Price £5.95**

13

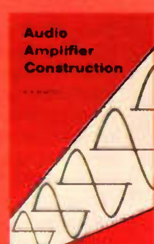


Projects for the Car and Garage, by Graham Bishop. *(XW31J) Cat. P85.* Previous Position: 13. **Price £6.95**

14

50 Projects Using Relays, SCR's and Triacs, by F.G. Rayer. *(RH30H) Cat. P84.* Previous Position: 16. **Price £2.95**

15

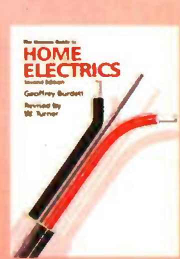


Audio Amplifier Construction, by R.A. Penfold. *(WM31J) Cat. P87.* Previous Position: 15. **Price £2.25**

16

Towers' International Transistor Selector, by T.D. Towers. *(RR39N) Cat. P79.* Previous Position: New Entry. **Price £14.99**

17



Home Electrics, by Geoffrey Burdett. *(RQ22Y) Cat. P75.* Previous Position: 9. **Price £4.95**

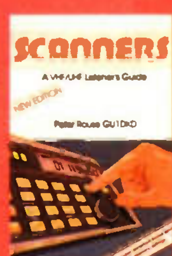
18

Model Railway Projects, by R.A. Penfold. *(WG60Q) Cat. P85.* Previous Position: 18. **Price £2.95**

19

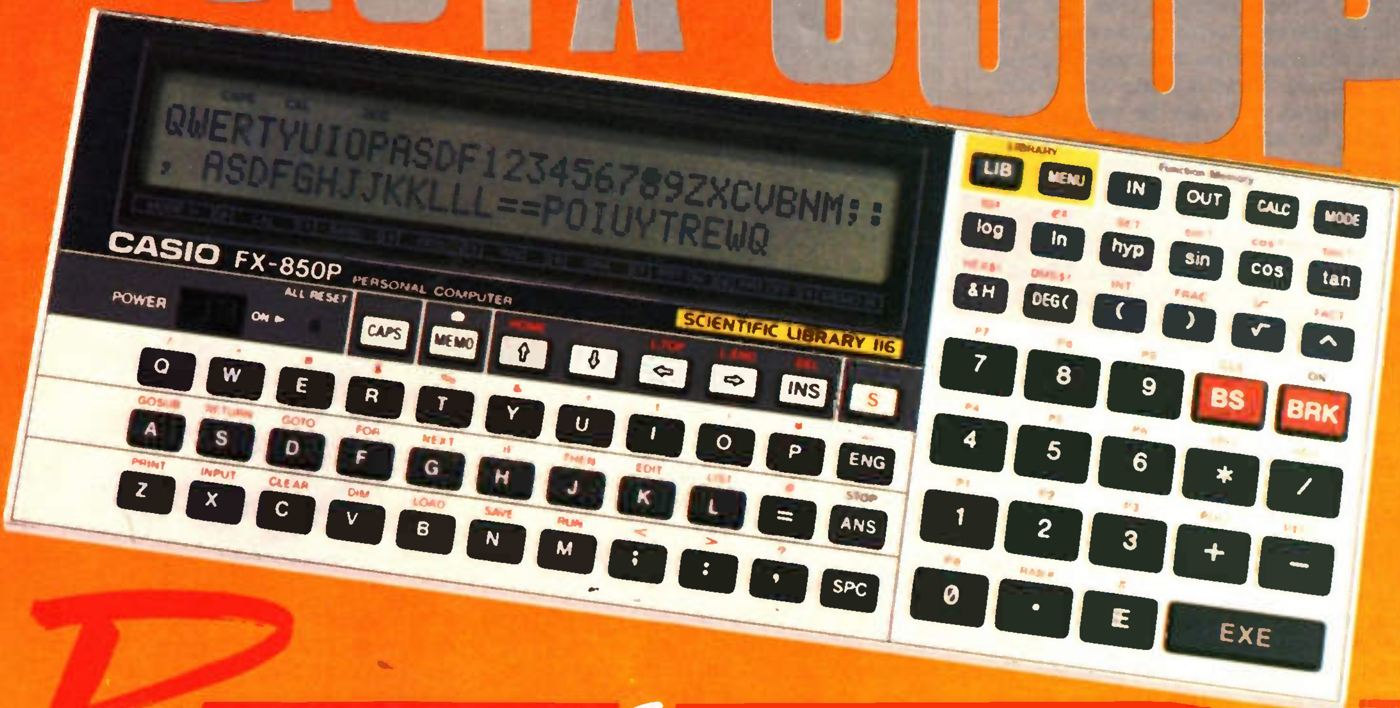
An Introduction to Satellite TV, by F.A. Wilson. *(WP99H) Cat. P92.* Previous Position: 19. **Price £5.95**

20



Scanners, by Peter Rouse. *(WP47B) Cat. P91.* Previous Position: New Entry. **Price £7.95**

CASIO FX-850P



Personal computer

Reviewed by Robert Ball A.M.I.P.R.E.

Pocket computers are not a new idea, but until now, the ones that were available were limited by memory capacity and by the power of the BASIC interpreter. Another problem was interfacing the computer to devices other than dedicated hardware made by the manufacturer. Casio have solved the problem by introducing the FX-850P Personal Computer and peripheral devices, these and other accessories are available from Maplin Electronics.

Pocket Sized

The Casio FX-850P really is pocket sized, similar in size to a cheque book, so it can easily be carried in a brief case or jacket pocket. Apart from being a powerful computer, with up to 40k Bytes of memory, the FX-850P is also a full function scientific calculator and a memo pad, ideal for calculating complex formulae and jotting down reminders. One special feature is the built in formula library, which has 116 pre-defined scientific, mathematical and statistical formulae, for calculating; quadratic equations, complex numbers, binary-decimal-hexadecimal, volume of a sphere, metric conversion, ac & dc circuits etc.

Presentation of the FX-850P is smart and functional, the finish is semi-matt with lettering in white, black and red. The keyboard is laid-out in the standard QWERTY fashion, with numbers provided on a separate numeric keypad, these being slightly larger than the other keys. There are also a number of other keys for shift, capitals, cursor movement, execute, break, scientific functions and mode setting. The 'feel' of the keys is similar to that of a Casio calculator and is quite responsive, without having problems from keybounce. Most of the keys also have a double function when 'shifted', such as insert which becomes delete. The on/off switch is located on the left, under the 2 line 32 column LCD display and has a firm, positive action. To allow for different viewing angles a display contrast control is provided on the right hand side of the unit. The interface connector is on the left-hand side and when not in use, the protective cover should be kept in place to prevent any contamination from foreign bodies or dust. The rear panel is secured by two very small cross-point screws, the rear panel will need to be removed to allow battery replacement and installation of the memory expansion RAM Pack. It is strongly advised that the correct sized screw driver is used otherwise the screw heads may become burred over or the case scratched. When the FX-850P is not in use, the protective hard cover may be slid in place, inside the cover is a list of error codes, which saves referring to the manual.

Modes of operation

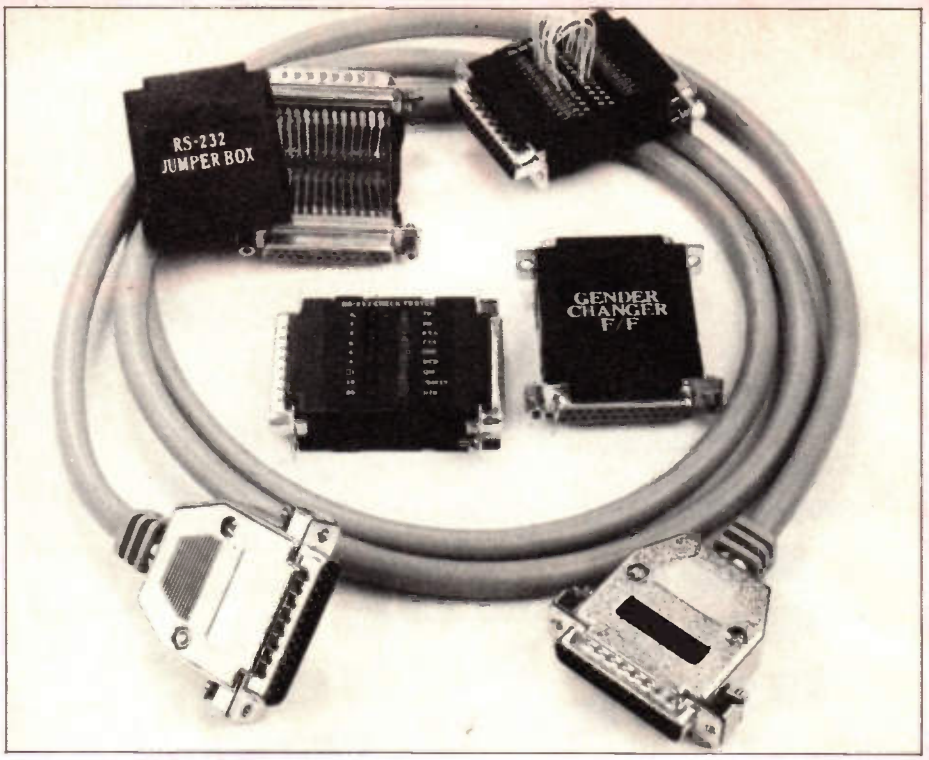
Mode 0 CAL, calculator mode, the FX-850P defaults to this mode when it is first switched on. Mode 0 allows the computer to function as a scientific calculator, one very useful feature is the use of algebraic variables, this means that values can be assigned to letters and the letters inserted into a formula. Formulae can be entered in the same order as written on paper, this makes the calculator function very easy to use. If a certain mathematical formula is to be used frequently, it may be stored in the function memory and recalled when required. For example, reactance of an capacitor; if the formula is typed in as XC=1/(2*π*F*C) and the 'IN' button pressed the formula is stored, on pressing the 'CALC' button, the prompt for frequency to be entered will appear 'F?', and a value can be entered (terminate entry by pressing 'EXEC') e.g. 200 (200Hz), next the prompt for capacitance will appear 'C?', and again, a value can be entered e.g. 1E-6 (1μF), on pressing 'EXEC' the answer will appear XC= 795.7747155 (ohms). Should the formula need to be recalled for editing, the 'OUT' button will bring the formula up on the display. Built into the FX-850P are 116 pre-defined formulae, these can be recalled by typing the reference number of the formula (see list in manual) and pressing the 'LIB' button or by pressing the

'MENU' button to bring up the library menu, the formulae may be stepped-through by pressing either the 'MENU' button or using the up and down cursor buttons, then pressing 'LIB' to select the formula. Screen prompts then ask for options to be selected or values entered, a full list of the formulae and usage is given in the manual. Whilst in Mode 0, data held in the 'memo pad' may be recalled by pressing the 'MEMO' button, if required a selective search may be performed by entering a word (up to eight letters in length) and then pressing the 'MEMO' button, the text will then be searched for the first occurrence of the word. Successive operations of 'MEMO' will search for the next occurrence of the specified word. Whilst in Mode 0, data in the memo pad cannot be modified.

Mode 1 BASIC, BASIC interpreter mode, when in this mode programs may be entered, edited and run. Up to ten separate BASIC programs (dependant on length and memory capacity) can be held in memory simultaneously. The computer's memory is battery backed-up, so that turning the unit off will not erase the programs (this also applies to the memo pad). The ten program memories, numbered P0 to P9, can be selected by pressing the red 'S' (shift) key and then pressing 0 to 9 (P0 to P9 respectively), to select the appropriate memory. The FX-850P defaults to P0 when mode 1 is selected. The powerful BASIC interpreter has a good range of commands available, so quite complex and versatile programs may be written easily. The versatility of the FX-850P is further enhanced by the data handling and input/output commands provided, which allow manipulation of data within the computer's memory and also communication with external devices and peripherals. Editing programs can be easily achieved using the EDIT command, which allows a line editor to step forward or backwards through the program. A couple of simple programs are listed for you to type in and try. *See Listings 1 and 2.*

Mode 4 DEG, Mode 5 RAD, Mode 6 GRA, angle modes, these modes allow angle units to be changed, the FX-850P defaults to DEG, but the angle units can be changed to radians (RAD) or grads (GRA), whichever suits the application. These modes apply to both MODE 0 (calculator) and Mode 1 (BASIC).

Mode 7 PRT ON, Mode 8 PRT OFF, printer control, these two modes allow control of screen output, and can be used to direct information to either the screen and printer (mode 7), or the screen only (mode 8). The computer defaults to printer off mode. Mode 7 can only be used in conjunction with the FA-6 multi purpose interface, which provides connection to a printer. Note; only screen information printed using the PRINT and LIST commands will be output, screen prompts and error codes are not outputted to the printer, PRINT may also be used in calculator mode to print an answer, e.g. PRINT SIN 25 will output the value 0.4226182617 to the printer.



Useful accessories.

Mode 9 MEMO IN, this mode allows entry of information and editing of information already held in the memo pad. When mode 9 is first entered the computer moves automatically to the next free location after any existing text, to enter more text, it can simply be typed in. To edit information, pressing the 'MEMO' button will recall the text, or if required the search facility, as mentioned previously, can be used to find a particular word. The up/down cursor keys allow movement line by line through the text and pressing the left/right cursor keys allows text to be edited, once editing is complete pressing the 'MEMO' button again takes the computer out of the edit mode.

Casio RP-33 RAM Pack

To enable large amounts of data to be stored or long programs to be held in memory, it is necessary to expand the size of the internal memory. This can be achieved quickly and easily with the RP-33 RAM Pack, installation of the RAM pack will increase the memory capacity from 8k Bytes to 40k Bytes. The RAM Pack is installed inside the FX-850P so everything is kept neat and tidy.

Casio FA-6 Multi Purpose Interface Unit

The FX-850P on its own is a very versatile and useful unit, but with the addition of the FA-6 Multi Purpose Interface Unit, see Photo, its usefulness is increased still further. The FA-6 allows the user to store programs or data on cassette tape using a high speed serial cassette interface, connect a parallel Centronics compatible printer for program, data or output listings and connect RS232C compatible devices to open up a whole range of communication possibilities, e.g. serial printer, uploading/downloading programs/data from another computer either directly or via a modem. The FA-6 is also very portable (though not pocket size!) and can be powered from either 4 AA sized batteries or an AC mains adaptor. The FA-6 is housed in a smart black case, connection to the FX-850P is via a short connecting lead and connector assembly. A good operational feature is that the FA-6 will only power up when the FX-850P is on, also if the FX-850P goes into standby, it turns off the FA-6, this is to conserve battery power.

The FA-6 is supplied complete with a set of batteries but connecting leads for various peripherals are NOT supplied, this is because of the wide range of possible applications that the FA-6 could be used for. A range of accessories are available from Maplin, allow connection of the FA-6 to a cassette unit, Centronics parallel printer and RS232 compatible devices. A suggested list of items and their order codes may be found at the end of the article, this list is by no-means complete, further useful accessories can be found in the current Maplin catalogue.

To facilitate connection to peripherals, the pin-outs of the FA-6 ports are shown in Figures 1, 5 and 7. Figure 1 shows the pin-out of the cassette port, Figure 5 shows the pin-out of the Centronics printer port and Figure 7 shows the pin-out of the RS232C port. All the connections are shown looking into the sockets.

Cassette Interface

The cassette interface provides a means of storing and recalling programs, data and information on standard cassette tape, connection diagrams are provided to illustrate how to connect to most standard cassette recorders. Figure 2 shows connection to a cassette recorder with EAR/MIC/REMOTE sockets and Figure 3 shows connection to a cassette recorder with a 5 pin DIN socket and

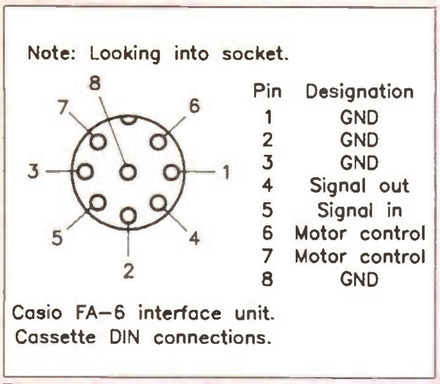


Figure 1. Pin-out of Cassette Port on FA-6.

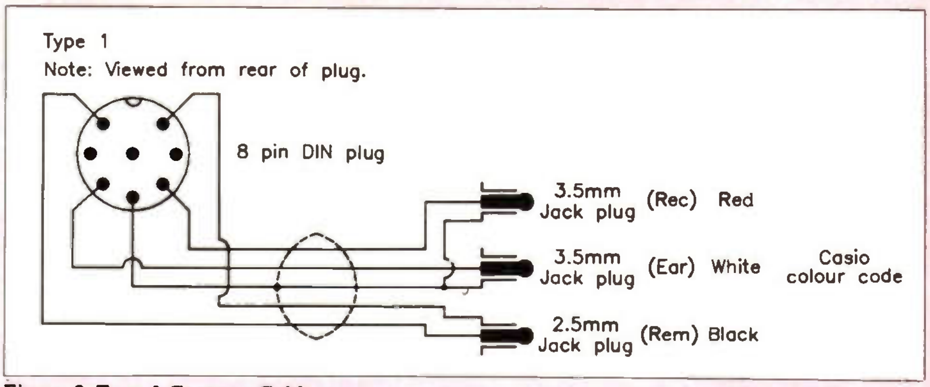


Figure 2. Type 1 Cassette Cable.

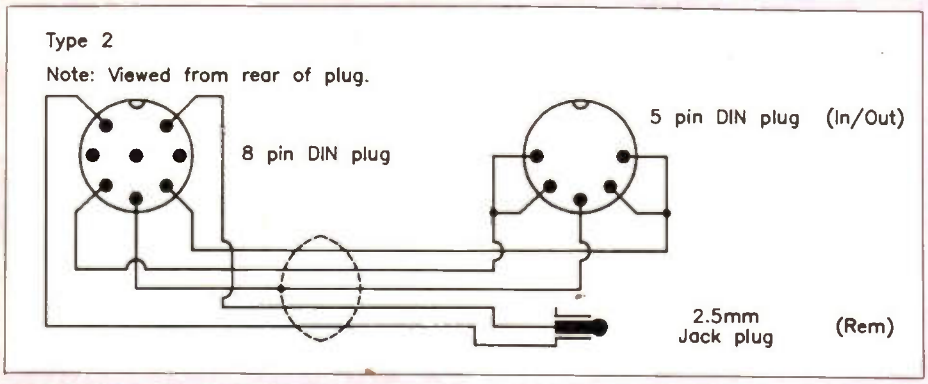


Figure 3. Type 2 Cassette Cable.

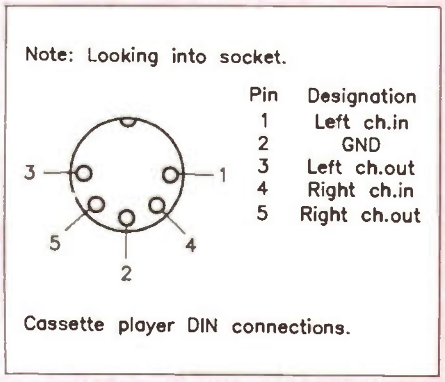


Figure 4. Pin-out of 5 pin DIN on Cassette

REMOTE socket. Figure 4 shows the pin-out of the 5 pin DIN socket found on some cassette recorders. Ready made cassette cables are available. The computer will turn on and off the cassette motor automatically under control of the LOAD/SAVE/VERIFY and file handling commands. The cassette can be used to store the information held in the memo pad as well as programs and other data. There are two speeds of data transfer provided; 300 BAUD and 1200 BAUD, and both proved to be very reliable during tests.

Centronics Printer Port

The Centronics printer port will interface to standard parallel Centronics printers, connections to the 36 way Centronics connector usually found on parallel printers are shown in Figure 6. A ready built 14 way to 36 way Centronics cable is available.

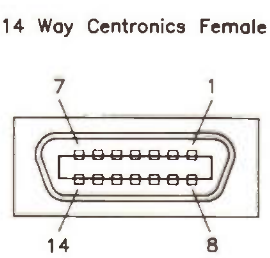
RS232C Serial Port

The RS232C serial port allows communications between other computers, downloading or uploading information and connection to serial peripherals and other devices e.g. serial printer. All the parameters are under software control and are set up with the OPEN command. There always seems to be some degree of confusion with RS232C over connector pin-outs so the full implementation is reproduced here, see Figure 8. For full details on setting serial parameters, see the manual.

DTE or DCE?

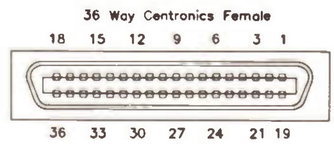
Defined in the RS232C standard are two types of equipment DTE (Data Terminal Equipment) and DCE (Data Communications Equipment). Computers or terminals are classed as DTEs and modems are classed as DCEs, the

Description	Terminal Number	Signal Name	Pin Connection	I/O
Data Strobe	1	Strobe		Output
Data Bit 0	2	D0		Output
Data Bit 1	3	D1		Output
Data Bit 2	4	D2		Output
Data Bit 3	5	D3		Output
Data Bit 4	6	D4		Output
Data Bit 5	7	D5		Output
Data Bit 6	8	D6		Output
Data Bit 7	9	D7		Output
	10	NC		
Printer Busy	11	Busy		Input
	12	NC		
	13	NC		
Signal Ground	14	GND		



NC = Not Connected

Figure 5. Pin-out of Centronics Printer Port on FA-6.



Description	Terminal Number	Signal	Terminal Number	Signal
Data Strobe	1	Data strobe	19	
Data Bit 0	2	Data 0	20	
Data Bit 1	3	Data 1	21	
Data Bit 2	4	Data 2	22	
Data Bit 3	5	Data 3	23	
Data Bit 4	6	Data 4	24	GND
Data Bit 5	7	Data 5	25	
Data Bit 6	8	Data 6	26	
Data Bit 7	9	Data 7	27	
Acknowledge	10	Acknlg ••	28	
Busy	11	Busy	29	
	12	•	30	•
	13	•	31	•
	14	•	32	•
	15	•	33	•
	16	•	34	•
	17	•	35	•
	18	•	36	•

• Dependant on printer
•• Not used with FA–6

Figure 6. Pin-out of 36 way Centronics socket.

definition is important as this specifies whether a device sends or receives data on a particular pin, otherwise two devices may try and send information in opposite directions down the same piece of wire! When the definitions of DTE and DCE are known, the connections of RS232C should be fairly simple, however there are some pieces of equipment which are not defined in the standard, i.e. serial printers. A printer is neither DTE nor DCE, so confusion exists, whether the pins are connected 'as for' DTE or DCE may depend on the manufacturer and this can be determined by consulting the printer handbook. If the printer is connected as a DTE, connection to a computer (DTE) will require some pin swapping, this is not as daunting as it first may seem as there are special adaptor boxes for this purpose, see Photo, which shows RS232 wiring adaptors. Once the connections have been finalized and tested, they may be permanently set using an RS232 jumper box. One of the most useful accessories for working with RS232 is a check tester, which shows the logic condition of lines on a set of red and green LEDs, this can enable problems to be traced very quickly as the signals are displayed visually, these and other RS232 accessories are available from Maplin. Some examples of RS2332 accessories are shown in the Photo.

The Golden Handshake

The data to be exchanged is transferred using the TD (transmit data) and RD (receive data) lines, with reference to SG (signal ground), however as the devices communicating may be able to send data faster than it can be processed, there is a need for controlling the flow of data, this is termed Handshaking, there are many different ways this can be achieved and is dependant on the equipment involved (again!). There are two main types of flow control, that which uses handshaking lines (RTS, CTS, DTR, DSR, etc) and that which uses software implemented control (XON/XOFF). Casio have provided a number of different software options that allow for various types of handshaking and for most purposes they can be configured for the desired application.

File Transfer

Programs or data may be uploaded or down loaded between the FX-850P and another computer using the FA-6 and RS232C cables, if the other computer is remotely located a modem can be used, otherwise desktop file transfer can be achieved using a Null Modem. The software requirements for the other computer will depend on the application and the machine in-question, but most comms packages should be suitable.

Use as a Terminal

The FX-850P may be used as a terminal for a remote computer or a device with an RS232C interface. A simple terminal program is given in Listing 2.

The FA-6 interface.

Conclusions

The FX-850P is certainly a very useful tool in any field involving mathematical calculations or storage of information and represents excellent value for money offering a host of facilities, the unit is nicely styled and robustly built. The BASIC interpreter incorporates all the normal functions found on most desktop computers, with a number of extra commands that allow use of the memo pad from BASIC, and give access to the cassette, serial and parallel communications ports. The versatility of the FX-850P is greatly extended by adding the RP-33 32k Byte RAM pack and the FA-6 multi-purpose interface, it is good to see that Casio has broken the tradition of providing only dedicated peripherals by giving industry standard interfaces instead.

Casio FX-850P Specifications

Basic Calculation Functions: Negative numbers, exponents, parenthesis brackets, true algebraic logic, integer division, integer division remainders, logical operators.

Built-in Functions: Trigonometric/inverse trigonometric functions (angle units: degrees, radians, grads), logarithmic/exponential functions, square roots, cube roots, powers, hyperbolic/inverse hyperbolic functions, conversion to integer, deletion of integer portion, absolute values, signs, coordinate conversions, factorials, permutations, combinations, rounding, random numbers, π, decimal-sexagesimal conversion, decimal-hexadecimal conversion & 116 scientific, mathematical and statistical formulae.

BASIC Commands: EDIT, LIST, LLIST, LOAD, NEW, NEW ALL, RUN, SAVE, VERIFY, ANGLE, BEEP, CLEAR, CLOSE, CLS, DEFSEG, DIM, ERASE, LET, LOCATE, LPRINT, PASS, POKE ,PRINT-SET, TROFF, TRON, VARLIST, DATA, END, FOR, NEXT, STEP, GOSUB, RETURN, GOTO, IF, THEN, ELSE, INPUT, INPUT#, ON ERROR, ON GOSUB, ON GOTO, OPEN, PRINT#, READ, REM, RESTORE, RESUME, RETURN, STOP, LIST#, LLIST#, LOAD#, SAVE#, NEW#, READ#, RESTORE#, WRITE#

Functions: ASC( ), CHR$( ), INKEY$, INPUT$, LEFT$, LEN( ), MID$( ), RIGHT$( ), STR$( ), TAB( ), VAL( ), VALF( ), EOF( ), ERL, ERR, PEEK( )

Calculation Range: $\pm 1 \times 10^{-99}$ to $\pm 9.999999999 \times 10^{99}$ and 0. Internal operations use 12 digit mantissa.

RAM Capacity: Standard 8k Bytes, expandable to 40k Bytes.

Number of Program Areas: Maximum 10 (P0 to P9).

Number of Stacks: Subroutine, 96 levels. FOR/NEXT loop; 29 levels.

Numeric Display Range: 10 digit mantissa + 2 digit exponent.

Display Elements: 32 column x 2 line dot matrix LCD display.

Semiconductor Fabrication: CMOS VLSI.

Power Supply: Mainframe, 2 x CR2032 lithium battery. Memory back-up, 1 x CR1220 lithium battery.

Power Consumption: 0.04W.

Auto Power Off: 6 Minutes.

Operating Temperature: 0°C to 40°C.

Dimensions: 11.6 x 193 x 78mm.

Weight: 197g.

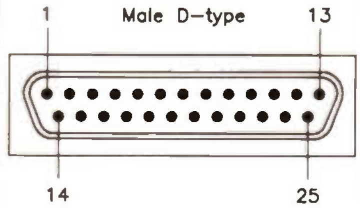
Listing 1. Number Quiz

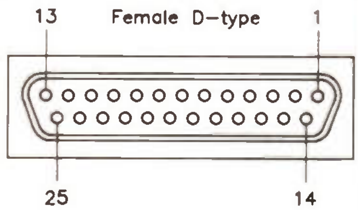
```
5   REM **NUMBER QUIZ**
6   REM **BY R. D. BALL**
10  PRINT "**********NUMBER
    QUIZ**********
    >>>>>>>>>>>PRESS
    EXE<<<<<<<<<<<<"
20  PRINT "I'VE THOUGHT OF A
    NUMBER BETWEEN0 & 99."
30  CLS
40  PRINT "SEE HOW MANY GUESSES
    IT TAKES TOGET THE NUMBER
    RIGHT!"
50  CLS
60  C=0
70  A=INT(RAN#*100)
80  INPUT "YOUR GUESS";B$:B=VAL(B$)
90  CLS
100 IF B<0 OR B>99 THEN PRINT
    "NUMBER MUST BE BETWEEN 0 & 99
    ";:GOTO 80
110 C=C+1
120 IF B<A THEN PRINT "TOO LOW!
    ";:GOTO80
130 IF B>A THEN PRINT "TOO HIGH!
    ";:GOTO80
140 FOR D=1 TO
    10:BEEP(RAN#*2):NEXT D
150 PRINT ">>>>YOU GUESSED THE
    NUMBER!<<<< ATTEMPTS =";C
160 CLS
170 INPUT "PLAY AGAIN (Y/N)";A$
180 A$=LEFT$(A$,1)
190 IF A$="Y" THEN GOTO 50
200 IF A$<>"N" THEN GOTO 160
210 PRINT "BYE!"
220 END
```

Listing 2. Simple Terminal Program

```
5   REM **TERMINAL PROGRAM**
6   REM **BY R. D. BALL**
10  CLS
20  PRINT "******CASIO COMMS
    PROGRAM****** ";
30  PRINT "****PRESS A KEY TO
    CONTINUE****";
40  IF INKEY$="" THEN GOTO 40
50  CLS
70  INPUT "TX ECHO (Y/N)";A$
80  A$=LEFT$(A$,1)
90  IF A$<>"Y" AND A$<>"N" THEN
    GOTO 50
100 IF A$="Y" THEN A=1 ELSE A=0
110 CLS
115 REM **SET SERIAL PARAMETERS**
116 REM **2400 BAUD, NO PARITY, 8
    BITS, 1 STOP BIT, CTS H/SHAKE**
120 OPEN "COM0:5,N,8,1,C,N,N,N,N" AS
    #1
130 IF EOF(1) THEN GOTO 160
140 B$=INPUT$ (1,1)
150 PRINT B$;
160 C$=INKEY$
170 IF C$="" THEN GOTO130
180 IF C$=INKEY$ THEN GOTO 180
190 PRINT #1,C$;
200 IF A=1 THEN PRINT C$;
210 GOTO 130
```

Description	Terminal Number	Abbreviation	Pin Connection
Frame (Chassis) Ground	1	FG	
Transmit Data	2	TD	
Receive Data	3	RD	
Request To Send	4	RTS	
Clear To Send	5	CTS	
Data Set Ready	6	DSR	
Signal Ground	7	SG	
Data Carrier Detect	8	DCD	
Reserved	9		
Reserved	10		
Unassigned	11		
Secondary DCD	12		
Secondary CTS	13		
Secondary TD	14		
Transmit Clock	15		
Secondary RD	16		
Receive Clock	17		
Unassigned	18		
Secondary RTS	19		
Data Terminal Ready	20	DTR	
Signal Quality Detector	21	SQ	
Ring Indicator	22	RI	
Data Rate Select	23		
External Clock	24		
Unassigned	25		

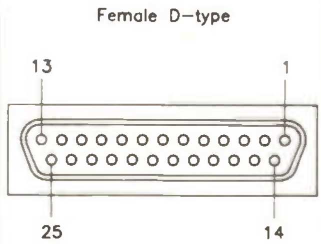




NC = Not Connected

Figure 8. Pin-out of RS232C Connectors.

Description	Terminal Number	Abbreviation	Pin Connection	I/O
Frame (Chassis) Ground	1	FG		
Transmit Data	2	TD		Output
Receive Data	3	RD		Input
Request To Send	4	RTS		Output
Clear To Send	5	CTS		Input
Data Set Ready	6	DSR		Input
Signal Ground	7	SC		
Data Carrier Detect	8	DCD		Input
	9	NC		
	10	NC		
	11	NC		
	12	NC		
	13	NC		
	14	NC		
	15	NC		
	16	NC		
	17	NC		
	18	NC		
	19	NC		
Data Terminal Ready	20	DTR		Output
	21	NC		
	22	NC		
	23	NC		
	24	NC		
	25	NC		



NC = Not Connected

Figure 7. Pin-out of RS232C Port on FA-6.

Casio FA-6 Specifications

Interfaces: Centronics Parallel Printer, RS232C Serial, Cassette Serial.

Connection
- Centronics Parallel: 14 way Centronics Socket.
- RS232C Serial: 25 way D-type Socket.
- Cassette Serial: 8 pin DIN Socket.

Centronics
- 8 Data Lines.
- Busy.
- Strobe (active low).

RS232C
- Asynchronous Full Duplex.
- BAUD Rate *: 150, 300, 600, 1200, 2400, 4800.
- Parity Bit *: Odd, Even, None.
- Word Length *: 7 or 8 Bits.
- Stop Bits *: 1 or 2 Bits.
- Handshaking/Flow Control:RTS, CTS *, DSR *, DCD *, DTR, XON/XOFF *.
- Note: * indicates software selectable.

Cassette
- File Format: Binary or ASCII or Sequential.
- BAUD Rate: 300 or 1200 BAUD.
- Signal Format: FM.
- Signal Phase: Normal or Inverse.
- Output Level: 3-5mV.
- Output Impedance: 10kΩ.
- Input Level: 2.5-50V.
- Input Impedance: 20kΩ.
- Remote Switch Contact Rating: 24V, <1A.

Power Supply: 4 x AA Batteries or AC adaptor.

Power Consumption: 1.0W.

Operating Temperature: 0 to 40°C.

Dimensions: 33 x 195 x 120mm.

Weight: 628g.

Casio FX-850P, Personal Computer, Order As YT74R Price £89.95
Casio RP-33, 32k Byte RAM Pack, Order As JL90X Price £39.95
Casio FA-6, Multi Purpose Interface Unit, Order As YT75S Price £79.95
14 way to 36 way Centronics Printer Cable, Order As FV93B Price £8.95

Cassette cables:
Type 1, 8 pin DIN Plug to 2 x 3.5mm & 1 x 2.5mm Jack Plug, Order As JB00A Price £5.95
Type 2, 8 pin DIN Plug to 1 × 5 pin DIN Plug & 1 × 2.5mm Jack Plug, Order As JB01B Price £5.95

RS232 Accessories:
RS232 25 way D Connector Male to Male Cable, Order As JC12N Price £7.95
RS232 25 way D Connector Male to Female Cable, Order As JC13P Price £7.95
RS323 Gender Changer Male to Male, Order As YP87U Price £4.95
RS232 Gender Changer Female/Female, Order As YP86T Price £4.95
RS232 Jumper Box, Order As YP78K Price £5.75
RS232 Wiring Box, Order As YP79L Price £9.95
RS232 Quick Tester, Order As YP81C Price £13.75
RS232 Null Modem, Order As YP85G Price £4.95

For other RS232 converters and accessories see pages 59 and 60 of the current Maplin catalogue.

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SONY C6 video recorder service manual £5. KEF B139 loudspeakers £40 pair. Wanted SME or similar tone arm. J. M. Shepherd, 2 Pentland Avenue, Thornbury, Bristol. BS12 2YB. Tel. (0454) 412720.

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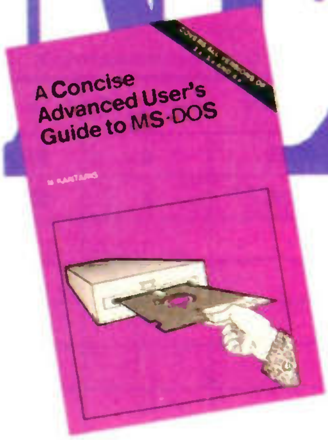

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R. A. Penfold

The first section of this book takes a look at the basic principles involved in converting an audio signal into digital form and then converting it back to an audio signal again. It also deals with some practical aspects that have to be borne in mind when considering digital audio projects. The second section contains some useful and extremely interesting, practical circuits for constructors to build and experiment with. By current standards the projects are not highly complex, but are probably beyond the scope of beginners and are more suited for someone with a moderate amount of experience in electronic project building.

1989. 81 pages, 112 x 178mm, illustrated.

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More Advanced MIDI Projects

by R. A. Penfold

The projects in this book fall into two main categories; those that are designed to overcome a deficiency in an item of equipment in the system and those that are designed to enhance performance of the system or to make it easier to use. Included are circuits for a MIDI indicator, THRU box, merge unit, code generator, pedal, programmer, channeliser and analyser. These projects are generally more complex than those featured in the MIDI Projects book, although a few simple units have been included as well. While most of the projects are not suitable for beginners, they should be well within the capabilities of someone who has a reasonable amount of experience in electronics construction. The circuits should also provide some useful electronic building blocks for use in readers own designs.

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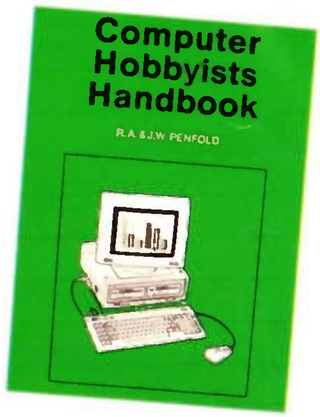

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R. A. & J. W. Penfold

How many times have you spent hours looking through computer books and magazines in an attempt to find some snippet of information? An ASCII code perhaps, or connection details for a computer port? The 'Computer Hobbyists Handbook' provides a range of useful reference material in a single source so that it can be quickly and easily located. The subjects covered include microprocessors and their register sets; interfacing serial, parallel, monitor, games and MIDI ports; numbering systems; MIDI codes; operating systems and computer graphics. There is also a useful glossary of computer terms, and appendices covering topics such as ASCII codes, Epson control codes and flowchart symbols. The reader is not simply presented with raw data, but in most cases there are useful explanations so that the information can be used by beginners as well as more experienced users. Although primarily aimed at the computer hobbyist, no doubt, this book will also prove to be very useful to those involved in computing professionally, as well as being a useful source of information for students.

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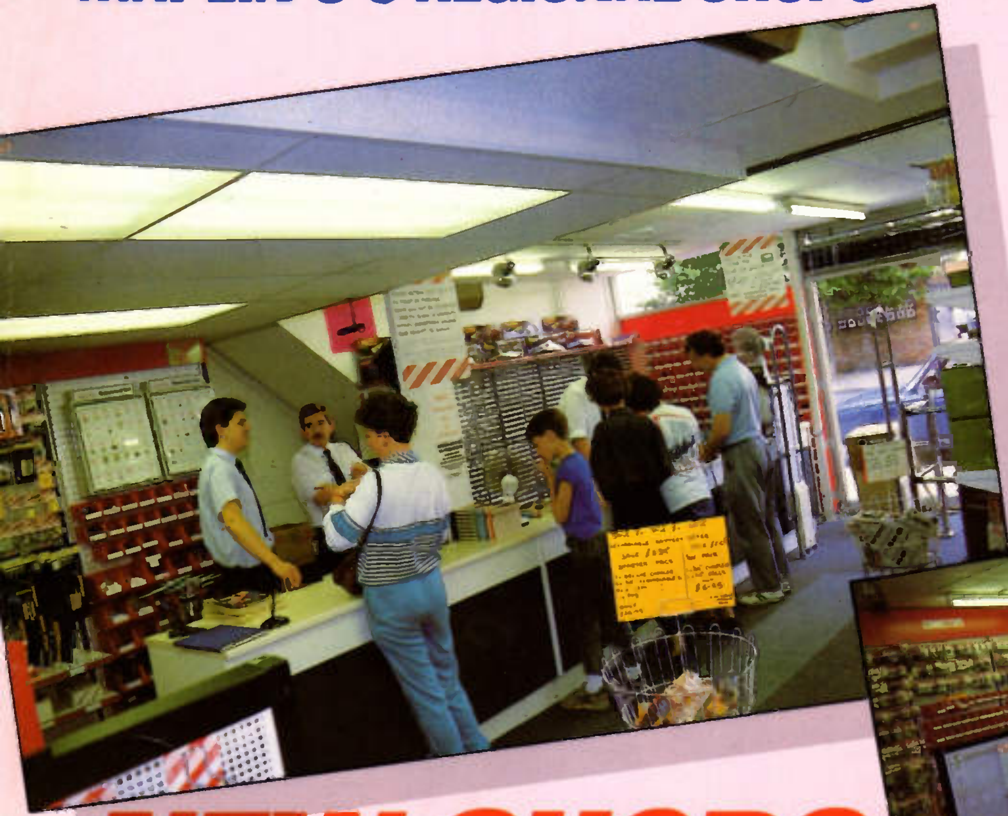

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