video colour inverter
with tricks in hand

dynamic pre-amplifier

a program for your 6845 video controller

simple battery condition meter

clean those ZX81 pulses!

dial another computer:
data exchange by modem

RS232/Centronics interface

news • views • people

readership survey results
<table>
<thead>
<tr>
<th>Description</th>
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<tr>
<td><strong>Junior Computer Kit</strong></td>
<td>£68 plus £1.50 p &amp; p</td>
</tr>
<tr>
<td><strong>Turned Pin Low Profile Sockets</strong></td>
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</tr>
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</table>
readership survey results ........................................ 10-18
news — views — people .......................................... 10-20
the Sinclair QL: first impressions ............................... 10-24
Our assessment of a first-class personal computer.
basicode-2 .......................................................... 10-25
New broadcasting schedules.
tuning fork .......................................................... 10-26
Provided with electronic prongs, this unit provides not one but ninety-six
discrete accurate tones.
balancing transformers .......................................... 10-30
Simple ways of matching aerials to transmission lines.
video colour inverter ............................................. 10-32
Changing the phase of the composite colour signal gives rise to a multitude
of interesting and often useful effects on the TV screen.
programming the 6845 ............................................ 10-38
The screen format selected by this cathode ray tube controller is deter-
minked by the contents of its internal registers. We offer a short BASIC pro-
gram to simplify the calculation of the contents.
missing link ......................................................... 10-41
Important modifications to, additions to, improvements to, or corrections
in, Elektor circuits.
PC board pages .................................................... 10-42
ZX81 cassette pulse cleaner .................................... 10-45
A circuit to improve the reliability of the FSK system used by many personal
computers.
direct-coupled modem .......................................... 10-48
As promised last month, this article describes the hardware for a versatile,
direct-coupled modem.
battery tester ...................................................... 10-56
A meter for quickly and simply determining the condition of any dry cell
or battery.
RS 232 centronics converter .................................. 10-58
A very useful device for overcoming problems caused by the incompati-
bility of RS 232 and Centronics interfaces.
dynamic pre-amplifier .......................................... 10-64
A new design, based on a single IC, of a unit that is always welcome with
many readers.
switchboard ....................................................... 10-73
appointments ...................................................... 10-75
readers' services .................................................. 10-80
index of advertisers ............................................. 10-82

A selection from next month's issue:
- burglar alarm
- 15 W valve amplifier
- night light dimmer
- TV receiver as monitor
- voltage locator

Readers' service:
- subscription service
- technical queries service
- software service
- front panel service
- back number service
- copy service
- printed circuit service
- book service

Details of all these can be found on pages 80 and 31.
Volume 10 – Number 10  ISSN 0308-308X

Electric and Magnetic Quantities

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Symbol</th>
<th>SI unit</th>
<th>SI symbol</th>
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<tr>
<td>electric current</td>
<td>I</td>
<td>ampere</td>
<td>A</td>
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<tr>
<td>electric charge, quantity of electricity</td>
<td>Q</td>
<td>coulomb</td>
<td>C</td>
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<tr>
<td>electric field strength</td>
<td>E</td>
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<td>henry</td>
<td>H</td>
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<tr>
<td>coupling coefficient</td>
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<tr>
<td>velocity of light in vacuum</td>
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<td>ohm</td>
<td>Ω</td>
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<td>S</td>
</tr>
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<td>G, p, G(o)</td>
<td>siemens per metre</td>
<td>S/m</td>
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<td>reluctance</td>
<td>R, Rm</td>
<td>siemens</td>
<td>S</td>
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<td>permeance</td>
<td>H</td>
<td>henry</td>
<td>H</td>
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<tr>
<td>phase displacement</td>
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<td></td>
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<tr>
<td>number of turns on winding</td>
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<td>X</td>
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<tr>
<td>period</td>
<td>T</td>
<td>second</td>
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<td>relaxation time</td>
<td>t</td>
<td>second</td>
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<td>K</td>
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<tr>
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<td>joule</td>
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SI Units

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<th>Symbol</th>
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<tr>
<td>length</td>
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<tr>
<td>mass</td>
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<td>kg</td>
</tr>
<tr>
<td>time</td>
<td>second</td>
<td>s</td>
</tr>
<tr>
<td>electric current</td>
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<td>A</td>
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<tr>
<td>thermodynamic temperature</td>
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<tr>
<td>energy</td>
<td>joule</td>
<td>J</td>
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<tr>
<td>force</td>
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<tr>
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<tr>
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<td>Pa</td>
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<tr>
<td>electric charge</td>
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<tr>
<td>electric potential difference</td>
<td>volt</td>
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<tr>
<td>electric resistance</td>
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<td>henry</td>
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<tr>
<td>magnetic flux density</td>
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Prefixes used with SI Units

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<tr>
<td>10^-1</td>
<td>deci</td>
<td>d</td>
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<td>10^-2</td>
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<td>10^-15</td>
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</tr>
<tr>
<td>10^-18</td>
<td>atto</td>
<td>a</td>
</tr>
</tbody>
</table>

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BARCLAYCARD welcome
Readership survey results

By and large, Elektor readers seem to be quite interested in what other readers think — witness the large number of remarks on the lines of "I hope you'll publish the results again, like you did last year". So, here we go.
To keep it short, we reproduce the computer print-out of the response so far and add comments where they seem relevant.

Contents
The leaders in the 'readers' interest' race are the same as last year: computer hardware, measuring equipment, and audio. The same applies throughout Europe as shown.
As to 'characteristic of the articles': in all honesty, some points of criticism were raised. In particular, "more information on how to modify a project for other applications", "more explanation of why this particular design approach was chosen", and "more test points to facilitate trouble-shooting". OK, OK — we'll see what we can do.

Reading habits
A word of explanation, and a word of warning. Several readers expressed particular interest in the results for 'other magazines'. To keep it manageable, we have eliminated those where the total for 'subscribers' and 'regular readers' was less than 10 per cent. For the remainder, the percentages are then corrected to give a total of 100 per cent within each group of questions.
So much for the explanation. Now for the warning (if you are avidly pro-Elektor, don't read this): these results are obviously based on what Elektor readers think. They cannot be taken as representative of what the 'average reader' of any of the other magazines thinks. In plain language: the results of, say, an ETI survey will probably be more pro-ETI and less unmitigatingly pro-Elektor (although I'd love to be proved wrong on that one! — Ed.)

Experience with projects
In general: no comment, save a word on 'component availability'. When the UK-only and Europe-wide results are compared, the difference is marginal (certainly when you consider that a good 20 per cent of the 'UK' response comes from overseas — and they score much higher in the 'problem' zone). So, don't ever again say that it's due to Elektor being 'foreign'...
Readership profile

Only one comment here: ‘students’ seem to be under-represented in the UK. Europe-wide, they represent 26 per cent of our readership. What has happened to the missing 10 per cent over here?

Computers

This is getting out of hand! Last year we had 47 per cent with no computer, 42 per cent with one, and 11 per cent with two or more. Now, the results are 22 per cent, 41 per cent, and 37 per cent respectively!

A further noteworthy point is the interest in ‘peripherals’. They score highest in the ‘interested in...’ category, and lowest in the ‘waste of pages’ group. More on this later...

Your comments...

A few points were raised quite frequently. A veritable deluge of “I love Elektor”, “Your PC boards are the best in Europe” and so on — these make great reading when you’ve just spent half the morning trying to source a particularly awkward component.

More seriously, “I’m still waiting for that superb VHF/FM receiver for my Elektor XL system”. Answer: “And we’re still working on it!”. Don’t give up hope — it’s certainly not dead. But we definitely won’t have anything in the near future. Miracles do take a little longer!

“Who makes Elektor?”; “How is it made?”; “How do you design those superb PC boards?”. Well! That’s asking. No promises, but we’ll see what we can do to dispel the image of ‘impersonal Dutch robots’. (Perish the thought! My great-uncle’s the one Conan Doyle wrote about — Ed.)

“How do you submit a project for publication?”. That’s easy — just send it in! We’re always interested in new ideas. All we need is the circuit and a brief description of what it does and why it’s so wonderful.

“Keep Elektor as an electronics magazine. The market’s already saturated with computer magazines!”. Answer: read on...

...and ours

Our thanks to everyone who took the trouble to respond. We’ve got a few new ideas, and...you never know!

One point remains to be clarified: what will be the position of computers in Elektor? Let’s make our intentions clear: we want to cover the whole field of electronics. Insofar as computers are electronic, they should and will remain part of our field. In practice, as regular readers will have noticed, this means that we are concentrating on ‘universally applicable hardware’ — devices — peripherals, memory boards et al — that can be used with many popular computers.

Also, we’ve used and will continue to use µP chips in dedicated applications — as part of a self-contained project. (We’ve got a couple of beauties coming up!). Information, too, when it seems called for: our own experience with the Sinclair CL, for example.

But...not in excess. We have a wide field to cover, and only a limited number of pages (unless, of course, our readers are all prepared to pay twice as much each month?). So, page-devouring projects like a way-out 16-bitter with all frills attached just won’t fit. If and when we come up with that sort of thing, we’ll relegate it to some alternative form of publication — a book, say, or whatever.

All in all: computer freaks, rest assured: we haven’t forgotten you. And computer haters, rest assured: we’re not going to change our title to Komputer!
Diamonds are forever
Burndet Electronics Limited commemo- 
rate their sixty years in radio communications by two mid-summer announcements: one to introduce a new range of hand-portable radio transmitter/receivers called the Dia-
mond Series, and the other to reveal a new range of hand-portable radio communications by two mid-summer announcements: one to introduce a new range of hand-portable radio transmitting/receiving equipment, and the other to reveal a new range of hand-portable radio transmitting/receiving equipment, the two to be made by Burndet Electronics to well over 70,000.
FKI Electricals PLC is an established manufacturing and engineering group with a remarkable record of profit and growth. For the past 11 years it has returned an increased annual pre-tax profit. Burndet fits particularly well into the FKI group activities and can provide much needed additional manufacturing plant at their Erith premises. They bring to FKI a high technology communications technique developed over the years and for conventional radio communications equipment, such as hand-portable and mobile units, but also the unique SARBE rescue beacons which are used throughout the world.
Entente cordial
A system to monitor and control a submarine cable-laying and embedding machine through fibre optic cable is being supplied by a British company for the laying of two pairs of underwater electricity cables between Britain and France. The distributed data acquisition system for telemetry and control, called System 86, will operate between the machine and the mother ship, and will be supplied by Oxford Automation, a member of the Oxford Instruments Group.
This is believed to be the first time that fibre optic cable has been used for remotely operated underwater vehicles and it was selected for its total immunity to electrical 'noise' generated within the umbilical cable which links the mother ship to the underwater unit.
The dual fibre optic cable has been designed to operate at lengths of up to 1000 metres. In operation, the System 86 communication's unit will receive and display on the control ship signals from more than 200 sensors, including up to 30 transducers for pressure, load and position, and a large number of individual detectors such as proximity switches. It will also provide control of three underwater TV cameras and of hydraulic valves on underwater winches.
Oxford Automation will supply one System 86 master station and six RU 256 remote units, each capable of handling signals from 256 sensors. Two remote units will be installed in the underwater vehicle, and these have undergone rigorous environmental testing up to a test pressure of seven bars, with a maximum rate of change of one bar/min, to ensure trouble-free operation under arduous conditions.
The equipment is being fitted to the cable-laying vessel at Middlesbrough, under the supervision of the contractors, Balfour Kilpatrick, for the British Central Electricity Generating Board (CEGB). Four pairs of cross-channel buried power cables will be laid between Folkstone, Britain and Sangatte, France — two pairs by Balfour Kilpatrick for the CEGB, the other two by French contractors.
The cables will be used to supply power on a reciprocal basis between the two countries during peak periods.
Sofia's choice
Audio control systems worth some £200,000 are to be supplied to Bulgaria's national radio and television networks, as well as to a major live performance venue in the country's capital, Sofia, by Neve Electronics of Royston, near London. Bulgarian Radio has ordered one of the company's major 32-channel 8128 model consoles for recording and post-production and Bulgarian Television has ordered an 8128 fitted with Neve's brand new N8128 automation system, together with 12 smaller consoles (ten 5442 consoles and two 16-track 5452 desks). Delivery is scheduled for late 1984. The New Congress Hall in Sofia has commissioned a 24-channel console, the 5114, which will be used for live performance in this large multipurpose theatre and concert hall. All three customers have previously purchased Neve and direct orders and have already a number of the company's consoles in place. The new equipment for the broadcast companies is expected to be installed in new studios — helping Bulgaria's efforts to achieve higher standards in the broadcast field.
The Necam 96 ordered for the television company was launched only in June. It is a brand new mixdown and post-production automation system offering a wide range of enhancements and facilities. Microprocessor technology guarantees the operator an unparalleled level of control and flexibility of operation without any requirement for specialist computer knowledge.
High-speed 'feather touch' precision motor-driven faders are claimed to make the Necam 96 the fastest post-production system for music, film, and video ever produced, while the intelligent roll-back feature and update facilities bring computer assistance right to the very heart of the post-production process, says Neve.
Cell mates
Production of stable low noise 'active' filters as a cheap and reliable alternative to the large, expensive and complicated crystals currently needed for cellular radio networks is under investigation at Exeter University.
Cellular radio networks need quiet, low-distortion filters with a big dynamic range because of the narrow bandwidths used. In every speech channel the first 0 to 200 cycles is normally wasted,' explains Patrick May, senior lecturer in the Exeter University's Engineering Science department. 'It is this very narrow channel that will be used in cellular radio networks handling mobile telephone communications. This presents problems in selecting and maintaining various channels in accordance with pre-allocated priorities as the mobile radiotelephone moves from 'cell' to 'cell'.
'The filter plays a vital role in conserving the frequency spectrum. We have now produced active filters in the laboratory that use integrated circuits. They are small, lightweight and will be considerably cheaper to
manufacture than current typus. 'However, further research is required. Filtered frequencies will have to be fixed and other concepts of filters explored and new circuits designed.'

Mr May is confident that the use of radio telephones in vehicles will become quite common in the next decade. Given the right economic climate and the opportunity to incorporate high technology with low cost systems, the radio telephone may become a standard accessory fitted to vehicles in the same way that many are fitted with radios today, he says.

Already plans have been announced for two competing cellular radio networks that will operate in Britain from 1986. The Cellnet system is being developed by a British Telecom/Securicor consortium and 'Vodaphone' will be launched by the Racal Electronics Group.

Scots, wha hae...

The Scottish Development Agency has won an industrial award in America for 'outstanding research' into Scotland's electronics industry.

The influential Industrial Development Research Council (IDRC) has commended Agency staff for an exhaustive study they produced, entitled 'The semiconductor industry in Scotland.'

Instituted in 1980, the awards are presented to organisations in recognition of outstanding original research on factors which influence industrial site location. The SDA study presented the main factors considered by potential investors in high-technology industries seeking a European manufacturing base and highlighted areas where Scotland had a distinct advantage over other possible locations. It presented research findings which covered a wide range of issues vital to the decision making process of inward investors.

SDA chief executive, Dr George Mathewson, said: 'The study usefully and thoroughly presents the factual information necessary for inward investment decision-making, effectively conveying the advantages of Scotland as a location for the development of semi-conductor manufacturing facilities.

Scotland is regarded by experts as a leading European centre for semiconductor production, and more than £300 million has been committed by six manufacturers — Motorola, National Semiconductor, General Instrument, Hughes Microelectronics, Nippon Electric Company, and Burroughs — in the last three years alone.

The Scottish semiconductor industry now accounts for 79 per cent of the UK's integrated circuit production and 21 per cent of European capacity.

Thinking computers

Computers that can think for themselves have come a step nearer with the merging of Anglo-Norwegian technologies.

A joint-venture agreement just announced in London brings together Britain's Racal electronics group and the Norwegian-based computer company, Norsk Data. They have formed a new Anglo-Norwegian organisation to develop advanced computer systems for 'artificial intelligence' applications in defence, engineering, education, petrochemicals, and finance.

Artificial intelligence covers all attempts to produce computers which can take decisions for themselves in an intelligent and reasoned way.

Chairman and Chief Executive of Racal, Sir Ernest Harrison said: 'This UK-based joint venture will benefit greatly from the complementary technologies of the two parent companies. Artificial intelligence techniques are rapidly gaining acceptance, and we expect to see customers with built-in Al software within the next two to three years, giving them a substantial competitive advantage.'

Racal has been investigating the potential use of artificial intelligence systems for almost two years, while Norsk Data has considerable expertise in specialized computer hardware which is suited to the further development of 'intelligent' machines.

As a result of the combination of the two companies' skills, it is thought that a new intelligent computer system can be developed in less than a year. It will be based on the Norsk Data processor.

The new joint-venture company Racal-Norsk Ltd is 51 per cent owned by Racal with Norsk taking the other 49 per cent. It will be administered as a member of the Racal Data Communications Group and based at Fleet in southern England.

More jobs in the Southwest...

Microchips with circuits having capabilities equivalent to 250,000 transistors will be produced in a new facility being established by Plessey Semiconductors at Plymouth, south-west England, under a five-year £50 million investment programme.

Construction of an 11,000 square-metre facility on a five-hectare site will begin immediately and be ready for production at the end of 1985.

This will cost some £14 million to establish and will eventually give Plessey a ten-fold increase in its metal oxide silicon chip processing capability.

Production will concentrate on application-specific integrated circuits — those which are designed for a particular function. Although the facility will be designed to handle 152 mm wafers at one micron, the initial production will be based on 127 mm wafers at two-micron resolution. These could give the equivalent of a quarter of a million transistors on a single chip.

Initial capability of the plant will be 100,000 127 mm wafer starts per week, rising to five thousand 152 mm wafer starts per week by 1990.

Plessey is already a major supplier of silicon chips with sales of more than £50 million a year, of which more than half go overseas — primarily to the United States and Far East. This investment at Plymouth comes only five months after Plessey announced another £50 million project to take gallium arsenide semiconductor technology from the research and development stage into an integrated circuit production capability at a new factory to be built at Towcester in the English Midlands.

... and in Scotland

Scotland's electronics industry received another boost when Harris Systems Ltd announced plans for a £3.6 million investment at Irvine, which will create around 100 new jobs by September, 1986.

Harris are to set up a 33,000 sq ft
plant in the Scottish new town which will manufacture two PBX (private business exchange) systems for supply to the UK telecommunications industry.

Production will be extended to include final assembly of word processing terminals and computer equipment for two other divisions within the Harris Group at a later date.

The company, a wholly-owned UK subsidiary of the Harris Corporation, the large, publicly-owned US electronics company based in Florida, already have a sales and service facility at Slough.

Harris' decision to select Irvine as its first UK manufacturing location provides further evidence of Scotland's growing role as a world electronics centre. It represents yet another significant success for Locate in Scotland, the Jobs Creation Team run jointly by the Scottish Development Agency and the Industry Department for Scotland.

Swedish match

British antenna manufacturer CSA (C&S ANTENNAS LTD) and the leading Swedish antenna company ALLGON ANTENN A.B. have agreed to co-operate in the design, development, manufacture, and marketing of their combined product ranges. Major items available from CSA include their established range of communications, broadcasting, and defence antenna systems, with ALLGON offering high quality mobile and base station antennas for both civil and military use, as well as large rotatables.

You can't do that over here...

Apple Computer Inc. have recently commenced two separate actions in the United Kingdom against vendors of alleged 'Apple Compatible' Computers: the Unitron 2200 and the Base 64A. Apple allege that both these products are copied from the Apple II range and that they infringe Apple Computer Inc.'s copyright in some of its operating programs and manuals (and in the case of the Base 64A their copyright case design also). Terms of settlement are currently being negotiated with defendants to both these sets of proceedings under which the defendants will undertake not to sell these products and will deliver up allegedly infringing stock to Apple for destruction. As regards one defendant who has not yet accepted terms of settlement, the proceedings are continuing.

Sirtel (UK) Limited, exclusive UK distributors of the MPF 11 Microcomputer which, like the Unitron 2200 and the Base 64A, emanates from the Far East, have now gone into liquidation. Sirtel gave undertakings to the court in proceedings brought by Apple last year that they would not dispose of their stock of MPF 11 RMS pending a full hearing of the proceedings. It is understood that the MPF 11 computers have now been sold by the liquidator of Sirtel (UK) Limited as scrap and Apple have requested the liquidator to deliver up the RMS themselves to Apple for destruction.

A solicitor's letter has also been sent to Copam Limited, which is selling the Base 64A Microcomputer in the UK. This letter indicates that, unless they stop selling this product and deliver up their stock to Apple Computer (UK) Limited, Apple Computer Inc. will commence proceedings against them.

... or down under

On 29th May 1984, three Judges of the Federal Court of Australia, New South Wales District Registry, General Division, overturned a majority a decision of Judge Beaumont J. in which he refused to grant Apple Computer Inc., and Apple Computer PTY Limited, an injunction restraining Computer Edge PTY Limited, and Michael Suss, from selling the Wombat Computer. This incorporates, Apple allege, copies of Apple's operating programs, Applesoft, System Monitor, and Autostart Rom. In refusing the injunction at first instance, Judge Beaumont J. had held that none of the computer programs sued upon were literary works within the meaning of the Australian Copyright Act 1968 (which is closely modelled on the present British Legislation: The Copyright Act 1956). This refusal to accord copyright protection to these programs caused considerable concern in the computer industry and, indeed, it was anticipated that if the decision was upheld on appeal the Australian Government would rapidly bring in legislation to ensure that computer programs were accorded protection under Australian Copyright Law.

On the appeal, two of the three judges found in Apple's favour and granted the injunction sought. Even the third judge in his dissenting opinion appeared to accept that copyright can subsist in computer source code (though he found against Apple Computer on the ground that reproduction of the object code form of a program does not infringe any copyright in the source code form. He said, however, that he had reached this conclusion 'not without some hesitation'). Although an Australian decision is not directly binding on the English Courts, it is likely that the British Courts will consider this decision highly influential if and when they are asked to decide whether or not the protection accorded under the Copyright Act 1956 to literary works extends to computer programs. (The view that the act does accord protection to computer programs has, of course, already been expressed in a highly influential report by a Government Committee - 'The Whitford Report' - and has been echoed by several British judges in interlocutory decisions in the British Courts, although none of them has, so far, had to decide formally on the question.)

Storehorse romps home ...

The largest order to date for the Storehorse wideband instrumentation tape recorder is announced today by Racal Recorders Limited. The order, worth almost £1 million, was placed by the United Kingdom Ministry of Defence (Procurement Executive) for 28 recorders to be used in airborne recording.

Deliveries have already commenced. Important factors in the choice of Storehorse were its unique ability to perform totally automatic calibration and equalization; long, high quality record times in operation; large recorder capability in a small package and its British design.

Nigel Vaughan, marketing director of Racal Recorders Ltd commented:

'Ve got a milestone in wideband recording and this important MOD contract underlines the advanced engineering that powers Storehorse ahead in the large portable recorder market.'

'Other recorders have the ability to
A song for Europe

British Telecom International has begun transmissions of the new MUSIC BOX cable television channel through their new docklands satellite earth station, the London Heliport, which was designed and built by Marconi Communication Systems Ltd of Chelmsford, UK.

In July GenRad Inc. announced a major facilities-expansion programme for its subsidiaries based in the UK. These are Cirrus Computers Ltd., at Fareham, Hants; Cirrus Designs Ltd., at Chaddle, Cheshire; and GenRad Uxbridge, an engineering support unit for the Company's Engineering Test Products Group.

The Cirrus capital expansion plan calls for consolidation of the operations now housed in three separate buildings on Fareham's High Street, into a newly-built 25000 sq ft facility. This will effectively double the office and laboratory space previously available to Cirrus engineers, working on software development for factory automation and computer-aided engineering projects. Ground will be broken in Fareham on a GenRad-owned site in the third quarter of 1984 for the facility scheduled for occupancy in September 1985.

Cirrus Computers Ltd. facilities will soon expand by more than 50% when that group relocates to new 10000 sq ft accommodation in Chaddle, Cheshire, near Manchester. In July, GenRad Uxbridge relocated its offices from the Howell Building, Brunel University, Uxbridge to a new 6500 sq ft facility — a 500% increase in the space available to the engineering staff supporting GenRad's Engineering Test Products Group in Santa Clara, California.

Mr Robert Bulgin, deputy chairman and deputy managing director of A.F. Bulgin Co. PLC. the electronic components manufacturers, has completed twenty-five years service with the company. He has been constantly involved in the sales development of the company, setting up and controlling the public relations and publicity sector in the 1960's prior to becoming sales marketing manager and his appointment to the board as export director in 1970.

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the QL: first impressions

We have spent the past few months getting ourselves acquainted with the three QLs we finally received in late June. Our first impression is that Sinclair has once again succeeded in setting new standards in up-to-date engineering and performance at a highly competitive price.

The hardware produced by Thorn is faultless: a traditional (by Sinclair's standards; good) keyboard that lacks a certain amount of 'feel', two microdrives that function well, and an uncluttered printed circuit. The picture quality is excellent: our television receiver (fitted with a SCART connector) constantly gave a sharp picture without any streaking or shifting and with good saturation of the colours. These features were certainly not so noticeable in the ZX and Spectrum equipment.

The super-BASIC, together with the Q-DOS operating system, is stored in a 48 K ROM (EPROM!). Super-BASIC is a new variant of BASIC in which aspects of Pascal and Algol have been incorporated. It makes programming a pleasure and avoids, for instance, those eternal declarations that are needed in Pascal. As may be expected, there are also aspects that fall below standard. The handbook, for instance, appears to have been printed before it had been edited and without typeset corrections. We also found that the connection diagrams of the RS232 socket and the video socket were incorrect. Sadly lacking is a contents list, not to mention an index: the incorrect. Sadly lacking is a contents list, not to mention an index: the incorrect.

Although the reading of our own files gave no cause for complaint, it would appear that the software delivered with the QL has been copied a little hastily. In one case we found it impossible to load the archive program supplied, and in another the text compiler cassette displayed a stubborn fault. Fortunately not a problem for us with three QLs, because we can interchange parts, but otherwise...

One of the three models suffered initially from picture distortion: vertical stripes, accompanied whenever the microdrive was started by horizontal ones. This fault was traced to low supply voltage and has since been corrected.

The power supply is a gem: contained separate from the QL in a black, plastic cube, it hardly gets warm and generates not a trace of hum. The 5 V voltage regulator in the QL itself is fitted onto a 'judicious' heat sink and gives the appearance of thermal excellence and reliability.

Each QL comes complete with four programs: 'quill', a text compiler; 'abacus' for arithmetical computations; 'easel' which enables the graphical representation of arithmetical work; and 'archive', a database. As far as operation is concerned, we have no complaint: instructions are always clearly indicated and invariably followed by further actions required. What we do not like is the speed at which various operations take place. Writing text gives no real problems, but during corrections the cursor moves exasperatingly slowly. It appears that after only half a page the text is written onto the microdrive, and since that means that the data have to be recovered first, reading back takes a lot of time. On the other hand, this is not unique to the QL: other well-known text compilers such as Wordstar suffer (but not so badly) from this inadequacy. However, when the cursor inertia is combined with the relatively slow microdrives, the times are only just acceptable in BASIC. It would seem that at least part of the programs will have to be rewritten soon!

The software was produced by PSION, the London software company, probably in a higher language and then translated to the 68000 code, which would explain the slow tempo. It appears that in spite of the 128 K RAM there is not all that much room left for text, so that storing in the microdrive is necessary almost immediately. There is no indication of this in the handbook, but our tests indicate that there is at most 40 K available for text. We can only hope that we have made a mistake, because after allowing for the 32 K for the video display, there are 96 K left: according to our findings this means that almost half of the remaining capacity is used for the internal management of BASIC and Q-DOS and that sounds unbelievable! But even the designers had reckoned on only 32 K ROM and consequently provided only two IC sockets. One of the three EPROMs fitted is that soldered piggy-back onto another!

In the light of our experiences, we find the level and volume of criticism levelled at the QL from virtually all sides grossly exaggerated. We accept that some of it is warranted by the delays and other factors reported in an earlier issue of Elektor, but criticisms such as "Why another new computer?"; and "Surely there is no market for this" just do not hold. Or do we detect an underlying tone in the vein of "At that price it cannot possibly be as good as claimed?"
What is the difference between the QL and, say, a Macintosh, which, by the way, is about four times as expensive as the QL. Is it that the Mac has a 'real' drive? Or a built-in monitor? Or is it the 16-bit wide 68000 microprocessor which makes the Mac slightly faster? In other aspect the two are quite similar: both have 128 K RAM and excellent graphic, the Mac only in black-and-white but with a superior resolution. Yet, nobody says about the Mac: "And what are we going to do with that?". And we have not heard too many complaints in respect of the Mac's RS232 printer output which is suddenly called 'non standard' in the QL. Moreover, nobody is in the least bit surprised that Apple have implemented their own operating system. One theory is that the Mac (mainly because of its price?) is geared towards the professional market, while the QL (mainly because of its price?) is intended for the hobby market and it is supposed to be here that there is no need for another machine. (It is true, of course, that the QL is based on a slightly simpler construction.) This would, indeed, be a remarkable philosophy, because what can there possibly be against an excellent piece of equipment that is available at a highly competitive price and is, moreover, so easy to operate? It is, of course, true that the software is not perfect, but when the redoubtable IBM-PC was launched, it offered little more than a text compiler. But, to remain with the Mac: its associated text compiler cannot handle more than 10 pages (!). And is it really so convenient to have to take your hand off the keyboard every time the cursor has to be positionned?

But enough of all this — we have no intention of criticizing any particular machine, only to draw fair comparisons. Nowadays, all systems tend to be so complex that teething troubles are unavoidable, and, as always, it's only a question of time for these to be solved. It is therefore even more surprising that there have been so many over-the-top reactions and demands that this new machine be perfect from day one.

basicode-2

Changes and additions to broadcasting schedules

In our October, 1983, issue we published two articles on 'basicode-2' (pp. 10-27 and 10-51). In the first of these we mentioned that basicode programmes are broadcast during the Hobbiescoop programme. As from 7 October the broadcast times on medium waves change to 19.10 — 19.15 (British time) on Hilversum 5, 1008 kHz, every Friday. The main programme, which is no longer transmitted on medium waves, can now be heard on Thursdays, commencing 25 October 1984, according to the following schedule (all times in GMT).

<table>
<thead>
<tr>
<th>Australia/New Zealand</th>
<th>07.50</th>
<th>09.50</th>
<th>Western Europe (cont'd)</th>
<th>10.50</th>
<th>12.50</th>
<th>14.50</th>
<th>15.50</th>
<th>17.50</th>
<th>19.50</th>
<th>21.50</th>
<th>23.50</th>
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<tr>
<td></td>
<td>9770 kHz</td>
<td>9715 kHz</td>
<td>Western North America</td>
<td>9650 kHz</td>
<td>9695 kHz</td>
<td>9735 kHz</td>
<td>9785 kHz</td>
<td>9835 kHz</td>
<td>9885 kHz</td>
<td>9935 kHz</td>
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<tr>
<td>South East Asia</td>
<td>11 730 kHz</td>
<td>11 740 kHz</td>
<td>Eastern North America</td>
<td>11 750 kHz</td>
<td>11 760 kHz</td>
<td>11 770 kHz</td>
<td>11 780 kHz</td>
<td>11 790 kHz</td>
<td>11 800 kHz</td>
<td>11 810 kHz</td>
<td></td>
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<tr>
<td>Africa &amp; Southern Europe</td>
<td>18 500 kHz</td>
<td>18 500 kHz</td>
<td></td>
<td>18 500 kHz</td>
<td>18 500 kHz</td>
<td>18 500 kHz</td>
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<td>18 500 kHz</td>
<td>18 500 kHz</td>
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<tr>
<td>Western Europe</td>
<td>09.50</td>
<td>09.50</td>
<td>Western North America</td>
<td>10.50</td>
<td>10.50</td>
<td>10.50</td>
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<td>10.50</td>
<td>10.50</td>
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<td></td>
<td>5955 kHz</td>
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By definition, a tuning fork is a two-pronged metal object set in vibration to produce a sound which serves to check the pitch of instruments and to give the pitch to voices. Its tone is virtually a pure note, lacking the upper harmonics which enter into the tone of normal instruments. The design presented here is a change from the basic device in two important aspects: the two prongs have become electronic circuits, and instead of a single tone it provides a frequency range of 32...7902 Hz in semi-tone steps.

One of the two prongs is a stable reference oscillator, which is controlled by a 4 MHz crystal, and the other consists of an a.f. amplifier driven by an Electret condenser microphone. The output of the prongs is applied to a frequency comparator.

Some background information

All musical instruments produce sounds which do not consist only of pure tones (like that of a tuning fork) but of a mixture of the fundamental and certain other harmonic frequencies. The mixture is particular for a given instrument and, indeed, determines the difference between tone-colours of instruments. You only have to strike the same note on a violin and a xylophone to hear what we mean!

Harmonics are generated because a vibrating string or air-column does not only vibrate through its whole length but also in aliquot parts (\(\frac{1}{2}\), \(\frac{1}{3}\), \(\frac{1}{4}\), and so on). Vibration of the whole length gives the lowest (fundamental) tone, which is sometimes called 'first harmonic'. The other harmonics, that is, the second, third, fourth, and higher, are at fixed intervals above the fundamental: an octave above it, then a perfect fifth above that, and so on, decreasingly, ad infinitum.

Tuning of musical instruments is carried out at a fundamental frequency so that if, for instance, a piano string is being tuned, its fundamental tone is compared with the frequency from the reference oscillator in the tuning fork. This gives rise to two problems: (1) the fundamental must be filtered from the composite sound produced by the piano string, and (2) as the frequency comparator functions with square waves only, the tone must be suitably converted.

A typical, composite sound is illustrated in the top half of figure 1; the lower half shows the rectangular pulses that result when the sound is applied to a trigger circuit. The irregular series of rectangular pulses contains not only the fundamental, but also a large number of harmonics. The fundamental is filtered out by a narrow-bandpass filter, the centre frequency of...
Table 1.

Frequencies in Hz of the chromatic scale over eight consecutive octaves

<table>
<thead>
<tr>
<th>tone</th>
<th>C</th>
<th>C#</th>
<th>D</th>
<th>D#</th>
<th>E</th>
<th>F</th>
<th>F#</th>
<th>G</th>
<th>G#</th>
<th>A</th>
<th>A#</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 4</td>
<td>4186.00</td>
<td>4409.45</td>
<td>4629.50</td>
<td>4850.70</td>
<td>5074.00</td>
<td>5300.50</td>
<td>5528.70</td>
<td>5769.70</td>
<td>6013.60</td>
<td>6260.50</td>
<td>6510.60</td>
</tr>
<tr>
<td>0 - 3</td>
<td>2093.00</td>
<td>2209.45</td>
<td>2328.45</td>
<td>2448.80</td>
<td>2570.00</td>
<td>2692.00</td>
<td>2815.00</td>
<td>2940.00</td>
<td>3067.00</td>
<td>3195.90</td>
<td>3326.50</td>
</tr>
<tr>
<td>0 - 2</td>
<td>1046.50</td>
<td>1108.73</td>
<td>1174.70</td>
<td>1244.50</td>
<td>1318.50</td>
<td>1396.90</td>
<td>1479.96</td>
<td>1568.00</td>
<td>1661.24</td>
<td>1760.00</td>
<td>1864.66</td>
</tr>
<tr>
<td>0 - 1</td>
<td>523.25</td>
<td>554.36</td>
<td>587.33</td>
<td>622.25</td>
<td>659.26</td>
<td>698.46</td>
<td>740.00</td>
<td>784.00</td>
<td>832.00</td>
<td>880.00</td>
<td>932.33</td>
</tr>
<tr>
<td>0 - 0</td>
<td>261.63</td>
<td>277.18</td>
<td>293.66</td>
<td>311.12</td>
<td>329.59</td>
<td>352.00</td>
<td>3729.31</td>
<td>3920.00</td>
<td>4153.11</td>
<td>4400.00</td>
<td>466.16</td>
</tr>
</tbody>
</table>

Circuit description

With reference to figure 3, the reference oscillator is formed by gates N1 and N2 and is controlled by a 4 MHz quartz crystal. The oscillator frequency is halved by binary counter IC3 and the resulting 2 MHz signal is applied to master tone generator IC1 (pin 2). This generator provides the twelve tones of an octave from which all other tones are derived. The frequency of each tone is exactly \( \sqrt{2} \) times higher \((C' x 1.059)\) than the preceding tone. For instance, the lowest output tone of the IC, the note C, is available at pin 16 and is 2 MHz : 478 = 4186 Hz. The next higher tone, C#, available at pin 4, is 2 MHz : 451 = 4434.91 Hz.

The output signals of IC1 are further divided in IC5 so that a total of eight octaves each consisting of twelve semitones is available. These semitones and the corresponding frequencies are given in table 1. The highest of the eight octaves is available at electronic switch ES9 and the lowest at ES1. The wanted octave is selected by switch S2. Finally, the selected tone is fed to frequency comparator IC8.

The sound from the instrument being tuned is collected by the microphone and then amplified in IC10 by 40...60 dB depending on the setting of P1. This is done to maximise the signal level for the control stage. The control stage serves to retain the slowly fading signal at a constant level for as long as possible, so that there is enough time for tuning the instrument. Next, the signal is fed to the bandpass filter and then to a schmitt trigger where it is converted into rectangular pulses. Finally, these pulses are transformed to square waves by a bistable multivibrator (flip-flop).
source T1/A1 to that part of its operating characteristic which ensures that its output remains constant as long as there is an input signal. This is accomplished by rectification of the output signal in A2/D1 and comparing this with the reference voltage derived from voltage divider R15/R16. The output signal of A3 is therefore either positive or negative depending on the level of the signal amplitude. Integrator A4 provides the input voltage for the current source.

The constant-amplitude sound signal at the output of IC9 is amplified by another JFET-input amplifier, A5, and then fed to the input of active bandpass filter IC2. The output signal of A3 is therefore either positive or negative depending on the level of the signal amplitude. Integrator A4 provides the input voltage for the current source.

At the output of the filter, pin 12, exists a stepped signal which is reshaped by low-pass filters R30/C10 and R31/C11 to a clean sine wave. That signal is then converted to a rectangular pulse by schmitt trigger A6. This pulse is applied to bistable FF3 so that the frequency ratios at the input of frequency comparator A8 are unity.

The frequency comparator functions, strictly speaking, as a summation integrator. It 'sums' the pulses emanating from the differentiating networks CI2/C13/R40 and CI4/C15/R41 (see also figure 2). The outputs of bistables FF1 and FF2 are converted into positive and negative pulses by D37 and D36 respectively. If the two sound frequencies are identical, there are as many positive as negative pulses, so that the output voltage of IC8 is nil. If, however, one of the frequencies is higher than the other, there will, for example, be more positive than
negative pulses, and a positive voltage ensues at the output of IC8. That voltage is amplified by A8 and then used to operate a centre-zero 100 µA meter. A positive output of IC8 is indicated by a deflection to the right; a negative one causes the meter to deflect to the left. The meter sensitivity can be increased by P2, but in most instances it will be sufficient if $P_2 = 0$ corresponding to unity gain in A8.

We have already discussed the selection of tones and octaves by Si and S2 respectively. As there is a limit to the number of mechanical switches that can be used conveniently, a number of electronic switches has been incorporated. This means that the octaves are not selected directly by S2 but by ES1...ES8 and ES9...ES16 which are controlled by S2. The first group of switches selects the frequencies for the bandpass filter and the second the reference tones. Switch S1A and the diode matrix enable the centre frequency of the bandpass filter to be set accurately.

The reference tone may be made audible by switching on monitor amplifier A7/T2 with S4.

**Calibration**

Before the unit is taken into use, it is important to check the signals at the pins of the socket for IC2 — the IC should not yet be inserted into the socket! Then switch on the mains and check that all supply voltages are correct.

There is no need for any calibration in the reference oscillator section: it is sufficient to listen (S4 on!) and select the various tones with Si and S2.

Next, tune the input amplifier to the music signal. It is necessary to find a compromise between the distance of the microphone to the instrument and the (gain) setting of P1; the criterion is that the output of IC10 is not limited. This is best verified with an oscilloscope, but if you have no oscilloscope, connect the positive input of the monitor amplifier to the output of IC10 and listen to the tone: it should be fairly loud, and sound 'clean'— not distorted! This is, unfortunately, not an easy matter with string instruments.

The music signal can then be followed to pin 9 of the socket of IC2 with either the oscilloscope or the monitor amplifier. If the sound is all right up to there, IC2 may be inserted (after the mains has been switched off!).

Switch on the mains again and select a reference tone. Hold the microphone at a distance from the loudspeaker which prevents overloading of the monitor amplifier. The meter should read zero: if not, adjust C13 until it does. It may also be necessary to increase the gain of A8 by adjusting P2.
A balancing transformer (often called a balun, which is a contraction of balanced/unbalanced) is any device used to couple a balanced impedance, for instance an aerial, to an unbalanced transmission line, such as a coaxial aerial feeder cable.

**balancing transformers**

An example of a balancing transformer is given in figure 1: in la it consists of two pieces of twin feeder cable, while in lb coaxial cable is used. In either case, the pieces of cable are a quarter wavelength long and are connected in parallel at one end and in series at the other. The two most important properties of such a balun are impedance transformation and symmetry transformation. Textbooks refer to these baluns as quarter-wave matching sections. In such sections, the parallel-connected ends present an impedance of Z/2, where Z is the characteristic impedance of the cable used in the transformer. This termination of the section is asymmetrical. The series-connected ends present an impedance of 2Z, and the section here is open-circuited and symmetrical.

**Figure 1. Illustrating the principle of a balancing transformer: (a) using balanced cable, and (b) using coaxial cable. Z is the characteristic impedance of the cable used.**

---

la

- Twin feeder cable
- Z/2 symmetrical
- λ/4
- Balanced → Unbalanced

---

lb

- Coaxial cable
- 2Z symmetrical
- λ/4
- Balanced → Unbalanced
**Air-cored transformers**

Dipole aerials for short-wave, UHF, and TV reception are normally connected to the radio or television receiver by a coaxial (75-Ω) cable. This causes the aerial to be loaded asymmetrically, even though its base impedance is equal to the characteristic impedance of the coaxial feeder cable. One effect of this is the flow of transient currents in the screen of the cable: the screen then acts as an aerial and this, of course, is not the intention!

The simplest way of preventing the flow of these transient currents is connecting the aerial to the feeder cable via a transformer intended for matching 75-ohm impedances as shown in figure 2a. The transformer is wide-band, no changes are necessary to the coaxial cable, and there is nothing to adjust: it could not be easier. Unfortunately, this set-up has the disadvantage of no longer acting as a pure inductor at high frequencies.

Figure 2b illustrates a matching transformer for connecting a 300-ohm aerial to a 75-ohm feeder cable. The transformer is wound from lengths of coaxial cable with a characteristic impedance, $Z_0$, of 150 ohms. The relation between $Z_0$, the aerial base impedance, $Z_a$, and the characteristic impedance of the feeder cable, $Z_f$, is given by $Z_0 = \sqrt{Z_a Z_f}$.

The length of the pieces of coaxial cable from which the transformer is wound should be not less than one tenth of the maximum wavelength and at least four times the inner diameter of the transformer. For an operating frequency of 100 MHz, therefore, the length should be not less than 30 cm, while the inner diameter of the transformer should not exceed 7.5 cm. The turns should be closely spaced and the connecting points should be protected against moisture ingress by a plastic spray.

**Toroidal transformers**

Winding the transformers on a ferrite toroid results in a small, space-saving balun. Figure 3a shows an arrangement electrically similar to that in figure 3a: two lengths of enamelled copper wire of 0.25 mm diameter (SWG 32...34) are twisted together and then laid in ten turns around the toroid. If a T50-2 core (available from Cirkit) is used, the transformer may be used over a frequency range of 12...280 MHz.

The configuration in figure 3b is similar to that in 2b and here again a bifilar winding of twisted enamelled copper wire of SWG 32...34 is used. This transformer matches a 300-ohm aerial to a 75-ohm feeder cable, that is, the impedance transformation ratio is 4:1. The correct terminals may be determined with a continuity test and then connected as indicated. The advantage is that this arrangement does not need 150-ohm cable which is not easy to obtain. On the other hand, a toroidal transformer is slightly more expensive.
Inverting the phase of video signals causes interesting effects on the screen. As proprietary equipment for this purpose is expensive, the low-cost inverter presented here may be of interest to many of you. The unit offers the choice of inverting the composite colour (= luminance + chrominance) signal, or the luminance (black and white information) signal only.

The inverter is of interest to three groups of people: video recorder owners who want to change the image on their television screens, video camera operators who want to incorporate trick images in their work, and amateur photographers who want to view their negatives as positives.

Depending on the setting of the relevant switch, the circuit provides normal, that is, non-inverted, images (which means that the inverter may be connected permanently), or inversion of the luminance and chrominance signals, or inversion of the luminance and adjustable inversion of the chrominance signal. The range of adjustment lies between full inversion and near-normal: the setting of the relevant control, P2, depends on the required effect and individual taste.

Applications
It should be noted that the inverter functions on the composite colour signal. Its input and output are therefore suitable for use only with equipment where this signal is readily available, for instance, via an A/V socket or BNC plug. This is, of course, no problem with modern video cameras, VCRs, and television receivers. Moreover, such a connection is easily fitted retrospectively to most older equipment. If you do not feel confident of carrying out this modification yourself, ask your local TV repair shop.

The use of the inverter as image modifier for video recordings is illustrated in figure 1. Your favourite piece of equipment may, for instance, be co-opted to function as part of a home discotheque. All you have to do is to record some suitable concerts and during playback to switch in the inverter at appropriate passages.

Figure 2a shows a suitable set-up for video camera operators. It is best to use a recorder with an electronic editing facility: the recorder is then stopped at the moment the switch-over from normal to inverted image, or vice versa, takes place, so that synchronization upsets are prevented.

If you are fortunate enough to possess two VCRs (for instance, a mains operated and a portable model), the set-up in figure 2b may be used. The advantage of this arrangement is that filming may be carried out as normal and the image modifications may be inserted during editing of the
Figure 1. Connected between a video recorder and a television receiver, the inverter may be used for 'magic' effects on the screen.

Figure 2a. Connected between a video camera and a VR, the inverter may be used to modify the information being recorded.

Figure 2b. This is perhaps the most interesting set-up, particularly for video camera operators: it will enable them to modify home-made film during the electronic editing.

recording. The video amplifier (for instance, the video distribution amplifier featured on page 12-36 of the December 1983 issue of Elektor) serves not only to compensate for losses in the recording and playback chain, but also to provide the possibility of using a TV receiver with A/V socket as monitor.

A suitable configuration for amateur photographers is shown in figure 3 which is self-evident, but has two important limitations. Firstly, the set-up is restricted to black-and-white negatives because it would be quite difficult to compensate for the orange mask on the negative, and, secondly, the video camera must be of
**Figure 3. A further application enables black-and-white film negatives to be viewed positively on the screen.**

**Figure 4.** This illustrates the basic composition of a line scan. Luminance and chrominance are firmly interwoven. Note that this representation and that in figure 5 is purely schematic: viewed on an oscilloscope it would look quite different.

**Figure 5.** Same information as in figure 4 but with the single line scan inverted.

Video signal

We have no intentions of embarking on a full course in video technology but will restrict ourselves to those aspects which are important to the circuit. The single line scan shown in figure 4 illustrates normal traversal of the composite colour signal. If we want to invert this signal without affecting the other functions of the TV Receiver, it is necessary to invert the line scans as shown in figure 5. Both the luminance and the chrominance signals are inverted, because the chrominance signal is 'interwoven' with the luminance signal. If the phase of the colour burst signal is also shifted by 180°, the colour information returns to normal while the luminance signal remains inverted. How this is achieved will be explained in the circuit description.

Circuit description

Switch S1 in figure 6 switches the inverter in or out of the circuit. With S1 in position as shown, the incoming signal is applied via input network C1-C3-R1-R2 to a clamping circuit formed by opamp IC2 and diode D3. The input network is necessary to transfer the signal from the camera or VR undistorted and present it with the right impedance. Unfortunately, it causes the signal to lose its d.c. offset which is required for the proper functioning of the inverter. The clamping circuit reintroduces the offset by pulling the lowest (most negative) component of the line scan to 0 V.

Because the clamping circuit has a high-impedance output, it is followed by buffer (voltage follower), IC1. The output of IC1 is available at pins 2 and 6 and is divided into two.

One part of the output is applied to comparator IC3 which regenerates the line...
synchronization pulse (available at pin 7). The leading edge of this pulse triggers monostable multivibrator IC4. This monostable controls the actual run-off via electronic switches ES1...ES3. Switch ES4 is controlled directly by the output of the comparator, which we will return to later in this article.

The other part of the output of IC1 is applied across colour saturation control P1. The Q output of IC4 is at logic 1, which keeps switch ES2 closed, until the end of the colour burst pulse train. With colour inversion switch S2 in position 1, the signal from P1 is then applied to the non-inverting input (pin 1) of opamp IC6 via ES2; the phase of this signal is therefore not (yet) inverted. When the monostable changes state, output Q goes low and output Q becomes logic 1. Switches ES1 and ES3 are then 'on' and ES2 is open. The signal from P1 is applied to the inverting input (pin 14) of IC6 via ES1, so that the phase of the composite colour signal at pin 7 of IC6 is shifted by 180°. At the same time, ES3 applies a reference voltage from voltage divider P3/R9 to the non-inverting input of IC6, ensuring a correct and positive signal level at the output.

When S2 is set to position 2 and P2 is turned fully open (wiper at M), the colour burst signal is phase-shifted 180° by the action of T1. The colour information at pin 7 of IC6 is then shifted a total of 360° and is in phase with the incoming signal.

It is evident that both inverted and non-inverted colour burst signals are present across P2 and this makes it possible for the degree of inversion of the colour information to be adjusted as required. In other words: colour may be continuously changed from normal to fully complementary, with P2 at the centre of its travel, there is no colour.

The line sync signal must, of course, be fed to the following circuit (TV receiver or video recorder) non-inverted and this is ensured by T2 and ES4. The switch is controlled directly by the output of comparator IC3.

Transistor T3 and resistors R16, R17 ensure a correct output impedance of 75 Ω.

The power supply is a conventional, voltage regulated ±5 V circuit. As the negative line is not loaded as heavily as the positive, the value of C13 may be rather smaller than that of C12.

Construction and calibration

If the printed circuit of figure 7 is used, there should be no special problems in the construction. The compact design enables the unit to be installed in a neat case. Amateur photographers should use presets in the P1...P3 positions, and this arrangement is also advisable for disco applications (so that not everybody can play around with the inversion settings). Others should find it advantageous to use normal potentiometers and fit these onto the case; connections between them and

Figure 6. The circuit diagram of the inverter: possible extensions are explained in the text.
the printed circuit should be made in screened wire with the screen connected to earth. Where potentiometers are used, it is convenient to provide a graduated scale around, or a skirt under, the control knob.

The type of input and output connector depends really on the equipment the inverter is to be used with. BNC connectors are very convenient and easily fitted but lose their advantages if adapter cables become necessary. If you use A/V sockets, interconnect all pins, except 2 (= composite colour signal), and connect pin 3 to the nearest earth point in the circuit.

Calibration is relatively simple and requires a video signal source and a test card (this may, for instance, be one recorded from a broadcasting station). Set switch S1 to position 'inverter on' and S2 to position 1. Controls P1 and P3 should then be adjusted to give rich colours and a good contrast respectively. Finally, set S2 to position 2 and check that colours can be continuously changed from normal to complementary by P2.

Other interesting facets

For another of our experiments we needed one half of the screen image inverted and the other half normal. This requires a lengthening of the time IC4 is triggered and this is achieved by connecting an additional preset in series with R10: the switch-over to inverting then takes place sometime during the line scan. If the trigger period is further extended, inversion does not take place until the next line scan. This gives the interesting picture of alternate normal and phase-inverted lines. Making the trigger period longer still (a 100 k preset in series with R10) causes the effect to be visible over one part of the screen image only. The additional preset is connected as shown
As the inverter is relatively inexpensive, particularly when compared with commercially available models, it is quite feasible to connect two or more of them in cascade. We think that four or five of them so connected will function without any problems, although we have not built so many prototypes ourselves and cannot therefore prove it. Such a set-up offers so many possibilities for achieving trick effects that it is impossible to envisage them all: we’ll give you two.

When two inverters are connected in series of which only one inverts the colour, the resulting picture is normal as far as black-and-white information is concerned, but the colour is inverted. The second example is illustrated in figure 9. Here, the onset of the first inverter is arranged so that one part of the picture remains normal; the second part, in the centre, has the black-and-white information inverted. The second inverter inverts the inverted black-and-white information and inverts the colour. The overall picture will then show: normal — black-and-white inverted — colour inverted. This all presupposes that both inverters are fitted with the additional preset P4.

For really accurate settings, you could use multi-turn preset or potentiometers, but this is really a matter of cost. In our experience, the inverter can be calibrated very well with just fingertip control.

A final tip: if you want to monitor the modified image being recorded, reduce R16 to 82 Ω, connect a 68 Ω resistor, R17, in parallel with R17 as shown in figure 10, and add a socket as appropriate.
Computers do not always have to perform difficult tasks to be useful. Very often it is the boring, repetitive, soul-destroying type of work we make them carry out. Calculating the hexadecimal values of the registers in the 6845 (or 6545) cathode ray tube controller (CRTC) for any given screen format could hardly be called mind-taxing but it is the sort of job that any computer, using this BASIC program, will perform correctly and as often as you like.

programming the 6845

a BASIC description of the CRTC registers

P. Fransen

The value of changing the screen format on your Elektor VDU card (or any other VDU card that uses a 6845 or 6845 CRTC) may not be immediately obvious but once hooked on the technique it is something you are likely to do more and more often. Furthermore this program is interesting and instructive in its own right.

The parameters

The 6845, and all the various details about structure, organisation of the screen format and the signals used, have already been dealt with in Elektor and in other books so we will not bother about that here. Any information required can be found in the literature listed at the end of this article.

The video norms currently in force in Europe use a line frequency of 15625 Hz and an frame frequency of 50 Hz. The time needed to sweep one line on the screen is

\[ \frac{1}{15625} \text{s} = 64 \mu\text{s} \]

and the time to sweep a complete frame is

\[ \frac{1}{50} \text{s} = 20 \text{ms} \]

We must now calculate the clock frequency required by the system.

Line synchronisation

Each character is based on a horizontal width of eight screen dots, each of which is scanned in one clock period. Knowing the number of horizontal characters now enables the clock frequency (which we will call \( f_x \)) to be calculated. The dot frequency is \( \frac{1}{f_x} \) and the character frequency is eight times this value. With a total of 128 horizontal characters the clock frequency is:

\[ 128 \times \frac{8}{64} = 16 \text{ MHz} \]

This is no coincidence, actually, as the figure of 128 characters is chosen because it allows the common, inexpensive 16 MHz crystal to be used.

Working out the character duration gives us:

\[ 8 \times \frac{1}{16 \text{ MHz}} = 0.5 \mu\text{s} \]

The total number of horizontal characters (minus one) between two horizontal sync pulses forms the contents of register R0. In this example we get:

128 - 1 = 127 or 7FHEx.

The contents of register R1 indicates the number of characters per line which in most cases will be 80, or 50HEX.

The position of the horizontal sync pulse is determined by the contents of register R2 (see figure 1). This is calculated as follows:

\[ HP = \left( \frac{TSL - DT - 1.5 \times LPB}{2} \right) + DTZ \]

where

- \( DT = \) the width of the usable window (in \( \mu\text{s} \))
- \( TSL = \) the line time (in \( \mu\text{s} \))
- \( LPB = \) breadth of the line sync pulse (in \( \mu\text{s} \)), and
- \( HP = \) the position of the line sync pulse (in \( \mu\text{s} \)).

The value of DT is:

80 \times 0.5 = 40 \mu\text{s}.

The value of LPB (see R3) is

8 \times 0.5 = 4 \mu\text{s}.

Inserting these values into the formula, we get

\[ HP = \left( \frac{64 - 40 - 1.5 \times 4}{2} \right) + 40 = 49 \mu\text{s} \]

The factor 1.5 is an optional character to permit the position of the window on the screen to be accurately set.

Register R2 will contain

49/0.5 = 98

which is represented by 62HEX.

Image synchronisation

In order to calculate the image synchronisation the number of screen lines per character must be known. The minimum number is eight, and this is generally used both for text and graphics characters. As the maximum number of character lines is 25, nine screen lines per character line are generally chosen. This gives 24 lines of characters on the screen. Each line then has a duration of

\[ 9 \times TSL = 9 \times 64 = 576 \mu\text{s} \]
and sweeping the whole 24 lines takes
24 x 576 = 13,824 µs.
This time is generally indicated by VT.
The contents of register 6 will be 24, or
18HE
The frame time must be as close as poss-
ible to 20 ms. With the line time
calculated above we see that
20,000/576 = 34.72 lines.
Rounded off, this gives 34 lines (24 of
which are usable) between successive
frame sync pulses. From this we obtain
the contents of R8: 34, or 21HE
As the
frame time is only
34 x 576 = 19,584 µs
there are still
20,000 - 19,584 = 416 µs
needed. A number of extra lines must be
swept to bring the total screen time up to
20 ms. The actual number is calculated by
dividing the remainder by the line time:
416/64 = 6.5
so this is rounded to 6, giving a value of
06HE.
Calculating the position of the frame sync
pulse is similar to that for the line sync:
VP = VT - (VT + 1,500)/2
Where VT is the frame time. In our
example:
34 x 576 + 6 x 64 = 19,968 µs.
The contents of R7 can be calculated from
VP:
(19,968 - (1500 + 24 x 576))/2 + 24 x 576 =
16,146 µs.

Table 1. Using this short BASIC program it is a
very simple matter to calculate the appropriate
hexadecimal addresses to insert into the 6845
registers for any given screen format.
This value is divided by the line time, 16,146/576 = 28.03, giving 28 when rounded, or 1CHEx.

Register 8 will almost invariably contain zero as we do not want to have an interlaced frame. The contents of register 9 is simply the number of screen lines per character line.

Table 2.

Table 2. When the four user-defined parameters have been loaded the contents of the CRTC registers are output in this way.

<table>
<thead>
<tr>
<th>RCN</th>
<th>HORIZONTAL LINE LENGTH (CHAR.):</th>
<th>128</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREQUENCY = 16 MHZ</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>CRYSTAL FREQUENCY (MHZ):</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>NUMBER OF CHARACTERS PER LINE:</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>NUMBER OF SCAN LINES:</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>NUMBER OF CHARACTER LINES:</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>SCREEN FORMAT = 80 x 24</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| REGISTER R 8 | = 7F |
| REGISTER R 1 | = 80 |
| REGISTER R 2 | = 558 |
| REGISTER R 3 | = 562 |
| REGISTER R 4 | = 580 |
| REGISTER R 5 | = 586 |
| REGISTER R 6 | = 588 |
| REGISTER R 7 | = 51C |
| REGISTER R 8 | = 88 |
| REGISTER R 9 | = 588 |
| REGISTER R 10 | = 549 |
| REGISTER R 11 | = 109 |
| REGISTER R 12 | = 588 |
| REGISTER R 13 | = 88 |
| REGISTER R 14 | = 88 |

| CLOCK PERIOD | .5 MICROSECONDS |
| LINE SYNC. PULSE WIDTH | 4 MICROSECONDS |
| LINE SYNC. PULSE PERIOD | 64 MICROSECONDS |
| HORIZONTAL DISPLAY TIME | 48 MICROSECONDS |
| HORIZONTAL POSITION | 49 MICROSECONDS |
| CHARACTER LINE PERIOD | 576 MICROSECONDS |
| FA#ER SYNC. PERIOD | 19968 MICROSECONDS |
| VERTICAL DISPLAY TIME | 13824 MICROSECONDS |
| VERTICAL POSITION | 16128 MICROSECONDS |

The cursor

The program dealt with in this article does not permit a very flexible programming of the cursor. This can be improved by including a few BASIC lines to add a choice of options as we will now see. Registers 10 and 11 define the upper and lower limits (the size, in other words) of the cursor respectively. Bits 5 and 6 of register 10 determine whether the cursor is present at all and if so whether it flashes or simply lights. As an example, assume we want a non-flashing cursor which has the form of a single underline. The register 10 configuration needed is given by the value 48HEX (more details of this are given in Paperware 3). As the lower limit of the cursor will be the last line swept (for any given character line), register 11 must contain 08HEX. Unlike what we have dealt with up to now, registers 12...17 do not lend themselves to individual calculations so we will have to be content simply to initialise them.

A few examples

Programming the 6845 is made easier in any system with the aid of the program shown in table 1. Given four parameters (the number of characters between two line sync pulses [horizontal total], which gives the ideal crystal frequency that should be used, the number of characters used per line, the number of scan lines per character line and the number of character lines on the screen) it returns the hexadecimal contents of all the 6845 registers concerned. An example of this result is shown in table 2. All the parameters can also be stated in decimal base.

Having let the program work out all these results the next question is what to do with them. If you are not using the Elektor VDU card and its software you will have to study your system's software to find out how to access the 6845 initialisation routine. In the Elektor system (detailed in Paperware 3) this initialisation procedure carries out two operations: one (routine MOVCRT) to change the look-up table containing the RAM and ROM parameters (CRT timing table) and the other to transfer the RAM parameters to the CRTC (routine CRTINT). This latter routine is the one we are interested in. Before starting it (by means of DISK!GO F36C, for example) the data calculated by the BASIC program of table 1 must be saved from address EFDCHEX (61404 decimal) onwards. As is often the case, changing the screen format demands a total erase so execute the RESET routine (F33DHEX) immediately and this simply calls the CRTINT routine needed to program the CRTC.

References:
Elektor Paperware 3 and 4
Motorola 8-bit Microprocessors Manual
Synertek Data Book
musical doorbell

(July/August 1984, page 7-87)

Please note that the ICs type UM3581/2/3/4 are available from Midas Telecom
1 Oaklands Grove
London W12 0JD
Phone: (01) 743 3882
The following pages contain the mirror images of the track layout of the PCB boards relating to projects featured in this issue to enable you to etch your own boards. To do this, you require an aerosol of 'ISOdraft' transparentizer (distributors for the UK: Cannon & Wrin, 68 High St., Chislehurst, Kent, 01 467 0935, who will supply the name and address of your local stockist on request, a mercury vapour lamp, sodium hydroxide (caustic soda), ferric chloride, positive photosensitive board material (which can be either bought or home made by applying a film of photo-copying lacquer to normal board material).

- Wet the photo-sensitive (track) side of the board thoroughly with the transparent spray.
- Lay the layout cut from the relevant page of this magazine with its printed side onto the wet board. Remove any air bubbles by carefully 'ironing' the cut-out with some tissue paper.
- The whole can now be exposed to ultra-violet light. Use a glass plate for holding the layout in place only for long exposure times, as normally the spray ensures that the paper sticks to the board. Bear in mind that normal plate glass (but not crystal glass or perspex) absorbs some of the ultra-violet light so that the exposure time has to be increased slightly.
- The exposure time is dependent upon the ultra-violet lamp used, the distance of the lamp from the board, and the photo-sensitive board. If you use a 300 watt UV lamp at a distance of about 40 cm from the board and a sheet of perspex, an exposure time of 4 ... 8 minutes should normally be sufficient.

- After exposure, remove the layout sheet (which can be used again), and rinse the board thoroughly under running water.
- After the photo-sensitive film has been developed in a sodium hydroxide solution (about 9 grams of caustic soda to one litre of water) for no more than 2 1/2 ... 3 mins at 20°C, the board can be etched in ferric chloride (500 grams of FeCl₃ to one litre of water). Then rinse the board (and your hands!) thoroughly under running water. It is advisable to wear rubber or plastic gloves when working with caustic soda or ferric chloride solutions.
- Remove the photo-sensitive film from the copper tracks with wire wool and drill the holes.
The ZX 81 is one of the most popular personal computers but it does leave a lot to be desired in certain respects, one of the most notable of which being its cassette interface. Any ZX 81 user who has had to type in a complete program again because it could no longer be loaded from cassette will confirm this. The pulse cleaner described here is designed to make such problems a thing of the past. This makes it a must not only for ZX 81 users but also for any other computer that uses a similar type of pulse/pause system for the cassette connection.

**ZX81 cassette pulse cleaner**

The Sinclair ZX 81's cassette interface uses frequency shift keying (FSK) with a single frequency. The signal is built up of a number of pulses, a pause, a number of pulses again, another pause, and so on (see figure 1a). The number of pulses between two pauses indicates the logic level: four pulses represent a logic zero and eight pulses are used to indicate a logic one. If this signal is stored on a cassette tape the 'digital' shape cannot be properly processed due to limitations in the recorder's electronics and the qualities of the tape itself. When the data is read from the tape it will enter the computer as a signal that looks something like that shown in figure 1b. The oscillation on the last pulse before a pause could cause the computer to falsely consider this as an extra pulse, with dire consequences. In order for the computer to be able to process it properly this signal should really be made into a digital signal with all the interference removed.

**The layout**

The various parts of the circuit are shown in the block diagram of figure 2. The incoming signal from the cassette recorder is first passed through an adjustable attenuator before being amplified and passed through a band-pass filter. This is followed by another amplifier and a high-pass filter. All this is necessary to remove any low frequency oscillations from the signal as the computer could interpret them as extra pulses. The filtered signal is then fed through a negative and positive peak rectifier. A Schmitt trigger compares these output signals with the signal from the high-pass filter to ensure that short noise pulses are also removed. The result is a clean digital cassette signal at the output. The output signal from the positive peak rectifier, incidentally, is also used to control the attenuator at the input.

**Figure 1.** These are the sort of pulses that appear at the ZX 81's cassette output (top). After processing by the cassette recorder the signal (bottom) does not look quite so 'clean'.

**Figure 2.** The circuit for the pulse cleaner, as the block diagram here shows, consists of some amplifiers and filters, a pair of peak rectifiers, a comparator section and an attenuator.
The circuit

The circuit diagram for the pulse cleaner is shown in figure 3. The input signal is first of all attenuated by preset P1 and then passes to the adjustable attenuator. The output of positive peak rectifier A2 determines the d.c. voltage at the base of transistor T1, which, in turn, decides the current passed through diodes D1 and D2 and therefore the impedance (or, strictly speaking, the differential resistance) of the diodes. When the output voltage of A2 is high the attenuation of the input signal will be correspondingly high. The moving coil meter in the collector line of T1 gives a visual indication of the strength of the signal.

The attenuator is followed by op-amp IC1 which amplifies the signal by a factor of eleven and then feeds it to the band-pass filter consisting of R4...R9 and C3...C8. The filtered signal is amplified by a factor of 100, by A1, to compensate for the attenuation introduced by the band-pass filter. The low frequency part of the signal is then removed by high-pass filter R12...R14/C11...C13 whose cut-off point is at about 9 kHz.

The treated signal is fed to the inputs of the two peak rectifiers, A2 and A3, and the non-inverting input of Schmitt trigger A4. Each rectifier consists of an op-amp with a diode at the output. A 22 n capacitor (C15 or C17) is charged to the maximum value of the input voltage via the diode, which is part of the op-amp's feedback loop. The 100 Ω resistors are needed to limit the charging current that the op-amps provide.

The output signals from the two rectifiers are added via resistors R19 and R21 and then go to the inverting input of A4. The other input of the Schmitt trigger, as we have already noted, is connected to the output of the high-pass filter so that A4 compares the rectifier signals with the differentiated cassette pulses provided by the filter. The output of the circuit is a clean rectangular waveform that can be fed directly to the ZX 81 cassette input.
**In practice**

Small though this circuit is we thought it worthy of a printed circuit board design. This is shown in figure 4. As the power supply is included on the printed circuit board the only external components are the transformer and, of course, the meter. The various connection points, input, output, meter and power, are all clearly marked. When everything is connected and mounted the two presets must be set. Calibrating and testing the circuit is done with the pulse cleaner connected between ZX 81 and cassette recorder. Now, while trying to load some (well recorded) programs from the cassette, trim preset P1 until all programs are received correctly.

When this is done set P2 so that the needle of the meter is in mid scale while programs are being loaded. The meter reading can be used as a reference point when loading programs. If the needle does not indicate mid scale P1 should be trimmed until the reference position is again indicated. In this way even programs that have been difficult to load in the past can now be loaded properly.

**Parts list**

- **Resistors:**
  - R1, R19, R21 = 22 kΩ
  - R2, R10, R16 = 1 kΩ
  - R3 = 10 kΩ
  - R4 = 150 kΩ
  - R5 = 470 kΩ
  - R6 = 1 kΩ
  - R7, R12, R17, 20 = 4.7 kΩ
  - R8, R13 = 15 kΩ
  - R9, R14, R23 = 47 kΩ
  - R11 = 100 kΩ
  - R15 = 470 kΩ
  - R18, R22, R24, R25 = 100 kΩ
  - P1 = 50 kΩ preset
  - P2 = 1 kΩ preset

- **Capacitors:**
  - C1, C9, C14 = 220 nF
  - C2 = 47 nF
  - C3 = 150 nF
  - C4, C20 ... C23 = 47 nF
  - C5 = 15 nF
  - C6, C11 = 10 nF
  - C7, C12 = 33 nF
  - C8, C13 = 1 nF
  - C10 = 390 pF
  - C15, C17 = 22 nF
  - C16, C19 = 100 nF
  - C18, C26, C27 = 1 µF at 16 V
  - C24, C25 = 470 µF at 16 V

- **Semiconductors:**
  - D1 ... D5 = 1N4148
  - D6 ... D9 = 1N4001
  - T1 = BC 550C
  - IC1 = LF 356
  - IC2 = TL 084
  - IC3 = 78L05
  - IC4 = 79L05

- **Miscellaneous:**
  - F1 = fuse, 50 mA slow blow
  - M1 = moving coil meter, ±250 µA f.s.d.
  - S1 = double pole mains switch
  - Tr1 = mains transformer, 2 x 9 V, 50 mA

Figure 4. The printed circuit board for the FSK pulse cleaner can be fitted into its own case or there may be room for it within either the computer or the cassette recorder.
A direct-coupled modem is the most reliable method of sending data via a telephone line that a computer user could hope for. It is not particularly easy to design a good and reliable direct-coupled modem but this is greatly simplified by using a dedicated modem IC. Using this IC, the AM7910, such a modem can be kept relatively small and inexpensive, as the design here shows. An important point about this modem is that it allows various different standards to be used, V21 and V23 being the ones that most concern us. The auto-answer facility enables the modem to receive messages without the computer user necessarily having to be present. The connection between modem and computer is made via an RS232 connector with V24 protocol and a modified connector for TTL levels.

**Type approval**

Quite understandably British Telecom want to be sure that any equipment connected to the telephone network meets a certain standard. For this reason modems, like other telecommunications equipment, must be submitted to the British Approval Board for Telecommunications before being connected to the telephone lines. At the moment the process of type approval is neither fast nor inexpensive but what will happen when BT is made private is anybody's guess.

In preparation for this project we published an article in last month's issue ('data transmission by telephone') to deal with the theory behind the connection of a modem to the telephone network. That article also dealt briefly with the AM7910 modem IC that is used in this project. Knowing that this IC is a 'single-chip modem' it may be surprising how many external components are needed to make it tick. All this is required for the two interfaces present and to generate and process the various signals used. In addition to this the modem must be able to receive the data even in the presence of interference and it must not itself generate any interference. We have, of course, designed this modem to the very highest standards but it must be noted here that, like any equipment connected to the telephone line, it must have type approval.
before it may be used.

The direct-coupled modem's superiority over its acoustically-coupled counterpart is easily stated: the chance of errors occurring during data transmission is much smaller. If you have ever had to spend hours debugging a program received via an acoustically-coupled modem it will soon seem that it might have been better to simply send a floppy disk in the post in the first case. As someone once said 'reliability is everything'.

Features

1. The modem can be switched to various different standards. The ones that most concern us are V21 and V23. As we noted in last month's article, V21 is the more common and has a 300 baud full-duplex operation. The V23 standard, on the other hand, is half-duplex with speeds of 1200 and 75 baud for the two channels. There are various other different standards possible with the AM7910 but, as we do not intend to use them, we will not deal with them here. Suffice it to say that they exist.

2. The auto answer facility means that the modem can accept data messages if there is nobody home. In order to do this the modem detects the bell signal and then it looks to see if there is actually another modem at the other end of the line. If not it simply 'hangs up'.

There are two input connectors: one RS232 with V24 protocol and a modified RS232 that operates with normal TTL levels. These two connectors make it possible to send and receive at a speed of 1200 baud. Signals for the 75 baud back channel are automatically converted to this low speed by the modem circuit and later reconverted. During this conversion the appropriate wait signals are, of course, sent to the computer.

3. The complete transmitter and receiver sections, including all the necessary filters, are contained in the AM7910. The great advantage of this is that the modem needs no calibration.

The actual circuit

The basics of the circuit are seen in the block diagram of figure 1. The heart of the modem is the AM7910 IC, which takes care of all the data transfer. All the other blocks are for what could be called extras.

- Transmitted carrier, pin 8. The modulated signal that is to be transmitted is found at this pin.
- Received carrier, pin 5. This is the input for the incoming analogue signal that must be processed by the modem.
- RING, pin 1. If this input is made '0' and DTR is also '0' the IC transmits a reply tone via TC to find out if is is being called by another modem.
- RESET, pin 3. A reset pulse is fed to this input from an RC network as soon as the power is switched on.
- XTAL1, pin 24. As could be expected, this pin is the clock input for the IC. The clock signal is supplied by the crystal oscillator based on T1 and operating at a frequency of 2.4576 MHz.
- MCO, MCI, MC2, MC3 and MC4, pins 17, 18, 19, 20 and 21 respectively. These inputs are used to enable the mode to be selected from the 32 different Bell or CCITT specifications available. A summary of these possibilities is given in table 1. In this modem we will only use the CCITT V21 and V23 modes so only MCO and MCI are connected to the 'switching logic'.

The normal communication between the AM7910 and a computer (or terminal) is conducted via the following pins:

1. Data terminal ready, pin 16. This signal indicates that the terminal is ready to work with the modem. As long as the terminal and modem are communicating with one another this signal must be low.
2. Request to send, pin 12. This indicates that the modem must switch to send mode. While data is being sent this input must remain low.
3. Back request to send, pin 11. The back channel (in V23 mode) must also be switched to send, by means of this pin.

Figure 1. The heart of the modem is the AM7910 IC, which takes care of all the data transfer. All the other blocks are for what could be called extras.
Figure 2. Our 'single-chip modem' (IC1) needs quite a number of extra components to take care of interfacing, selecting different modes, baud rate conversion and so on.

This input is not, however, used for V21 mode. Note that RTS and BRTS may never both be low at the same time; in our circuit this is prevented by linking pin 11 to pin 12 via an inverter.

- Clear to send, pin 13. After the terminal has given an RTS signal this input goes low to indicate that the modem is ready to begin transmission.

- Back clear to send, pin 14. This pin has the same function as CTS except that it is for the back channel in V23 mode.

- Transmitted data, pin 10. The data that must be transmitted is presented to this input.

- Back transmitted data, pin 28. Data that must be sent via the back channel is fed to this input. This is only possible in
Table 1

<table>
<thead>
<tr>
<th>MC4</th>
<th>MC3</th>
<th>MC2</th>
<th>MC1</th>
<th>MC0</th>
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<td>0</td>
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<tr>
<td>Bell 103 Orig loopback</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bell 103 Ans loopback</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bell 202 Main loopback</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bell 202 with equalizer loopback</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCITT V.21 Orig loopback</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCITT V.21 Ans loopback</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCITT V.23 Mode 2 main loopback</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCITT V.23 Mode 2 with equalizer loopback</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCITT V.23 Mode 1 main loopback</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCITT V.23 Bäck loopback</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2

<table>
<thead>
<tr>
<th>RS232/V24</th>
<th>TTL-port</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitted Data</td>
<td>2</td>
</tr>
<tr>
<td>Received Data</td>
<td>3</td>
</tr>
<tr>
<td>Request to Send</td>
<td>4</td>
</tr>
<tr>
<td>Clear to Send</td>
<td>5</td>
</tr>
<tr>
<td>Data Set Ready</td>
<td>6</td>
</tr>
<tr>
<td>Signal Ground</td>
<td>7</td>
</tr>
<tr>
<td>Data Carrier Detect</td>
<td>8</td>
</tr>
<tr>
<td>Back channel Data</td>
<td>12</td>
</tr>
<tr>
<td>Carrier Detect</td>
<td>13</td>
</tr>
<tr>
<td>Back channel Clear</td>
<td>14</td>
</tr>
<tr>
<td>to Send</td>
<td></td>
</tr>
<tr>
<td>Back channel</td>
<td></td>
</tr>
<tr>
<td>Transmitted Data</td>
<td></td>
</tr>
<tr>
<td>Back channel</td>
<td></td>
</tr>
<tr>
<td>Received Data</td>
<td></td>
</tr>
<tr>
<td>Data Terminal Ready</td>
<td></td>
</tr>
<tr>
<td>RS232-TTL port</td>
<td></td>
</tr>
<tr>
<td>switching</td>
<td></td>
</tr>
<tr>
<td>Busy signal during</td>
<td></td>
</tr>
<tr>
<td>1200 to 75 Baud</td>
<td></td>
</tr>
<tr>
<td>conversion</td>
<td></td>
</tr>
</tbody>
</table>

V23 originate mode, otherwise BTD must be '1'.

- Received data, pin 26. The data received by the modem is available at this output.
- Back received data, pin 15. Data received by the modem on the back channel in V23 answer mode is available at this output.
- Carrier detect, pin 25. When the carrier wave is present at the input of the modem this pin is low.
- Back carrier detect, pin 27. This pin has the same function as CD except that in this case the carrier is received on the back channel in V23 answer mode.

The RS232 section of the circuit is seen at the upper left-hand side of the circuit diagram, complete with the 28 pin D-type connector. Details about both connectors (K1 and K2) are contained in table 2. Some of the pins (2, 4, 14 and 20) are connected to IC1 via an RS232 to TTL-level converter (R3...R6, D3...D6) and four three-state inverting buffers (to convert to the active low levels required). Signals from IC1 to the RS232 connector are inverted and converted to RS232 levels by op-amps A1...A6. There is no need for any level conversion in the case of the second connector but four three-state buffers are included after the inputs, pins 1, 2, 9 and 10. Remember that the output pins in the TTL connector have exactly the same signals as the outputs of IC1 and some of these are active low. Note that pin 3 in the TTL connector must be connected through to pin 8 (ground). When a connector is inserted into this TTL socket the input signals are fed to IC1 via N17...N20 and three-state buffers N13...N16 make the RS232 inputs high impedance. If both connectors are inserted into the modem K2 (the TTL connector) will therefore always have priority. When the UART, IC19, is converting a character from 1200 to 75 baud pin 7 of K2 feeds a busy signal ('0') to the terminal so that it will not transmit any new data. As soon as the transmitter buffer is empty TBMT (pin 22) goes high. The four LEDs are used to indicate various conditions: main channel carrier present (D1), back channel carrier present (D2), incoming data on main channel (D3) and incoming data on back channel (D4). The baud rate converter, formed by IC18, IC19 and ES1...ES8, is only used in V23 mode. The clock signal provided by TI is reduced to frequencies of 19,200 Hz (output Q7 of the 4040) and 1200 Hz (output Q11). These frequencies are sixteen times as high as the transmission rates of 1200 and 75 baud because the UART needs a clock frequency sixteen times as high as its transfer rate. The electronic
direct-coupled modem
elekter october 1984

switches are used to ensure that the data travels in the right direction. When a back carrier is detected the 1200 Hz clock is used for inputting data and the 18,500 Hz clock for outputting data. The back channel data is fed to the serial input of the UART, whose serial output goes to the "back transmitted data" line in the two connectors. Characters are therefore input via the back channel at 75 baud and output at 1200 baud on the main channel. Data may also travel in the other direction on the two channels if the two clock connections as well as the serial input and output are interchanged. The 1200 baud data that the terminal wants to send on the back channel is now converted to 75 baud data by the UART. While it is doing this IC19 feeds a busy signal to pin 7 of the TTL connector. This conversion works for both connectors and has the great advantage that the terminal need only work with data at 1200 baud. This whole conversion section is not used at all when the modem is operating in V21 mode.

The next section we will deal with is the switching logic based around S1. Using this switch MCO or MCI or both can be grounded. This gives a choice of four different modes: 300 baud originate, 300 baud answer, 1200 baud originate and 1200 baud answer. LEDs D10...D13 indicate which mode has been selected. For 1200 baud transmission and reception only MCO is zero. The change from transmission to reception, or vice versa, is made by switching the RTS and DTRS level (via N8, N31 and N9). Whenever a new switch position is selected the circuit around A7 and N30 supplies a short pulse to the DTR input of IC1 in order to reset this chip.

The bell detector section, which also takes care of the switching between telephone and modem, is quite extensive. The transmit and receive inputs of the AM7910 are connected to transformer T1. Although outgoing TC signals do not pass through IC22, incoming signals are amplified by this op-amp before being passed through to RC. The other winding of the transformer is connected to the telephone network via relays Rel and Re2. In the output mode (when neither relay is operated) the telephone is linked to the line connection. Part of the reason for this set-up is to enable the telephone to be used normally when the modem is switched off. Whenever the power is switched on flip-flop FF2 is reset with the result that the selector circuit (N4...N6, N21, N22, N26, N27 and MMV2) will automatically select the 'telephone' position and neither relay will be operated. A relay can then only be operated when a different position is selected with switch S2. When this happens N22 triggers MMV2 and this monostable then sends a set pulse to FF2 causing it to deselect the obligatory ('telephone') position. If the 'modem' position is selected R1 is operated via N5 so the telephone is disconnected from the line. At the same time FF1 is set and Re3 is then operated.

### Parts list

| Resistors: | C4 = 10 µ/6 V |
| R1...R6,R11...R15, R21...R27,R31...R45, R56,R60,R61 = 4,7k |
| R7,R8,R13...R33, R49 = 220 Ω |
| R9 = 680 Ω |
| R10 = 120 k |
| R16,R50 = 1 k |
| R17,R18 = 2.6 k |
| R19,R20,R40,R41 = 22 k |
| R28 = 18 k |
| R29 = 15 k |
| R30 = 1 M |
| R34,R57,R58 = 2k2 |
| R35 = 100 Ω |
| R36 = 33 k |
| R37,R38,R46...R48, R51 = 100 k |
| R39 = 330 Ω |
| R42 = 39 k |
| R43,R44 = 8k2 |
| R52 = 4M7 |
| R53 = 82 k |
| R54 = 470 k |
| R56 = 56 k |

| Capacitors: | C1 = 4µ/6 V |
| C2, C3 = 470 n |
| C4,C15,C27,C28, C31...C35 = 100 n |
| C5 = 10 n |
| C6,C7,C16,C17 = 1 n |
| C9 = 39 p |
| C10 = 120 p |
| C11...C13 = 47 p |

### Semiconductors:

| D1,D2,D7...D13, D19...D21 = LED, 3 mm |
| D3...D6 = 4V7/400 mW |
| D9,D14...D18, D22...D24,D27,D28,D31, D38,D39 = 1N4148 |
| D40 = AA119 |
| D25,D26 = 5V6/400 mW |
| D29,D30 = 27 V/400 mW |
| D32...D37 = 1N4001 |
| T1 = BC547B |
| T2 = IN4001 |

### Miscellaneous:

| F1 = fuse, 500 mA, complete with PCB-mounting fuse holder |
| K1 = 25-pin D-type connector, female 90° |
| K2 = 18-pin D-type connector, female 90° |
| L1 = coil, 10 µH |
| Re1,Re2 = miniature 5 V relay |
| Tri = mains transformer, 8 V/375 mA |
| T1 = line transformer, type VLL3719 |
| X1 = crystal, 2.4576 MHz |

# Case

- [Relex Elbox RE 3](https://www.loop-definition.com)
- [Heatsink for IC14](https://www.loop-definition.com)
- [kV telephonic plug and socket](https://www.loop-definition.com)
via N7. The line is then connected to Tr2 and the modem can operate via the telephone network. In the 'auto' position only Re1 is operated (via N5) and in this case the line is linked to opto-coupler IC13 via R11, C18, D28 and D30. The telephone is now switched off but if a bell signal (about 75 V a.c. at 25 Hz) is detected the LED in the opto-coupler lights and causes the photo transistor to conduct. As long as the bell signal is present for at least the RC time of R55 and C19 MMV3 will be triggered. This feeds a clock signal to FF1, which, in turn, operates relay Re2 to connect the modem to the line. At the same time the modem receives a RING signal via N35 so IC1 initiates a procedure to find out if there is another modem connected to the line. If the carrier disappears in the course of a transmission this is detected by the action of N25, MMV1, FF3, FF4 and MMV4. If the carrier is absent for more than about a half second, or if the second modem does not transmit any carrier at all, the connection is automatically broken.

The power supply section is unremarkable. A pair of voltage regulators provide the necessary + and -5 V. Note that the transformer in the power supply will become warm in use; this is quite normal and nothing to become alarmed about.

Construction

Great care should be exercised when building this modem as it will be connected to the telephone network. The component overlay shown in figure 3 indicates where everything should be fitted, in the usual order. The relays are soldered directly to the printed circuit board. When all the components have

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Figure 3. The printed circuit board for the modem is quite crowded but this does help keep the size small. The actual layout of the copper tracks is not shown here as the board is only available as part of a kit.
been mounted on the board the case must be prepared. If the LEDs are fitted directly into the front panel each will require a hole of 3 mm diameter. If clips are used the holes should be 4.5 mm diameter. Suitable holes must also be drilled for the rotary switch spindles. The diameter will depend on the type of switch used. A number of holes and slots must be cut in the back of the case for the mains cable, telephone cable, two connectors and mains switch. The old carpenter’s maxim of ‘measure twice and cut once’ is very appropriate here. After sticking the adhesive front panel to the case the LEDs and rotary switches can be fitted. There is no difficulty in wiring switch S2 as this is simply a matter of connecting it to points 10, 11, 12 and + on the board. The anodes of LEDs D19, D20 and D21 are linked together and this junction is then wired to point 9 on the board. The cathodes are connected to points 6, 7 and 8 respectively. Wiring S1 requires slightly more attention. The contacts of the switch must be connected to points 2, 3, 4 and 5 and to the cathodes of LEDs D10…D13, and the common pole is connected to ground. The anodes of the remaining four LEDs, D1, D2, D7 and D8, are first linked together and this common point is then fed to the + point on the board. The cathodes connect to points D1, D2, D7 and D8.

The mains cable can now be connected, via S3, to the board. The power can then be switched on and the voltages checked. If both positive and negative 5 V supplies are correct the power can be switched off again and the ICs (with the exception of ICl) inserted into their sockets. When the power is switched on again the ‘telephone’ LED beside the leftmost switch lights, and only when the switch is operated will a different LED light to indicate the position selected. The logic levels appearing at pins 17 and 18 of ICl can be measured at S1 for the four positions that can be selected. The table in the margin here indicates what the levels should be. If this is correct the power can be switched off again so that ICl can be inserted into its socket. Be careful when doing this as the AM7910 is an expensive IC and it can easily be damaged by static. Connect a telephone to the ‘line’ connection and select ‘MODEM’ with S2. (The white and blue wires in the telephone cable are connected to the points marked ‘phone’ on the board and the red and green wires go to the points marked ‘line’.) If S1 is now switched a peep tone should be heard (after a few seconds delay) for each of the four positions. The ‘AUTO ANSR’ position is then selected with S1. Link pins 4 and 5 of ICl3 (the opto-coupler) via a 1 k resistor and a tone should be heard for about 10 to 15 seconds. This should happen for all positions of S2. The tone’s pitch varies gradually but this may not be noticeable in all positions. ‘MODEM’ is again selected and pin 2 of the RS232 connector is connected to −5 V. A change in pitch should be heard. This applies for the two 300 baud and the 1200 baud answer positions. For 1200 baud originate pin 14 is connected to −5 V via a 1 k resistor instead and this pin is then touched with a finger. Finally pin 20 is connected to −5 V and then no tone should be heard. If all these tests are correct then you can assume that the modem is working.

The operation of the circuit can be more carefully checked using an oscilloscope. To measure the output voltage start by disconnecting the modem from the telephone and connect a load of 600 Ω (560 Ω in series with 39 Ω) across the ‘line’ terminals. There should be an a.c. voltage of 275 mVrms across this load. Next test to see if the right frequencies are being produced:

| V21 ORIG: space = 1180 Hz | mark = 980 Hz |
| V21 ANSR: space = 1850 Hz | mark = 1650 Hz |
| V23 ORIG: space = 450 Hz | mark = 380 Hz |
| V23 ANSR: space = 2100 Hz | mark = 1300 Hz |

The frequency of the reply tone (except for V21 ORIG, which does not give any reply tone) is always 2100 Hz. The start-up cycle can easily be followed on the oscilloscope: first there is 1.9 s of silence, then a reply tone for 3 s and then the mark or space tone.

The modem can now be placed into its case and the wiring tidied up but do not close it just yet. The DIL switches still have to be set: refer to table 3 to find the correct settings.

Using the modem

One point we have not yet mentioned is the communication between computer and terminal, which is very important because if this is not correct there is no way data can be transferred properly. This presupposes that the connection between computer and terminal will be a serial one. With a real terminal this is taken into account so all that is needed is an RS232 cable as the necessary communication software will already be available. The

Table 3. A number of different character formats can be selected using DIL switches S4 located beside the UART chip (IC19).

<table>
<thead>
<tr>
<th>Switch</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td>Parity</td>
</tr>
<tr>
<td>c</td>
<td>Number of bits per character</td>
</tr>
<tr>
<td>b</td>
<td>Number of stop bits</td>
</tr>
<tr>
<td>e</td>
<td>Number of stop bits</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Switch</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0 = odd parity</td>
</tr>
<tr>
<td>1</td>
<td>1 = even parity</td>
</tr>
<tr>
<td>0</td>
<td>0 = parity bit present</td>
</tr>
<tr>
<td>1</td>
<td>1 = no parity bit</td>
</tr>
</tbody>
</table>

Table 3

<table>
<thead>
<tr>
<th>Switch</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Parity</td>
</tr>
<tr>
<td>b</td>
<td>Number of bits per character</td>
</tr>
<tr>
<td>c</td>
<td>Number of stop bits</td>
</tr>
<tr>
<td>d</td>
<td>Number of stop bits</td>
</tr>
<tr>
<td>e</td>
<td>Number of stop bits</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Switch</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0 = odd parity</td>
</tr>
<tr>
<td>1</td>
<td>1 = even parity</td>
</tr>
<tr>
<td>0</td>
<td>0 = parity bit present</td>
</tr>
<tr>
<td>1</td>
<td>1 = no parity bit</td>
</tr>
</tbody>
</table>
Elektor universal terminal described in the November 1983 issue is an example of this. There is another possibility if you have a computer with an RS232 interface. The computer's handbook should advise about the signals present at the various pins of the RS232 connector and the software used to drive the interface. Some computers with an RS232 interface even allow operation at 1200 and 75 baud, which does away with the need for the baud rate converter in the modem. In this case IC16...IC19 can be removed and wire bridges can be used to connect pins 2 and 3 and also pins 9 and 10 of the IC16 socket. Some computers, unfortunately, do not have any serial connector so for these computers the only thing to do is to make a parallel port and write a small machine code program to control it. We will deal with this latter point in a very general sense to give an idea of how to go about writing this routine but each user will have to 'tune' our ideas to suit a particular machine. If this seems like a daunting task you may be lucky enough to find somebody in your computer club or user's group who already has such a routine. It may be better in any case to use an existing program if it is available as it is very important to standardise as much as possible when transmitting data over the telephone lines.

The first thing to decide is what format the character will have. The most common format uses 8 data bits for the character, preceded by a start bit (which is always '0') and followed by a stop bit (which is always '1'). If no data is being transmitted there is always a '1' on the line. The build-up of this sort of character is shown in figure 5, from which it is clear that bit 0 is transmitted first and bit 7 (the highest bit) last. In the Elektor modem transmission rates of 300, 1200 and 75 baud are possible. Other points to note are:

- Use a parallel I/O port on the microprocessor (and remember to connect pin 3 of the modem's TTL port to ground, pin 8).
- Initially the control signals are not used. The modem itself switches automatically to 'transmit'.
- One bit in the port is used as serial input and one bit is used as serial output.
- At the modem side the TTL-compatible port is used.
- The serial to parallel and parallel to serial conversions are carried out by means of a few software loops (with the necessary shift operations).
- It may prove advantageous to introduce a small change into the system to jump to an interrupt routine whenever a start bit appears. This is can be particularly useful in conjunction with scrolling.
- Ensure that the bytes read in are written to the correct memory locations.
- The output driver often ends with a RAM memory address and a RETURN. The address of the modem output driver is then stored at the position indicated by this return.
- The stop bit must not be used for test purposes as this costs too much processor time.
- Not all terminals can work with full-duplex but as long as this is taken into account at both ends of the telephone line it is not a problem.

These are the basic guidelines to keep to when writing the machine code routine. We have purposely not dealt with certain points such as recognising specific terminal commands as these are not necessarily standard. Note, however, that the busy line in the TTL port can be used when the UART is making a conversion from 1200 to 75 baud. An alternative for the parallel to serial conversion is to use an ACIA just as the 6851 was used in the CPU card published in Elektor in November 1983.

This sort of terminal or modem program can be as basic or as extensive as any particular user wants provided both sides of the line keep to the same protocol. Deciding this protocol within a user's group will make standardisation of programs for any processor much easier and will facilitate the exchange of data.
The advances in electronics and, in particular, the push towards ever greater miniaturisation means that our lives are becoming more and more filled with battery-powered radios, clocks, cassette recorders, calculators and so on. It is very often a matter of guesswork to know how long the batteries will last as it is not possible to estimate a dry cell's capacity simply by looking at it. This battery meter simplifies matters considerably and, as it has been kept as uncomplicated as possible, the price is low enough to make this circuit a very attractive proposition.

**battery meter**

indicates the approximate capacity of a dry cell

The more battery-powered equipment we use the more difficult it becomes to remember how old all the various batteries are. All the various aspects of Murphy's Law come into the equation and just in the middle of an important recording the batteries in your cassette recorder give up the ghost. (The law of conservation of energy immediately starts working, of course, with you rushing around trying to find some good batteries thereby compensating the universe for the energy no longer supplied by the batteries.)

With all due respect for the Laws of Life it is a bit annoying not knowing the capacity remaining in a battery. A battery 'contents' meter is what is needed but this is not quite as simple to implement as it might appear at first sight. The first thing that must be determined is how the battery capacity is measured.

Looking for an answer to this question we note that batteries can be divided into two broad types. The first type consists of batteries that supply an almost constant voltage during their whole life. Examples of this type are lithium, mercury and silver oxide batteries, all of whose voltage drops so little (about 0.05...0.11 V) that it is virtually impossible to measure the remaining capacity as a function of the output voltage. Other methods are too complicated to enable a measurement to be made quickly so we must conclude that there is no simple way to estimate the contents of these batteries. This type of battery is used mostly in watches, calculators and cameras and, as the leakage is so small (only a few percent per year), it is probably best to leave the battery in the equipment until it fails and keep a replacement close at hand.

The second group of batteries includes the carbon zinc and alkaline manganese types, the first of these being much cheaper and more common. Most 'normal' batteries sold in the shops are carbon zinc types but recently the alkaline manganese types have been gaining popularity. The reason for this is that they last longer, which, the consumer hopes, makes up for the higher price. Both of these types display a marked voltage drop during their lifetime and this fact can be used to determine the capacity remaining in the battery. To do this we need a voltage meter that can provide fairly accurate measurements in the range of 1...1.5 V (per cell) and a suitable load (in the form of a resistor). This resistor is necessary to enable the terminal voltage of the battery to be determined at any point in its life, knowing that the internal resistance increases with decreasing capacity.

The meter

As we stated at the beginning of this article the layout of this circuit is very simple. The method used does not give a perfectly accurate indication of the remaining capacity, but this was never the intention and it is hardly needed considering that the batteries in question are themselves not very accurate. Furthermore, accepting this slight 'imperfection' makes our task much easier. The circuit for the battery meter is shown in figure 2. The load for the battery to be measured is provided by resistors R1...R6. The load current is based on the IEC's so-called radio test. This gives about 20 mA for HP11, HP7, 'duplex' and 'normal' types, 40 mA for HP2
and about 10 mA for a PP3 9 V power pack. Alkaline manganese batteries are now being offered as an inexpensive alternative for silver oxide types so our meter includes a position (with a load current of 1 mA) to enable these cells to be tested. The meter section consists of M1, D1...D6 and R7...R11. A normal 100 µA f.s.d. moving coil meter is used for M1. A single diode (D1) and resistor (R7) are in series with the meter when measuring 1.5 V batteries. With the values shown the meter deflects fully at a voltage of about 1.6 V. The diode provides a threshold so that the measuring range of M1 lies from 0.6 to 1.6 V. This suits our purpose admirably as the voltages that interest us are from 1.5 V down to 0.8 V. This latter value is generally held by the battery manufacturers to signal the end of an alkaline manganese cell's life; the corresponding value for carbon zinc is 0.9 V.

This range may seem to be a bit limited given the different batteries we need to measure but the difficulty is overcome by 'spreading it' over almost the whole meter range. Different battery types are catered for by changing the resistance (from a minimum of 6kΩ, R7 only, up to a maximum of 49kΩ, R7...R11) and the number of diodes in series with this (from one, D1, up to six, D1...D6). The result of this is to change the effective range of the meter; so it always shows a relative value (the 'contents' of the battery) rather than an actual one (the battery voltage).

Without a scale the meter is useless, so a scale suitable for M1 is given in figure 3. The white section indicates that the battery still contains more than half of its maximum capacity, grey shows that the battery is between half and completely empty and a reading in the black end of the scale can mean only one thing: the battery is flat. Two scales are shown: one for carbon zinc and the other for alkaline manganese. For those of you interested in specific values, we classify 'half full' as 1.3 V for carbon zinc and 1.2 V for alkaline manganese. The 'empty' points are 0.9 V and 0.8 V respectively.

The battery meter is as simple to use as it is to make: connect the battery to be measured to the circuit's terminals and see if the meter deflects. If not either the battery is flat or its polarity is incorrect. In the latter case M1 is protected by D1. If the meter does deflect the test button must be pressed to connect the load across the battery. The reading on the meter then clearly shows the remaining capacity of the battery.

Figure 2. As the whole purpose of this circuit is to economise on 'battery expenditure' its price must be low enough to be quickly recovered. The meter is, in fact, the most costly component. Incidentally all empty batteries are harmful to the environment so they should be disposed of in the right place.

Figure 3. This scale should be used for the meter. The upper section is for carbon zinc batteries; the lower for alkaline manganese types.

Note: more information about batteries can be found in infocard 62.
Nobody can seriously claim that the continuing progress in the field of electronics and computers is neither necessary nor useful. Progress rarely comes without any drawbacks, however, and, particularly as regards computers, this often manifests itself as new equipment not retaining compatibility with older machines or standards. One of the most frustrating aspects of this incompatibility is the difficulty encountered when trying to use some peripheral equipment with a computer where one of these has a parallel and the other has a serial port. This interface is designed to counter just this difficulty, thus making it easy to interconnect an RS232 and a Centronics port.

RS232 / Centronics converter

Characteristics
RS232 — Centronics converter with handshake signals.

Parallel to serial mode
- buffered Centronics input
- 8 data lines
- Strobe/Busy/Acknowledge
- RS232 0 V/5 V or -12 V/5 V output
- Data Terminal Ready input

Serial to parallel mode
- RS232 0 V/5 V or -12 V/5 V input
- Data Terminal Ready output
- buffered Centronics output
- Strobe/Busy/Acknowledge

Format of the serial data
- 5, 6, 7 or 8 data bits
- parity enabled/disabled
- 1 or 2 stop bits
- error signals (parity, format and overflow)

Transmission speeds
- Two different speeds can be used during simultaneous parallel to serial and serial to parallel conversions.
- 75 - 109.9 - 135 - 150 - 200 - 300 - 600 - 1200 - 1800 - 2400 - 3600 - 4800 - 7200 - 9600

The value of this parallel to serial and serial to parallel converter will be obvious from the list of characteristics given in the table here. A look at figure 1 shows that most of the various parts and functions are fairly self-evident so we will concentrate instead on a number of specific points.

Points to note
The serial output (pin 2 of the RS232 connector) and the DTR output (Data Terminal Ready, pin 20 of the RS232 connector) are switched by normal current sources (T1 and T2). Their low logic level can be changed by the user to suit the peripherals in use. (We will return to this point later.)

The DTR output is controlled by flip-flop N23/N24, which itself is fed by the DAV output signal (pin 19 of IC3) and the Centronics ACK or BUSY signals. In this way the flip-flop alternately indicates that the serial to parallel converter cannot receive any new information and then, after the converted data has been accepted by the Centronics peripheral, that the converter can again accept serial data. The format of the data during transmission (number of data bits, stop bits, etc.) can be programmed by means of switches S1...S5. Any errors detected during the conversion are indicated by LEDs D12...D14.

Glancing at figure 1 we notice input buffers N1...N9 and output buffers N10...N18 for the Centronics interface; figure 1b shows the oscillator used to generate the various different transmission speeds. To get a clear idea of the operation of the converter it is essential to study the internal structure of the AX3-1015 UART (IC2) so we will have a quick look at that.

The basic blocks making up the UART are shown in figure 2. There is a block...
marked transmitter (parallel to serial) and one called receiver (serial to parallel), each of which is separate and distinct from the other. The clock signals to these two sections can even be at completely different frequencies so the converter could also speed up or slow down the transmission rate (as we will see later). The data strobe signal (DS) causes the parallel data to enter the transmitter's input buffer, from where it is passed on to a shift register to start the conversion. Even before the conversion is complete the input buffer is freed so it can accept another 'word' of parallel data. The receiver, on the other hand, receives serial data into its shift register (even if the output buffer still contains the data from the previous conversion). The parallel data is transferred from the input shift register to the output buffer only at the end of the conversion, during the first stop bit, actually. After this transfer has been completed the UART sets the DAV (Data AVailable) line high to indicate that the parallel data is now present at the output.

The parallel to serial conversion
The process of the conversion is shown in figure 3. When the Centronics interface's data strobe line STR goes low the eight parallel bits are loaded into the input buffer and the TBMT (Transmitter Buffer eMptY) line goes low to show that the UART cannot receive any more parallel data for the time being. This makes the Centronics BUSY line go high. The output shift register is empty so the data can be transferred there immediately. The conversion then starts; the TBMT line returns high as soon as the input buffer becomes empty and can receive new data. The BUSY line goes low again, taking the ACK.
Figure 1b. Although we are particularly interested in the internal structure of the UART used in this circuit, the oscillator, on the other hand, has little to attract our attention. Purely as an aside, note that the quartz oscillator frequency (F16) and half this frequency (F15) are present on pins 18 and 19. We do not, however, use either of these in our circuit.

Figure 2. A look at the innards of the UART (Universal Asynchronous Receiver/Transmitter) shows the presence of two autonomous sections: one for the parallel to serial conversion and the other for the serial to parallel conversion.

The serial to parallel conversion
Serial data reception starts as soon as the SI (Serial In) line first goes from high to low. Note, however, that the UART will recognize this as a start bit only if it lasts for at least a half bit. This high to low tran-
sition of SI resets the DAV output line to zero via the RDAV line. This is necessary to ensure that after conversion the serial data can be transferred from the input shift register to the parallel output buffer, which must therefore be empty. To call the output buffer 'empty' is a bit of a misnomer, in fact, as it is never actually empty. What is important is that the previous converted data, which is still present there, has already been read by the peripheral. The Centronics protocol demands that the peripheral signal when it has received data by means of a high to low transition on either the BUSY or the ACK line. The timing chart of figure 4 shows that the conversion is started as soon as the first stop bit is received. The UART’s DAV line then goes high and activates the strobe output, STR, on the Centronics interface. The RS232’s DTR output line goes low, via flip-flop N23/N24, to signal to the source of the serial information that the previous data converted has not yet been loaded by the ‘object’ equipment. When this latter equipment does read the parallel data a falling edge appears either on the BUSY or the ACK line and flip-flop N23/N24 toggles. The DTR output line goes high again and this indicates that the converter is ready to receive more serial data. Note in passing that the DAV line could be reset by applying the falling edge of BUSY or ACK to RDAV instead of using the SI line for this.

If the DAV line has not been reset when the new serial data is transferred from the shift register into the output buffer the UART signals a pile-up of data by activating the OR (Over-Run) output. In our circuit the RDAV line is always activated by the new data’s start bit and flip-flop N23/N24 toggles. The DTR output line goes high again and this indicates that the converter is ready to receive more serial data. Note in passing that the DAV line could be reset by applying the falling edge of BUSY or ACK to RDAV instead of using the SI line for this.

If the DAV line has not been reset when the new serial data is transferred from the shift register into the output buffer the UART signals a pile-up of data by activating the OR (Over-Run) output. In our circuit the RDAV line is always activated by the new data’s start bit and flip-flop N23/N24 toggles. The DTR output line goes high again and this indicates that the converter is ready to receive more serial data. Note in passing that the DAV line could be reset by applying the falling edge of BUSY or ACK to RDAV instead of using the SI line for this.

The PE (Parity Error) output of the UART goes high whenever the receiver detects a parity error. If the NP (No Parity) line is high (S5 open), in which case there is neither an odd nor even parity bit, the PE output remains permanently low. The FE (Framing Error) output goes high if the receiver does not receive a valid stop bit.

<table>
<thead>
<tr>
<th>S2</th>
<th>S3</th>
<th>number of data bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>open</td>
<td>closed</td>
<td>5</td>
</tr>
<tr>
<td>open</td>
<td>open</td>
<td>6</td>
</tr>
<tr>
<td>open</td>
<td>closed</td>
<td>7</td>
</tr>
<tr>
<td>open</td>
<td>open</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 1: Obviously, these error signals only apply for serial input data. Programming the format of the serial data (with S1...S5, see table 1), on the other hand, applies for both reception and transmission. An interesting point about this programming is that it can be done either manually, with the switches, or via the output port of a microprocessor. The logic levels on lines EPS, NB1, NB2, TSB and NP are valid when the CS line (pin 34) goes high (in our case it is connected permanently to +5 V).

Construction and use

Having seen the protocol involved in this project, it is now time to deal with the actual hardware. When building the circuit on the board shown in figure 5 remember to interconnect the two points marked A, one between C1 and C3 and the other beside IC5. There are two possibilities for R30...R38: either an SIL...
Parts list

Resistors:
R1, R3, R6, R9, R15, R17, R19...R21 = 10 k
R2 = 1 M
R4, R25...R29 = 4 k7
R5 = 470 Ω
R6, R12 = 22 k
R7, R13 = 8 R2
R8, R14 = 1 k
R10, R11, R16, R18 = 47 k
R22...R24 = 220 Ω
R30...R38 = 47 k (may also be a single 9 x 47 k SIL resistor network)

Capacitors:
C1 = 10 µ/16 V
C2, C6, C8 = 100 n
C3 = 47 µ/16 V
C4 = 1 n
C5 = 10 n

Semiconductors:
D1...D11 = 1N4148
D12,...D14 = LED, red
T1, T2 = BC5578
T3...T5 = BC6478
IC1 = MC14411 (Motorola)
IC2 = AY-4-1015 (see text)
IC3...IC5 = 4050
IC6 = 4049
IC7 = 4093

Switches:
S1...S5 = 8-way DIL switch (3 ways unused)
S6 = double-pole toggle switch
S7, S8 = single-pole 12-way wafer switch

Miscellaneous:
X1 = quartz crystal, 1.8432 MHz
1 off 25-pin D-type (RS232) male connector
1 off 25-pin D-type (RS232) female connector
2 off 26-pin male sockets (for female ribbon cable connector)

Figure 5. All the components from figures 1a and 1b are fitted to the same printed circuit board, except for the two rotary wafer switches. These are not needed if a fixed baud rate is used, in which case it will be necessary to connect points RCP and TCP to the appropriate output of IC7 by means of a short length of wire.
network or nine discrete resistors with one common side simply connected together in the air and with a separate wire to the board. Similarly, diodes D12...D14 have their anodes commoned and connected to +5 V. Be careful with the wiring of switch S6; when S6a is open S6b must be closed, and vice versa. The serial data input (‘3’ on the diagram of figure 2) is called S6b on the component overlay for the printed circuit board; this is, in fact, the common pole of switch S6b. The current consumption is about 50 mA (at +5 V) and this may possibly be drawn from certain Centronics outputs (refer to your user’s manual). The -12 V is only needed for serial output signals where the receiver is unable to distinguish between ground potential and the logic level defined as zero volts. In that case a wire bridge will have to be used to join R to T (instead of R to S). Inputs SI and DTR are just as happy with logic levels between 5 V and 0 V as between 5 V and -12 V. There are various ‘equivalents’ or predecessors of the AY-3-1015, such as the AY-3-1013 or MM5303, that could also be used in this circuit provided the -12 V is applied to their pin 2.

Should you wish to modify or add to this circuit it may be useful to note that there are two unused Schmitt trigger NAND gates and a buffer in IC6 and IC7. Now that the circuit has been built all that remains is to learn how to use it. The three fundamental ways of using the converter are indicated by figure 6. In figure 6a a computer transmits serial data to a printer with a parallel input. The numbers given correspond to those for a D-type connector on an RS232 interface and for a Centronics interface. In figure 6b it is the printer that has a serial input while the computer has a parallel output. If the clock signal (sixteen times the frequency for the desired transmission rate) is applied to the receiver section (the UART’s RCP input) in the first of these two examples it is fed to the transmitter section (TCP input) in the second case. Note that in figure 6c the clock signal is applied simultaneously to inputs RCP and TCP. The real interest in this format lies in using two different frequencies for the two clock signals, to cause the transmission rate to be increased or decreased. In this case the converter’s Centronics output must be connected to its own Centronics input (handshake lines included). It is very important to look at the DTR line before each new serial data is emitted if the transmitter speed is greater than the receiver speed.

Finally, a word about the function of S6. This switch allows the serial data emitted by the UART to be fed right back to its own input. For this so-called ‘local mode’ S6a is then in position ‘a’ and S6b in position ‘b’. This permits any errors in the serial output signal (such as PE or FE) to be detected. If the DTR input line has been forced high the OR output remains inactive and LED D13 does not light.
It is not all that long ago that we published a pre-amplifier (MC/MM phono preamp — April 1983 page 4-26), but that was intended as part of the XL audio series. None the less, there is always interest in this type of unit, so we continued experimenting and the results are covered in the following pages.

The design incorporates a few special characteristics that make it a little more than just another pre-amplifier. It is intended primarily for fitting in the record player. Such an arrangement precludes the use of a long feeder cable between the pick-up and the main amplifier. A lengthy feeder cable is a source of hum and adds a considerable capacitive load across the pick-up. Because the length of the cable would vary from installation to installation, it would be impossible to put a value to the capacitance. Yet, to achieve a straight frequency characteristic, it is imperative that the pick-up is terminated into the correct impedance. The inductance of the pick-up coil and the input capacitance of the pre-amplifier form a resonant circuit, the frequency of which is used by the manufacturers to get the high-frequency end of the characteristic right. A capacitive mismatch therefore causes either a premature fall-off in high frequencies or a peak that is shifted towards the centre of the characteristic.

Because the present pre-amplifier does not use a long feeder, matching between the pick-up and amplifier can be optimized. Since the amplifier is mounted on board the record player, it becomes possible to use a symmetrical input circuit. This further reduces the likelihood of hum and saves an input capacitor.

The de-emphasis characteristic meets the relevant requirements of the IEC (International Electrotechnical Commission) and has been adopted by virtually the whole of the recording industry in the western world and such organizations as the AES (audio engineering society), the RIAA (record industry association of America), and the NARTB (national association of radio and television broadcasters).

The unit is easily modified to provide a normal asymmetrical input, enabling it to be built into the main amplifier instead of the record player. It can also be built as a microphone amplifier by omitting the de-emphasis circuit.

Some background theory
There are two fundamental types of recording: constant-velocity and constant-amplitude, a combination of which is generally used.

In constant-velocity recording, if different frequencies at the same level are processed in turn by the recording amplifier, each drives the recording cutter with the same maximum velocity during each audio cycle. This type of recording cannot be used, however, below about 500 Hz...
because it is accompanied by an increase of amplitude which is inversely proportional to the frequency, with the result that the usual spacing of grooves (about 100 μm) would be inadequate.

In constant-amplitude recording, different frequencies at the same level are processed so that they have the same maximum amplitude on the record. In this type of recording, the maximum velocity is proportional to the frequency because the stylus has to traverse the given amplitude in less and less time as the period is reduced. Therefore, in constant-amplitude recording, the velocity doubles each time the frequency is doubled. For each octave increase in frequency, there is a 6 dB increase in velocity, corresponding to a 30 dB greater velocity at 16,000 Hz than at 500 Hz. This is a substantial pre-emphasis, but not sufficient to result in the required recording characteristic. That is achieved by electrical means in attenuating the low frequencies and boosting the high frequencies as shown by the recording pre-emphasis characteristic in figure 1. It should be noted that the high-frequency boost results in a much higher signal-to-noise ratio on playback (thus considerably reducing the surface noise).

To obtain a uniformly flat frequency response during playback, the pre-amplifier must boost the bass frequencies and attenuate the high frequencies according to the playback de-emphasis characteristic shown in figure 1. Note that the de-emphasis characteristic is the inverse of the recording pre-emphasis characteristic. The curves are characterized by three time constants associated with the low, middle, and high frequency regions of the audio spectrum respectively.

The de-emphasis characteristic may be obtained in several ways: by passive networks either preceding or following the amplifier; by suitable feedback loops; or by a combination of these. The block diagram in figure 2 illustrates the latter solution: a low-noise amplifier with symmetrical input is followed by a low-pass filter with a time-constant of 75 μs, corresponding to a turnover frequency of 2120 Hz. This is followed by a second amplifier with a frequency-dependent feedback loop, which gives time-constants of 3180 μs and 318 μs, corresponding to turnover frequencies of 50 Hz and 500 Hz respectively.

Circuit description

The pre-amplifier is based on a type TDA 3420 IC, which has been designed for applications in good-quality stereo audio systems. Each channel consists of two independent amplifiers: the first one has a fixed gain (28 dB) while the second is an operational amplifier for audio applications.

With reference to figure 3, the sym-
Figure 3. The circuit diagram given here is only for one channel: A1 is a low noise pre-amplifier stage with internal feedback and a predetermined gain of about 28 dB. A2 is an operational amplifier. Total gain at 1 kHz is of the order of 40 dB.

Network R2/C3/C4 provides a time-constant of 75 μs, corresponding to a turn-over point of 2120 Hz. The other two turn-over points are provided by amplifier A2 and its negative feedback loop. Amplification at low frequencies is high due to resistors R6, R5, and the parallel combination R3/R4. It decreases at higher frequencies because the (diminishing) reactances of C5 and C6 shunt R5. DC amplification is fixed at about 8 dB by R6, R5, and R3. As the d.c. output voltage of A1 (A1') is about 2.8 V, that of A2 (A2') becomes just about half the 15 V supply voltage which ensures an optimum dynamic range.

The supply voltage is stabilized by IC2, a type 78L15 voltage regulator. The input to this IC may conceivably be taken from the field winding of the record player motor. If this is not possible, a supply line may be taken from the main amplifier, or a simple power supply added to the pre-amplifier. Current consumption of the pre-amplifier amounts to a mere 10 mA. As stated earlier, the input circuit may be made asymmetrical, which may be propitious if the circuit is built into the main amplifier, particularly if this has only one signal line per channel. The circuit then becomes as shown in figure 4. It is necessary to reduce the value of C2 because it is shunted by the capacitance of the feeder cable. The d.c. amplification of A2 (A2') is somewhat smaller because the d.c. output voltage of A1 (A1') is reduced by the omission of the connection to pin 6.

Application as linear (for instance, microphone) amplifier with symmetrical input is illustrated in figure 5a and with asymmetrical input in 5b. That in 5a is to be preferred because it makes it possible to connect a symmetrical microphone without an input transformer. Note that in both figures the components determining the de-emphasis characteristic have been omitted. The d.c. amplification of A2 (A2') has been suitably altered. The 680-ohm resistor is necessary for matching the microphone output.

Figure 4. The input stage of the pre-amplifier has here been arranged in asymmetrical configuration. Capacitor C2, in conjunction with the capacitance of the cable between pick-up and input circuit, serves to match the cartridge and input impedances. The resistor in the R3 position must be reduced to 120 kΩ to ensure an optimum dynamic range.

And now to work
The component layout and track side of the printed circuit board are shown in figure 6. As you will see, the printed circuit is intended for a stereo amplifier with symmetrical inputs. Construction of the printed circuit itself should not present any special problems, but good care should be taken with the installation, and connecting to, the record player. The symmetrical input makes it necessary that...
the screens of the signal lines are not connected to earth. A look at the pick-up cartridge shown schematically in figure 7 shows that four differently coloured pins emerge from it: white and blue for the left channel and red and green for the right channel. These are taken to the connecting box at the turntable via wires running through the tone arm. At the connecting box the blue and green wires are connected to earth and these must be disconnected and then connected to terminals 2 and 2'. The white and red lines should be connected to terminals 1 and 1' respectively.

The metal casing of the cartridge is often connected to the blue or green pin by a small tag to ensure it is earthed. With a symmetrical input this connection must be broken but it is essential that the casing remains earthed. If a tag has been used, it may be easy to undo the connection. If
Figure 6. The printed circuit of the pre-amplifier with symmetrical input circuits. With suitable modifications, the other versions of the unit may be built onto the same boards.

Parts list
Symmetrical version

Resistors:
R1,R1' = 100 k, metal film
R2,R2' = 1 k, metal film
R3,R3' = 220 k
R4,R4' = 10 k
R5,R5' = 27 k
R6,R6' = 27 k
R7,R7' = 270 k

Capacitors:
C1,C1',C2,C2' = 220 p, polystyrene
C3,C3' = 68 n, plastic foil
C4,C4' = 6n8, polystyrene
C5,C5' = 1n5, polystyrene
C6,C6' = 8n2, plastic foil
C7,C7' = 4.7/16 V tantalum
C8,C8' = 1.45, plastic foil
C9 = 100 n polyester
C10 = 1 μ25 V, tantalum

Semiconductors:
IC1 = TDA 3420
IC2 = 78L15

Changes for asymmetrical version:
R5,R5' = 120 k
C1,C1' = 2u2/16 V tantalum

there has not, check whether there is an internal connection between the casing and the blue/green wires. If so, there is a slight risk of hum occurring. In that case, make sure that the metal cartridge is isolated from the remainder of the tone arm by, for instance, fitting the cartridge in a nylon or polyester headshell. If hum still occurs (is the tone arm earthed properly?), try the asymmetrical input. This may be done simply by modifying the input circuit as shown in figure 4. The printed circuit track to pin 6 (10) of the IC should be cut with a track cutter or sharp pen knife.

Because with an asymmetrical input the d.c. output voltage of A1 reduces to about 1.5 V, the amplification of A2 has to be modified to retain the optimum dynamic range. This is accomplished by replacing the 220 k resistor in the R3 position by one of 120 k.

All capacitors, except C7, C7', and C10, are polystyrene or plastic film types because of the small tolerances available in these.

The outputs are conventional stereo: left and right channels and earth. They should be connected to the LINE or DIN input of the amplifier (for instance, 'aux'). DO NOT use the MD input because this would result in a double de-emphasis correction as well as serious overloading of the amplifier.

Power supply requirements are fairly lenient, particularly since the pre-amplifier has a built-in voltage regulator. The (unregulated) input voltage may lie between 18 and 30 V. In many instances this voltage may be taken from the field winding of the record player motor. If that is not possible, you will have to construct a supply from a small mains transformer (current requirement is only about 10 mA), a bridge rectifier, and a smoothing capacitor. It may also be possible to obtain the supply from the main amplifier. If this happens to be about +15 V (maximum 18 V — regulated), the two extreme pins of IC2 should be shorted by a wire bridge.

When the supply voltage is derived from the main amplifier, take care to avoid earth loops. The negative line of the supply circuit is almost certainly connected to earth, and therefore to the input circuit screening, in the main amplifier. The negative line in the pre-amplifier is also connected to earth. In this situation, the braid of the screened cable in either the main or the pre-amplifier must be disconnected from earth.

The unit may be constructed as a linear (microphone) amplifier on the same printed circuit board. The circuit diagram for this configuration is given in figure 5 which shows that in certain positions different value components must be fitted or omitted altogether.
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