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Satellite loudspeakers are not a separate category of sound reproducing equipment; any loudspeaker whose bass performance is improved could be classified as such. It is often decided that because they are invariable satellites, because their dimensions prohibit proper reproduction of frequencies below about 100 Hz. The article in this month's issue follows on the Active subwoofer (March) and deals with the satellite loudspeakers that complement the subwoofer to give complete coverage of the audio spectrum.
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**PRICES**

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Video in decline?

Now the semiconductor markets are beginning to show signs of a slow revival, it seems to be the turn of video revenues (and therefore profits) to start declining. The reason for this is that some forty per cent of households in the industrialized world already have a VCR (video cassette recorder).

To retain their share of the consequently declining market, the 20-odd Japanese (and some other Asian) manufacturers have become engaged in a price war that is hotting up.

What they are all hoping for is a miraculous expansion of the market, or a new market. But that is pie in the sky, because market observers believe that such an expansion or new market will only occur if a technically new, yet lasting and exciting, equipment is introduced. Moreover, such equipment must be relatively inexpensive, easy to operate, and offer a high degree of standardization.

The only equipment that seems to meet most of these requirements is Sony’s new 8 mm video system. But since this is not compatible with the 100-odd million half-inch VCRs already in use, it has a long, hard slog ahead of it.

In the meanwhile, the video market is likely to go on declining at an increasing rate. As guarded estimates suggest that nearly a fifth of Japanese electronics sales consists of VCRs and their components, some sectors of the Japanese industry are in for a leaner time than they have experienced for years. The question is: what are they going to do about it?
New marketing manager for X-TEC

Mark Robson has been appointed UK Marketing Manager of X-tec Limited, the networking communications company based in Reading, Berks. He brings 13 years' experience in the computer industry to this newly-created position.

X-tec Limited, founded in 1982, is an all-British company which manufactures and supplies specialized communications products for a wide variety of networking requirements. Principal customers include British Telecom, the Atomic Energy Authority, and Imperial College, London.

PCB upswing in western Europe

According to a recent report from Frost & Sullivan, The Printed Circuit Board Market in Western Europe (+£E791), a combination of significant developments and vastly widening sales within the telecommunications industry are sending western Europe's printed-circuit board's market into a formidable upswing. The report expects total sales in 1990 to reach close to £1800 million, a substantial rise from 1984's total market value of just under £1000 million. The report finds the current largest areas for use to be computers and peripherals and telecommunications, with both sectors given equal market shares of 28 per cent. However, the study predicts that by 1990 telecommunications will be the top end user with a market share of around 40 per cent, almost double that of computers and peripherals.

For the product itself, the most striking development is the rapid growth in the value of the multilayer market, which is expected to take 50 per cent of the market in 1990, rising from 33 per cent in 1984. This will be at the expense of double-sided boards, whose share is predicted to fall from 49 per cent in 1984 to 37 per cent in 1990. The most striking fall, however, is that expected of single-sided boards, which will plummet from 12 per cent to 8 per cent.

New vice presidents for SERT

The Society of Electronic and Radio Technicians (SERT) announces the appointment of three new Vice Presidents of the society. They are: S L H Clarke, BSc. (Cantab), CEng., FIEE, FBCS - Deputy Director of the Alvey Programme; Professor William Gosling, BSc. (Special), DSc., ARCS, CEng., FIEE, FIERE - Technical Director of the Plessey Company PLC; and Brigadier G M Hutchinson, MA (Cantab), RA - Deputy to the Director General Electrical and Mechanical Engineering (Army).

Laurence Clarke held the post of Assistant Technical Director (Computing and Automation) at GEC PLC prior to joining the Alvey Directorate. He is vice chairman of the Control and Computer Board of the IEE, and is a visiting professor in the Computer Science Department of University College London.

William Gosling is a past President and Fellow of the Institution of Electrical Engineers; Fellow of the Institution of Electrical Engineers; Fellow of the Institute of Directors; and a Chartered Engineer. An Honorary Fellow of Plymouth Polytechnic, and currently, visiting professor of Communications Engineering at Southampton University, he is the author of seven books on engineering topics and about fifty papers in scientific journals, for one of which he received the Clark Maxwell Prize (IERE).

Brigadier Malcolm Hutchinson joined the Army in 1958 on a graduate direct entry commission in the Royal Electrical and Mechanical Engineers. He attended the Army Staff Course at Shrieverham and Camberley in 1967 and 1968 respectively. He has commanded a number of REME units in Federal Germany and the Far East, and has held a number of Weapons Staff appointments at the Ministry of Defence and in the USA, the last of these being Project Manager in the Guided Weapons and Electronics Directorate of MoD(P(FE)).

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* 5761 Causeway, London SE1 6BL; telephone 01-403 2351
Korea vs Japan for share of US memory market

According to The Korean Semiconductor Industry, a new multi-client study from Product Assessment* and Benn Electronics Publications**, the much heralded Korean foray into world semiconductor markets will result in a four-fold increase in Korean overseas sales, from $47 million in 1985 to $203 million in 1986. The campaign is aimed primarily at the world memory market.

It is estimated that Korea will capture up to 7 per cent of the US MOS memory business by the end of the year, largely at the expense of Japanese vendors, with highly competitive pricing tactics used by both sides: an unwelcome development for hard pressed US and European producers.

Korea currently has twelve indigenous semiconductor producers, plus the world's largest sub-contract assembly facility, Anam, as well as seven multinational assembly factories. This impressive line-up has taken Korea to the number three position in terms of value added by country, overtaking Federal Germany at the end of 1985 (see Table 1). Whilst the Koreans are initially aiming their export drive at the memory markets, the major companies have a rapidly expanding range of products and technologies available (see Table 2).

Factron has announced plans to invest over $40 million in capital equipment for its European operations over the next three years. Factron is already Europe's premier supplier of ATE and test automation products for the electronics systems market place, and the only one of the world's major ATE companies with European design and manufacture. This massive investment will extend Factron's technological lead and further its penetration in the key market sectors of telecommunications, computer, office automation, and defence. These investments will be in equipment alone and will be matched by further significant investments in engineering staff.

The first slice of the investment—45 per cent—will fund Computer Integrated Manufacturing—CIM—engineering tools. Operations will account for 35 per cent of the investment. Extra space will accommodate state-of-the-art PCB assembly systems, and Factron will participate in a joint-venture development of a robot facility for inserting relays into PCBs.

The existing management information system will be upgraded and complemented with a company-wide networked data base which will link into the current satellite-based intra-Schlumberger packet-switching communications system.

Applications and sales are seen as providing the vital link with the customer. Factron will direct 20 per cent of its investment into these areas, with an aggressive expansion programme to increase its share, and eventual domination, of the market.

In marketing, the emphasis will be on joint ventures to develop computerized management of test and fault data, automatic PCB handling, advanced test programme generation facilities, and the development and evaluation of a new generation of advanced solutions for the electronics manufacturers of tomorrow.

In short, Factron intends to become the world leader in computer-aided systems.

Table 1

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Source: The Korean Semiconductor Industry (C) BEP Luton, UK.

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* Current Capability
P Planned

Source: The Korean Semiconductor Industry (C) BEP Luton, UK.
**QUAD 306 power amplifier**

Quad Electroacoustics Limited was founded in 1936 as the Acoustical Manufacturing Company. First news in its 50th anniversary year is the announcement of a new power amplifier. The QUAD 306 is designed to provide the most accurate and realistic music reproduction in high-quality domestic systems. Power output is more than adequate for the vast majority of systems (70 watts into 8 ohms on music programmes). The QUAD 306 uses a highly refined and developed version of the feed forward error correction circuit, which Quad patented in 1975 and nicknamed current dumping. Some of the more obvious features of the QUAD 306 are separate power supplies for each channel, derived from separate secondary windings on a common toroidal transformer, an absence of fuses or relays in the signal paths, and a signal plus-noise to noise ratio of 110 dB. It is fully protected against damage, accidental or otherwise. The QUAD 306, which is now being delivered to Quad dealers at £229.00 incl. VAT, incorporates the experience gained from half a century of design, development, and manufacture of power amplifiers, and the performance, design, construction, and reliability are the hallmarks which QUAD owners worldwide have come to recognize.

* Huntingdon, Cambs PE18 7DJ; telephone (0480) 52561; telex 32348

**British Telecom seeks to develop opportunities in India**

British Telecom and Mahindra & Mahindra Ltd of Bombay recently signed a memorandum of understanding, whereby the two companies agree jointly to explore and possibly develop opportunities in the telecommunications and information technology fields. British Telecom, one of the world's largest telecommunications companies, had a turnover last year of £763 million (Rs 13 423 crores), pre-tax profits of £1480 million (Rs 2596 crores), and employs a staff of 235 000. It is a world leader in the application of latest technology to provide effective and economic telecommunications. Recent modernization of networks and services in the UK has involved the installation of major digital exchanges, the continued use of satellites, optical fibres, microwave links, and undersea cables. Its services cover the complete range of public and private telecommunications networks, including such facilities as high-speed text and data transmission, computer-controlled international telex; car and hand-held mobile radio telephones; specially designed small rural exchanges; and modern cash and credit card public payphones. Mahindra & Mahindra, established in 1945, is India's ninth largest company with a workforce of 14 000. Its activities range from manufacture of jeeps, light commercial vehicles and tractors, to process-control instruments. It has twelve subsidiary and associate companies whose manufacture includes alloy steel, textile machinery, synthetic resins, elevators, and reinforced plastics. The company is moving into new high-technology activities, and will shortly begin production of electronic private automatic branch exchanges (PBAXs) in collaboration with Oki of Japan for the Indian market. The chairman of the company, Mr Keshub Mahindra, is one of India's leading industrialists. He is chairman of seven major companies, and a director on the board of sixteen others. President of the Employers' Federation of India, he has served on a number of government commissions and advisory committees.

**Scottish dealer wins first Star Porsche**

Mr Michael Fowle of Pulse Business Systems, Edinburgh, was recently presented with the keys to his brand new Porsche 924S sports car on the Star Micronics' stand at the Which Computer? show. The competition, which has been running since September last year, was based on sales of printers into dealerships. An end-user competition for a second Porsche 924S is currently in progress and the winner will be announced at the beginning of this month.

* Craven House, 40 Uxbridge Road, Ealing, London W5 28S; telephone (01) 840 1800; telex 946521
AIM Cambridge = AIM Technology

Following the move to its new base at Perry, Combs, AIM Cambridge has changed its name to AIM Technology*. The new name and image reflect AIM's main role as a product and process design consultancy applying advanced technology and engineering skills. It also clears up any confusion now that the company has moved further away from Cambridge itself. The company employs over 50 staff, the majority of whom are highly skilled in software, electronics, and mechanical engineering. It undertakes a wide variety of product design, consultancy, problem solving, and process development projects. Among recent projects that AIM has been involved with are the market-leading Tempo mains time-switch, an electronic wand, which is used interactively with children's quiz books to enhance learning and enjoyment; electronic music synthesizers; and a price-shattering OCR reader for the personal computer market.

The new site, Gaynes Hall at Perry near Grafham Water, is a Grade II listed Georgian mansion set in 16 acres of parkland. It provides 12,000 ft² of usable area: twice the space that AIM had at its previous location. The entire area has been fitted out to provide purpose-designed electronics, software, and mechanical design laboratories. Ducts have been fitted around each floor for the installation of fibre optic networking cables, and special computer rooms hold the company's VAX-based software design facility.

IMO opens PC training centre

Term began at IMO Precision Controls* last January when their new training centre was used for the first time. Part of a 10,000 ft² development at Staples Corner, NW London, the new suite will be used to train engineers in the workings and usage of IMO's new C-series of communicating Programmable Controllers. Courses have been designed to acquaint engineers with the extensive capabilities of the C-series to ensure that maximum benefit is derived from their implementation.

Surface-mount prototype service

Frazer-Nash Electronics* has a production capability geared to providing clients with a facility to undertake small proving runs of pre-production quantities before they commit themselves to substantial investment in manufacturing set-up costs. As an electronics design and development company, it is vital for Frazer-Nash to remain abreast of new technologies so that the company may pass on any benefits to clients in the designs that are undertaken. This has been the case with the growth in use of surface-mount devices-SMDs. Frazer-Nash Electronics has been involved with surface-mount technology-SMT— for over four years and has built up experience over this period of the various problems associated with the introduction of small outlines-SOs—and SMDs into existing or new designs. The production department can also call on the expertise of Frazer-Nash's design and development team to advise clients of the pitfalls to avoid in any new design or to suggest the most cost-effective way to rework an existing product to take full advantage of the benefits of SMT.

* Gaynes Hall, West Perry, Huntingdon, Combs PE18 0ST; telephone (0480) 811995; telex 32707

* 1000 North Circular Road, Staples Corner, London NW2 7JF; telephone (01) 452 6444

* Randalls Way, Leatherhead, Surrey KT22 7TX; telephone (0372) 379717; telex 946405
Regisbrook restructure

Regisbrook Ltd and Pulseview Ltd, the sister opto-electronic companies, have been restructured into more effective trading units controlled by a new company, Regisbrook Group Limited. The restructured company has raised new venture capital in excess of £1 million to finance expansion and an increased stockholding. The re-financing, handled by Venture Link, resulted in funds from a number of sources, including the Foreign and Colonial Enterprise Trust, the Water Authorities’ Superannuation Funds, Equity & Law, and the Venture Link controlled M4 Syndicate.

The restructuring is intended to improve the group’s potential for successful trading. Both companies are forecasting a significant increase in business this year; several substantial new orders are already on the books. Regisbrook will continue to expand its product portfolio with new developments in opto-technology, while Pulseview are undertaking a major sales initiative aimed at capitalizing on the company’s successful development of a range of advanced new products and services.

Private satellite networks

Satellites are not only changing the face of broadcasting, they are also changing that of business. Today, major growth is occurring in the market for private satellite networks, and a number of satellite systems specifically to service to telecommunications requirements of business have been developed. Satellite Private Business Network Terminals in the US 1985-1995 (1494), a new Frost & Sullivan study forecasts that the market for private satellites will grow from $564 million in 1984 to $8.35 billion in 1995. Annual sales of private satellite network earth stations, now estimated at $315 million, are expected to increase to $1.2 billion by 1995.

The 297-page report includes complete competitive information, including market share, discussions of technology, marketing techniques, and a look at how each industry makes use of satellite communications.

German PCB plant for Scotland

Federal German electronics company Isola Werke AG, of Düren near Aachen, is to set up a £10 million plant at Cumbernauld in Scotland’s Silicon Glen. The project will create 200 new jobs over the next five years.

Isola, a leading European producer of printed circuit board laminates, chose Scotland for its first manufacturing plant outside the Federal Republic to get closer to its major UK customers. It will also provide a base for servicing their overseas markets. Isola has an annual turnover of £77 million, a workforce of 1200, and has been supplying the world electronics industry for over 25 years. It is a subsidiary of Rutgerswerke AG of Frankfurt, an organic chemical and plastics group with over 11,000 employees and a turnover in excess of £1000 million.

Isola director Dr Rainer Tilissen said that the company intended to increasingly serve the UK market from the Cumbernauld base by 1987.
Plessey GaAs components marketed by Tekelec

Towcester-based gallium arsenide components manufacturer Plessey Three-Five Group Limited has announced an agreement with Tekelec, a leading frequency-tuning components marketing company.

Under the agreement, Tekelec is licensed to market the full range of Plessey gallium arsenide components and monolithic microwave integrated circuits—MMICs—in the UK.

Tekelec Limited was formed in 1977 as a wholly owned subsidiary of Tekelec-Airtronics SA of France. Since 1977, Tekelec Ltd has grown into a multi-million pound concern, employing a skilled technical sales force selling Tekelec products in the USA and Europe. In addition, Tekelec Ltd represents in the UK a number of electronics manufacturers.

The photograph shows the signing of the agreement by Alan Price, managing director of Three-Five, and Jack Siddle, managing director of Tekelec Ltd.

Scottish boost to UK's electronics success

Scotland's electronics expansion last year helped the UK to number one place in Europe for market growth. The UK has now pushed its market share up to almost 20 per cent. This success is partly due to the growing number of US, Japanese, and European companies setting up in the UK, particularly in Scotland, according to the West Europe Electronics Data Yearbook for 1986, published by Benn Electronics Publications*.

Scotland's semiconductor production is now 20 per cent of total European output and contains eleven of the top twenty data processing companies in Europe.

The total value of the West European market last year was estimated to be £64,000 million, up from £60 billion in 1984. It is expected to reach £81.3 billion in 1989.

European economic expansion is confidently predicted to be higher than in the USA in 1985. Growth rates for Federal Germany and the UK are likely to be higher than the average.

Although Europe's balance of trade in electronics products has worsened considerably since 1979, the UK was one of only two countries to reduce the deficit. In 1983, the UK's deficit was £2.73 billion; in 1984 it was £2.46 billion; and in 1985 it is estimated to have fallen further.

Surfboards aid surface-mount prototyping

Global Specialties* has introduced a completely new concept for building prototype circuits with surface-mount devices. With its Surfboard, the designer places a plastic ledged chip carrier—PLCC—into a chip carrier socket to give him instant breadboarding access to the electronics in the chip, without soldering or permanent connections.

The Surfboard provides a numbered breadboarding tie-point for each lead on the chip carrier. Connection of a particular lead is effected by inserting standard 22-gauge hook-up wire into the corresponding tie-point.

Changes are easily made without damage to chip carriers, PCB boards, or components. More than one surface-mount chip can be included in a prototype circuit through the use of additional Surfboards connected through breadboarding. Three Surfboard models are available to accommodate 44-, 68- and 84-pin PLCCs.

* Shire Hill Industrial Estate, Saffron Walden, Essex CB11 3AQ; telephone (0799) 21682; telex 817477

Amateur Radio & Electronics Hobby Fair

The Amateur Radio & Electronics Hobby Fair which will be held at The Wembley Conference Centre, London, on Saturday 5 and Sunday 6 July, 1986, is a major new event in the Amateur Radio rally calendar.

The two-day fair is expected to be attended by a large number of retailers and manufacturers in amateur radio; RTTY, satellite TV and communications, microwaves, hobby components. The event is organized by Amateur Radio Promotions of Woodthorpe House, Cloppgate Lane, Birmingham B32 3BU; telephone (021) 476 8091.
SATELLITE LOUDSPEAKERS

Following on last month's Active subwoofer, this article deals with the satellite loudspeakers that complement the subwoofer to give complete coverage of the audio spectrum. These satellites are, however, also perfectly suitable for independent use.

Satellite loudspeakers are not a separate category of sound reproducing equipment; any loudspeaker whose bass performance should be improved could be classified as a satellite. So-called bookcase speakers are invariably satellites, because their modest dimensions prohibit proper reproduction of frequencies below about 100 Hz.

If you are planning a new loudspeaker system, you could do worse than to opt for a subwoofer-satellites system. It is then, of course, best right from the start to design the satellites for optimum performance with the subwoofer and vice versa. It is on this basis that the present article has come about: the results are very satisfactory, indeed.

Even those who are not terribly interested in the subwoofer will find that the bass performance of the satellite speakers (−3 dB point at 65 Hz) is perfectly adequate for their requirements. Although the design of a loudspeaker enclosure is never an easy task, the one proposed here presents the constructor with relatively few difficulties. This is, of course, largely due to there being no need of paying much attention to the bass reproduction. A response down to 100 Hz would be perfectly adequate; true, an octave further down would be very nice, but is, in this case, not necessary.

This immediately removes the problem of choosing the right shape and size of enclosure and deciding how many "ways" the system should have. The enclosure decided on is a normal closed box, while it was felt that a two-way system would be perfectly acceptable, provided that the chosen drive units would allow this. The latter aspect also requires less arithmetic and fewer measurements than, e.g., a three-way system.

These considerations have resulted in a very satisfactory practical realization, both as regards the enclosure and the number of drive units. As a bonus, the bass performance measured is considerably better than that aimed at. In short, the proposed design is compact, easy to build, not expensive, and, even without a subwoofer, gives an excellent overall performance.

The drive units

As said, the design is based on two drive units. Since the majority of

Fig. 1. The Dynaudio Type 17W75 was used as the bass and middle frequency drive unit in the prototype system. Noteworthy aspects of this unit are the centre magnet and the PHA (phase homogenous area) propylene cone.
middle-frequency units are not really satisfactory above about 2000 to 2500 Hz, which causes problems in the choice of tweeter. Dynaudio units were used for the prototypes. These units did not only meet the requirements for the present design better than most, they also offer the advantage of an excellent match with the subwoofer (which also uses a Dynaudio drive unit). The units are the Type 17W75, a 170 mm bass and middle-frequency unit, and the Type D-28 AF tweeter.

The 17W75, shown in Fig. 1, is a drive unit with a relatively large voice coil (75 mm) in hexacoil technique, which, in combination with the unusual shape of the one-piece cone, gives an ideal transfer of the acceleration force from the coil to the PHA (phase homogeneous area) cone. Another advantage of the big voice coil is the short rise time (fast transient response) of 50 μs. Very low distortion and excellent phase characteristics are a result of the total concave shape of the cone.

The D-28 AF, shown in Fig. 2, is a 28 mm soft dome tweeter. The voice coil is coupled with the aid of ferro fluid. The unit has a noteworthy fast transient response (short rise time) of 12 μs. It offers the great advantage of having been designed specifically for use with 6 dB/octave filters: not many dome tweeters have a -1.5 dB correction. Moreover, R1 smoothes out a small unevenness in the tweeter characteristic; its value must, therefore, not be changed under any circumstances. The characteristic in Fig. 4 represents the output voltage of the filter, measured across the two drive units. Note that the cross-over point only appears to be at -5 dB; it is actually at the customary -3 dB. The characteristic of the 17W75 has a slight peak at the cross-over frequency, and this has been corrected by a slightly earlier action of the filter. Acoustically, everything is, therefore, as it should be.

Construction of the filter should not give any difficulties if the PCB (Type 85916) shown in Fig. 5 is used. Note, however, that L1 should be fastened with glue or a brass/nylon bolt; a...
Fig. 4. Characteristic curve of the output voltage of the cross-over filter measured with the drive units connected.

Fig. 5. The printed-circuit board for the cross-over network (Type 86016 — available through our Readers' Services).

**Parts list**

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<tr>
<td>( L_1 )</td>
<td>0.5 mH air-cored inductor; wire diameter 1 mm</td>
</tr>
<tr>
<td>( C_1 )</td>
<td>22 ( \mu ) bipolar electrolytic or polyester</td>
</tr>
<tr>
<td>( C_2 )</td>
<td>10 ( \mu ) polyester</td>
</tr>
<tr>
<td>( R_1 )</td>
<td>5 9.5 W</td>
</tr>
<tr>
<td>( R_2 )</td>
<td>0.47 9.5 W</td>
</tr>
<tr>
<td>( R_3 )</td>
<td>22 5.5 W</td>
</tr>
<tr>
<td>Dynaudio Type 17W75 drive unit</td>
<td></td>
</tr>
<tr>
<td>Dynaudio Type 0-28 AF drive unit</td>
<td></td>
</tr>
<tr>
<td>chip board or plywood, 18 mm thick, as required (see Fig. 6)</td>
<td></td>
</tr>
<tr>
<td>about 0.25 m² rubber-backed floor covering</td>
<td>about 0.25 m² rock-wool 1 variovent; 110 mm; (Dynaudio) connector terminals as required</td>
</tr>
<tr>
<td>wood glue, screws, and nails as required</td>
<td></td>
</tr>
</tbody>
</table>

Steel fastening would affect the value of the inductor. Also, observe correct polarity when the drive units are connected to the board. The PCB may be conveniently mounted —on spacers— on the bottom lid or against the back panel of the enclosure.

**The enclosure**

According to the manufacturer's data, the 17W75 is best housed in a 10 to 15 litre closed box, which has been provided with a so-called variovent (acoustic resistance).

Although theoretical considerations point to a somewhat larger volume, in practice the manufacturer's recommendations proved to be correct. In a damped closed box of exactly 10 litres volume, the bass performance of the 17W75 was surprisingly good. The difference between a box with, and one without, a variovent is slight. The variovent only serves to attenuate the resonance peak, and this results in a somewhat more rigid performance at low frequencies.

Although some photographs accompanying this article show a beautifully styled pentagonal, pyramid-shaped prototype enclosure (courtesy Dynaudio), the proposed enclosure has been kept rather simpler. Note, however, that the pentagonal enclosure is available from Dynaudio as a kit: it is acoustically excellent, but quite difficult to build. Our own proposal, shown in Fig. 6, offers similar advantages as the Dynaudio design: no parallel side panels; leaning backwards; upward tapering front panel; but does not demand the craft of a furniture maker.

The material is 18 mm fine-chip board; plywood may, of course, also be used, but is rather more expensive. The front, back, and side panels have exactly the same dimensions. If these are sawn very carefully, all four can be glued together in one go. The bottom and top lid must be sawn very carefully to ensure a good, tight fit onto the leaning vertical panels. The top lid may be glued in place, but the bottom panel is best fitted with screws and sealing tape so that access is possible at a later stage, if required. Next, the holes for the drive units, the variovent, and the connector terminals should be cut. The variovent should be glued into
Technical characteristics

System: passive, two-way
Enclosure: closed box
Net volume: about 10 litres
Cross-over filter: 6 dB/octave, cross-over point at about 2500 Hz
Frequency range: -3 dB points at 60 Hz and 20 kHz
Amplifier rating: 30-100 watts
Sensitivity: 89 dB

While the drive units should be screwed on. Afterwards, the gap between the rim of the drive units and the front panel should be sealed with suitable tape.

The best place to fit the cross-over filter is at the back panel between the variovent and the connector terminals.

Panel resonance is further prevented by gluing strips of rubber-backed floor covering at the inside of all panels and then covering these with 30 mm thick rock-wool. If this material is amply cut, the strips will be push-fit, obviating the need for gluing them into place.

The finnish of the exterior of the enclosure is left to your own taste and preference.

**Performance**

It is, of course, easy (and tempting) for a designer to sing his own praises, so the performance of the system can be gauged from the measured impedance and frequency response characteristics illustrated in Figures 7 and 8 respectively. The smooth impedance curve should not present any problems to a good output amplifier. The frequency response curve was measured with $R_2 = 0.47$ ohms. When this is increased to 2.2 ohms, the characteristic shifts down by about 2 dB above 2 kHz. Response at low frequencies was ascertained by close-proximity (20 mm) measure-

Fig. 6: Construction details of the proposed enclosure. The material may be 18 mm plywood or good quality chip board.
Fig 7. Characteristic impedance curve of the completed satellite system.

Fig 8. Frequency response curve of the completed satellite system.

The acoustics of the test room has such an effect that measurements at greater distances give no meaningful information as to the behaviour of the system at low frequencies. For measurements at middle and high frequencies, the test microphone was placed at a distance of about 2 metres at roughly the height of the acoustic centre of the enclosure.
Whatever speeds their manufacturers claim for them, modern printers still need a lot of precious time to complete lengthy listings. This article presents an intelligent inter-peripheral buffer device with a large memory to be loaded at one swoop by the computer. While the printer buffer patiently feeds the printer, the computer is free for the next programming session.

Generally speaking, any peripheral is slow compared with the controlling computer system. Printers, plotters, modems, etc. require computer handshaking arrangements to allow for the time they need to complete their tasks; the computer must inevitably wait until the peripheral device is ready to receive a new character, and this is obviously a waste of (software) time. Indeed, many programmers are forced to go and have a cup of tea while their ever so fast computer feeds the printer for a quarter of an hour or so. A possible solution to this inconvenience would be to reserve a large in-computer memory area for buffer use, from which characters are sent to the peripheral by means of a special, usually interrupt-pollled, program. It will be self-evident that this software-based spooler lays a rather high claim on available computer memory space and main-task processing speed.

This article, however, deals with the hardware approach; it presents a microprocessor based, dedicated buffer device with its very own large RAM memory, I/O, and controlling software. To the computer, this novel inter-peripheral will appear as an unusually fast printer which is loaded via the standard Centronics output port with an appropriate command such as LPRINT, LLIST or equivalents. After being loaded, the buffer independently deals with the

Features:
- 16, 32, or 64 thousand characters holding capacity
- Start-up text verifies printer operation and connection
- Space and/or form feed cancel modes
- Single sheet printing and copying
- Switch-selectable default operation
- Selectable number of lines per page
- Buffer contents repetition (max. 100 times)
- Cost effective design
Choice of components for the present design was mainly guided by common availability and low cost. Therefore, a configuration with Z80 CPU and Type 4164 dynamic RAMs was decided on because these offer a simple memory refresh setup, high speed, and ease of machine language programming.

**Buffer memory**

As apparent from the circuit diagram shown in Fig. 2, relatively few parts are required to construct this versatile buffer device. A further interesting detail is the absence of 280-family LSI support chips; their application in this circuit might have resulted in an even more compact PCB, but a number of cheap LS-TTL circuits also work to full satisfaction. The Z80 CPU reads its instructions from a Type-2716 EPROM, starting at address 0000 after power-up. As the EPROM has its OE(output enable) input connected to CPU address line A16, it will be evident that read/write operations involving RAM memory must be effected with A15 at high level (logic 1). The memory refresh method specific to the Type 4164 dynamic RAM has been dealt with in the series of articles on the high-resolution graphics card; see the October 1985 issue of Elektor Electronics.

**Refreshing software**

As always with microprocessor based designs, simplified hardware requires an extra software effort. However, as long as the additional instructions do not considerably slow down system performance, the software has been opted for, and this will be reverted to later. For now, it is useful to know that the Type 4164 dynamic RAM has eight multiplexed address inputs, A0...A7 which latch the most significant address byte (MSB) when RAS (row address strobe) is low, and the least significant address byte (LSB) when CAS (column address strobe) is low. In this way, any bit out of 65536 (8K) contained in the chip cell-matrix can be selected for a read or write operation. How signals RAS and CAS are generated in the present design is explained below.

**RAS timing:** CPU signals M1 and MREQ are low during every CPU instruction fetch cycle; this condition will keep the output of bistable N0-N1, and thus RAS, high. After this fetch cycle, the contents of the R register (refresh, this will be reverted to) are placed on A0...A1, and the CPU starts an execution cycle with MREQ going high, followed by M1. Only when MREQ goes low again will bistable N0-N1 toggle to activate the RAS lines, which will remain low until the next CPU fetch cycle.

**CAS timing:** This signal will be active (i.e. logic low) during every CPU read or write cycle with A15 at high level and A16 also high to avoid enabling the EPROM. Note that RAM memory WR lines are driven with the inverted CPU RD line to avoid possible fan-out overloading of the 280 WR output. If a mere 32 Kbytes of buffer RAM are required, it is possible to fit only IC1...IC4. This implies that every byte is split into two nibbles by the CPU and stored at two four-bit memory locations. After power is applied to the circuit, the CPU examines the width of available RAM memory in order to determine its method of character storage. It is even possible to install only 16 Kbytes with IC1 and IC2 fitted, and bytes will be stored and read as four sequentially placed two-bit units. However, with the price of 64 Kbyte dynamic RAMs considerably reduced over the past few months, it would seem advisable to install the full 64 Kbyte at once.
ware solution' is often preferred over a corresponding hardware configuration, simply because CPU instructions are free once the thing is running properly; it is just as well to get the most out of that instruction set!

The Type Z80A microprocessor features an internal memory refresh register R which is accessible through accumulator A. During every CPU opcode execution cycle, the contents of R are placed on CPU address outputs A to specify one of 128 rows in the RAM chips for collective refresh with a RAS pulse; address line A is not involved in this process. Therefore, only dynamic RAMs featuring a cell matrix of 128 rows and 512 columns may be used in the present design. After every execution cycle, R is automatically increased by one byte. This software-based refresh using the multiplexed address lines eliminates a good deal of hardware whilst opening possibilities for ROM-RAM bankswitching within the total addressable area of 64 KByte. As pointed out above, the only disadvantage with this method is the extra number of CPU instructions.

Every memory read or write operation is started with placing the upper eight address bits (most significant byte, MSB) into R. Next, a normal read or write instruction is issued to complete the address with the lower eight bits (least significant byte, LSB). Note, however, that MSB address lines A, A, A,, A, and A are 'don't care' at that stage because R holds the correct MSB. To avoid memory contention problems with the EPROMs, A and A must be kept high while reading from or writing to RAM memory.

A practical programming example will help to shed light on this slightly odd combination of refresh and selective RAM addressing in a 64 KByte configuration.

Suppose that the byte (i.e. printer character) at RAM address 7255 hex is to be read into the CPU accumulator A for transfer to the buffer output port. The program below shows that register pair H-L is used as a RAM address pointer with MSB modified into FF hex to avoid enabling the

---

Fig. 2. Circuit diagram of the printer buffer. The number of dynamic RAMs fitted determines the buffer holding capacity.
EPROM. The correct MSB \(72_{\text{hex}}\), however, is put into \(R\):

\[
\begin{align*}
215FF & \quad \text{LD} \quad \text{HL, FF5S} \quad \text{set virtual RAM address} \\
2E72 & \quad \text{LD} \quad A, 72 \quad \text{load real MSB} \\
ED4F & \quad \text{LD} \quad R, A \quad \text{for RAM R/U} \\
7E & \quad \text{LD} \quad A, (\text{HL}) \quad \text{get byte at \$725S} \\
& \quad \text{but disable EPROM}
\end{align*}
\]

Figure 3 shows the timing diagram relevant to this sequence of instructions. It will be noted that row MSB+1 instead of MSB is selected because \(R\) is automatically increased by one byte after each instruction fetch cycle. However, this flaw causes no problems because it occurs both with write and read operations.

The proposed addressing method interrupts memory refresh cycles, so as to avoid loss of data; the contents of \(R\) must be saved in an auxiliary register and restored after each memory read or write action. Given the CPU clock speed of 4 MHz, however, the slight increase in actual refresh time is insignificant.

**Buffer I/O**

Circuit diagram Fig. 2 shows the following hardware for processing printer characters under CPU control:

- I/O channel selector: a single Type 74LS154 4-to-16 decoder/demultiplexer \(I_{\text{C}}\), which decodes CPU address lines \(A_0 \ldots A_{13}\) as inputs and supplies a strobe pulse \(\text{STB}\) to indicate that data is stable and valid. The character is clocked into octal bistable \(I_{\text{C}}\), and output \(Q\) of bistable \(F_1\) is set to signal a BUSY condition to the printer, i.e. the buffer needs time to process the received character. It will be evident that BUSY will be kept active much longer than with a printer connected directly to the computer!

An instruction

IN \(A, (3)\)

will cause I/O decoder output 3 to go low (\(I_{\text{C}}\)), which in turn enables \(I_{\text{C}}\) to transfer four bits into the CPU accu. One of these bits, \(D_3\), represents the inverted BUSY level; if it is read as a high level, this implies that no strobe pulse has been received from the computer. When \(D_3\) is logic low, however, the buffer CPU knows that a new character is available in latch \(I_{\text{C}}\), and may be copied into accu with

IN \(A, (2)\)

and subsequently stored in RAM.

The next instructions are

OUT \((A)\), A

which reset BUSY and supply an ACK pulse for the computer respectively, in order to prompt it for a new character.

It has happened that data processing by the printer buffer is so fast that a computer supplied \(\text{STB}\) pulse was still present when the buffer demanded another character, finding \(\text{STB}\) still present, it would enter the same character twice or even three times because the \(\text{STB}\) pulse from the computer was far too long. To prevent this from happening, a differentiator R-C network may be fitted onto the appropriate input connector pins, this will be reverted to in the section on construction.

- Output interface: the connected printer supplies an ACK (acknowledge) pulse to indicate that it is ready to receive a new character from the printer buffer. This pulse will clock a low level into bistable \(F_2\) and enter the CPU accu as \(D_3\) when \(I_{\text{C}}\) is enabled with

IN \(A, (4)\).

Thus, reading \(D_3\) as low indicates that a new character may be got from buffer memory for transfer to the output latch \(I_{\text{C}}\), as effected with

OUT \((6), A\).

Next, a strobe pulse is issued on \(\text{STB}\) with instruction

OUT \((6), A\)

which will also set \(F_2\) output high again to indicate that the character output loop may be started once more.

**Command keys**

A number of small momentary push-to-make buttons have been provided to set operation as desired by the user. There is also a block of DIP switches inside the buffer housing which default to set operation. Switch 57 enables the user to cancel spaces (ASCII 32) in the printout, while Switch 57 cancels computer form feeds, if required. With these two switches set, a significant amount of printer paper may be saved with some applications.

The **TEST**/+10 key is used to run a checksum procedure which verifies EPROM contents; if correct, '99' will appear on the 7-segment displays.

Next, the buffer sends the message 'Elektor Printer Buffer' followed by the entire ASCII character set to the printer for verification of proper operation and buffer connection.

The **COPY** key is depressed to send the entire buffer contents to the printer once more. Before this can happen, however, the buffer ascertains that no more characters are being received from the computer, which is next decoupled from the buffer as indicated by the dark CC LED inside the **RESET** key.

The **NUMBER** key is used to set the number of copies to be printed as indicated on display. Depressing this key will step the indicated number; if the user wants to make a fast setting, **NUMBER** may be kept depressed to start the auto-increase mode. The **RESET** key is used to restore computer-buffer connection (CC LED lights) and put the buffer in the character load mode.

The **SPM** (single page mode) key is depressed when the user wishes to stop printing after every form feed command issued by the buffer. This mode is indicated by \(D_3\) lighting.
The PrC (printer connect) key continues printing after the necessary user action has been taken during SPM mode.

The LPM (last page mode) key, used in conjunction with COPY, enables the user to print a maximum of 100 copies of the page just printed (note that display reads '00' for 100).

The OFF key is depressed to reset all internal buffer bistables; also, all above modes are switched off.

As for the hardware associated with the function keys, refer once more to circuit diagram Fig. 2. Switch S1e (TEST/+10) is connected direct to three-state buffer IC1 and read as D3 by CPU instruction IN A, (3).

Note that this instruction reads status of BUSY, NUMBER, CC, TEST/+10, and LPM which appear as databits D8...D1 in CPU accu to be separately tested with a further appropriate instruction. The NUMBER key is connected to IC1 via Schmitt trigger debouncer circuit N16-N17 which also functions as an auto-repeat device; when NUMBER is kept depressed for some time, oscillation will occur at about 2 Hz to speed up setting the number of copies. Depressing the RESET key effects a logic low level at the CPU RESET input and also activates Schmitt trigger bistable N13-14, which lights LED D10 to indicate a CC (computer connected) condition.

Combination C2-R4 effects computer connection after buffer power-up; furthermore, the R-C delay time prevents immediate system restart when RESET is accidentally depressed. Command keys S13...S17 are connected to the reset inputs of four set/reset type bistables contained in IC13. All bistables may be set with the OFF key (S17), while the PrC bistable is also under CPU control with OUT (9), A.

After power-up, capacitor Cs activates PrC, whereas Cs deactivates the remaining three functions.

Display

Two 7-segment displays (LD1-LD2) are driven by two Type 9368 display drivers (IC12-IC13) which feature an internal latch and hexadecimal 7-segment representation (0...F). Instruction OUT (OA), A loads the latches and changes the displayed value into that of the accu contents.

After power-up, the displays indicate the available amount of RAM-memory; 16, 32, or 64 Kbytes. In case a fault exists in the RAM section of the circuit, the displays will indicate 'OF'. The number of copies is displayed after NUMBER has been depressed, but note that '00' means 100 copies.

Power supply

The power supply of the printer buffer is shown in Fig. 4; it is highly conventional and supplies up to 700 mA at 5 V. To keep normal dissipation within reasonable limits, the transformer secondary voltage should be kept as low as possible. If necessary, ventilation holes may be drilled at suitable places in the buffer housing.

The construction will be detailed in next month's issue.
The most frequently used equipment in an electronics laboratory or workshop is arguably an all-purpose power supply. Such a unit should not only provide a variable, stable output, but also be able to withstand the occasional overload. The supply described here does all that: twice over!

**VARIABLE DUAL POWER SUPPLY**

Internal protection circuits prevent the output current exceeding safe limits under overload conditions. Since the whole of the supply is housed in a standard ABS verobox, great attention has been paid to the problem of internal heat generation, which could be as high as 60 joules. A novel pre-regulation system, which reduces the input to the series regulators in a controlled manner, is used to overcome this problem.

Anyone with some experience of testing electronic equipment will appreciate the accuracy, stability, and ease of control of the present power supply. This consists of two identical units to cater for those situations in which two independent outputs are required, as, for instance, opamp circuits.

Technical characteristics

- **Output voltage**: 2x0...20 V
- **Output current**: 2x0...1.25 A
- **Output ripple**: 5 mV peak-to-peak
- **Current limit**: 1.3 A
- **Internal resistance**: 0.002 ohms
- **Internal dissipation**: 2x8 W
- **Ambient temperature**: 25 °C

Figure 1 illustrates the basic operation of one section of the supply. The smoothing capacitor is charged via the bridge rectifier only if the (electronic) switch in the pre-regulator is closed. For a given load current, this effectively lowers the direct voltage across the capacitor and, therefore, the dissipation in the series regulator.

The switch is controlled in proportion to the load current as will be detailed under Circuit description. Figure 1 also shows that each section of the supply is provided with a three-digit indication of the value of output voltage or load current.
Circuit description

The circuit diagram of each of the two sections of the power supply is shown in Fig. 2, which, for convenience, has been divided into three parts: pre-regulator (2a), series regulator (2b), and display (2c).

Preregulator circuit (Fig. 2a)

Basically, this looks very similar to a conventional rectifier-smoothing capacitor circuit; the only difference being the semiconductor switch T1 and associated parts. Diodes D1 and D2 act as a zero-crossing detector, whose output is applied to thyristor Th. Figures 3 illustrates that Th is off at the moment of zero-crossing, which means that switching transistor T1 does not conduct. When the voltage at the anode of Th rises, T1 will switch on and connect the bridge rectifier negative supply line to the negative terminal of smoothing capacitor C7. When the voltage drop across R6-117-13 exceeds about 8V, T2 will trigger the thyristor, which in turn short-circuits the gate and source connections of T1. This transistor then stops conducting, so that the smoothing capacitor is discharged via the series regulator and the load, if connected. The gate current of Th will drop to zero, but the device remains in its triggered state. This chain of events will start all over again at the next zero-crossing. The voltage across C7 is set by PI to a value which is 8V higher than the output voltage.

At an output current of 1.25A, the ripple across the smoothing capacitor will be about 5.5V, which means that there is a minimum voltage drop of 2.5V across the series regulator, enough to work on for the present design. Components IC1, D1 and Cs provide a separate voltage for the control section of the series regulator, because this voltage should be free of ripple. The preregulator offers a considerable reduction in dissipation, since the series regulator only dissipates about 8W at any output voltage and the maximum load current of 1.3A (this supposes a voltage drop of 6V, a worst case value which allows for a considerable ripple voltage). A conventional series-regulated supply dissipates at least about 30W under the same load conditions (unregulated voltage 28V, output 5V at 1.25A).

There is, however, a small disadvantage with the proposed method of voltage reduction, because it will be obvious that the on-time of the preregulator MOSFET will decrease as the output voltage is lowered, since the device is only switched on during the rising slope of the pulsating voltage; more precisely: on the steeper part of this slope. Since the total charge, Q, contained in a capacitor equals

\[ Q = It \]  

[coulombs]

where \( I = \) charge current <amperes>; and \( t = \) charge time <seconds>, it will be understood that \( I \) will have to increase to obtain the same total charge. This implies that the pulse load requirements for the bridge rectifier and power supply transformer are heavier than usual and this has been allowed for in the present design. Rather than roughly calculating the transformer secondary current from about 1.4 times the DC load connected to the rectifier circuit, a factor 3 should be used instead.

Series regulator (Fig. 2b).

Fig. 2b shows the actual voltage regulation and variable current limiting of the output. To enable setting the output voltage to 0V linearly, the opamp configuration outlined in Fig. 4 is used. This is basically a conventional differential amplifier with an output voltage

\[ U_o = U_i(R_s/R_b) V \]

when \( P << R_s \).

In this setup, \( U_i \) and \( U_o \) need not
have the same earth return line. If the wiper of \( P_2 \) is set to point to the positive reference voltage, \( U_C \) will be 0V, and the opamp output voltage, theoretically, also at 0V. Turning the wiper towards the minus connection of \( U_C \) will result in a higher opamp output voltage. Provided the opamp can be set to a zero output voltage using its offset, the voltage setting will be linear from 0 to \((R_2/R_1)U_C\) volts.

The current limiting circuit is arranged around ICs. The voltage drop across the current sense resistor \( R_2 \) is compared to a preset value provided by \( P_2 \). When the output current exceeds this user-defined value, ICs toggles (low output level) and thus lowers the voltage at the strobe input, pin 8, of ICs; this results in the base of \( T_5 \) being held low, and the device will act as a constant current source. The current limit LED will also light at this stage.

Diodes \( D_4 \) and \( D_5 \) provide a wired OR function; therefore, the \( T_1 \)-\( T_4 \) circuit is also capable of strobe control at ICs, and consequently, output voltage shutdown. These parts keep the output voltage low until the potential across \( C_1 \) has risen above 8V to prevent voltage spikes being generated by the power supply during its first few milliseconds of undefined operation after power-up. This preventive measure will be appreciated by anyone familiar with the detrimental effects these spikes have on TTL integrated circuits.

To protect the power supply from accepting a negative voltage, \( D_5 \) has been connected across its output terminals. A prevention against reverse current flowing into the regulator section is provided by \( D_5 \) fitted with the preregulator parts. Reverse current may occur when the supply is accidentally connected to a large, charged capacitor or another power unit with a higher output voltage.

Display section (Fig. 2c).

There are two identical, separate 3-digit displays for output current or voltage indication of each supply section. A Type 3162 A/D converter-multiplexer directly drives a Type 3161 7-segment display driver. Note that this entire circuit has its own supply voltage obtained from a separate 8V winding on the power transformer.

Selection of voltage (V) or current (A) is achieved with two-pole toggle switch \( S \) and MOSFET \( T_7 \). In the 'A' position, section \( S.b \) of the switch selects the decimal point on the left-hand display LD. The gate of \( T_7 \) is positive in this condition, so that this device will conduct, short-circuiting \( P_2 \) and connecting the HIGH input of ICs to point B, which is the right side of the current sense resistor \( R_2 \). The LOW input is connected to \( C_3 \), to the effect that ICs measures the voltage across \( R_2 \), which is a measure of the output current supplied by the present circuit. The current sense resistor has a value to give a voltage of 1mV for every 10mA of output current, so that the resolution of the display unit is 10mA. The 3162 accepts a maximum input voltage of 999mV. With \( S.c \) set to the 'V' position, the gate and source terminals of \( T_5 \) are connected to give a very high drain-source resistance. This enables ICs to measure the voltage across divider network \( R_3-P_3 \), which is directly proportional to the output voltage.

The network has been dimensioned to divide the voltage at \( A \) by 100, so that the display resolution in the 'V' position equals 100mV. Resistor \( R_4 \) has a high value to provide a small offset current for \( P_3 \) to enable a common zero setting arrangement with \( P_2 \) for both the current and voltage indication.

**Construction**

Since the present power supply is a highly dense unit, as can be seen from the photographs with this article, special attention should be paid to its construction, for some parts are quite difficult to reach once the supplies have been put together. It is, therefore, wise to carefully check...
Fig. 4 This opamp setup enables the output voltage to be set to 0 volts, without the need for a negative supply line.

Parts list

Resistors:
- $R_1, R'_1 = 100$
- $R_2, R'_2, R_3, R'_3 = 1k$
- $R_4, R_5 = 680$
- $R_6, R_7, R_8 = 1k$
- $R_9, R_10, R_11, R_12 = 10k$
- $R_13, R_14, R_15, R_16 = 100k$
- $R_17, R_18 = 47k$
- $R_19, R_20 = 1k$
- $R_21, R_22 = 220$
- $R_23, R_24 = 82k$
- $R_{25}, R_{26} = 820$
- $R_{27} = 47k$
- $R_{28} = 1k$
- $R_{29} = 100k$
- $R_{30} = 1k$
- $R_{31} = 10k$

Capacitors:
- $C_1, C'_1 = 3300$
- $C_2, C'_2 = 47n$
- $C_3, C'_3 = 10p, 40v$
- $C_4 = 2200, 40v$
- $C_5, C'_5 = 470, 40v$
- $C_6, C'_6 = 100n$
- $C_7 = 100n$

The completed circuit boards before actually mounting them inside the verobox.

Track layouts and component mounting plans for the preregulator and main PCBs are shown in Fig. 5b and 5a respectively. Note that these PCBs hold all parts for the dual power supply. The large free areas on the main PCB leave sufficient space for the front-panel mounted multturn potentiometers. As shown in the photographs of the completed unit, the main PCB is mounted vertically, a little behind the front panel. Note that this PCB is a double-sided type, but not through-plated, which necessitates great care in soldering component leads, because this will have to be done on both sides of the PCB. However, it is best to start construction with the preregulator PCB; there are two identical sections on this conventional board, its completion should not cause any problems. Both MOSFETs require a U-shaped heatsink, bolted directly to the transistor...
body. Fit soldering pins of suitable diameter into the holes marked 1...4, 1'....4' and ~.
Since the main PCB is mounted close to the front panel, it has holes for cable feedthrough. Four soldering pins are fitted on the PCB component side (points 5, 6, 5', 6'), and another eight (1, 2, 4, 7, 1', 2', 4', 7') at the soldering side.
Because of the high component density on the main PCB, some parts will have to be fitted vertically, and they must be soldered at both sides of the PCB. This method of construction requires a certain amount of care and attention, since it is not easy to remove a part mounted in this way. It is, therefore, strongly recommended to start completion of the main PCB with fitting these components. As for the plastic metal-foil capacitors, make sure to leave a little space between these and the PCB tracks to avoid short-circuits which are difficult to find later. Note that Cm and Cm' are mounted at the soldering side.

All ICs are preferably mounted in sockets; the displays, however, require wire wrap sockets with leads which are long enough to bridge the distance between front panel and main PCB; the wire wrap leads may in turn be plugged into conventional IC sockets on the main PCB. In any case, the displays should be pressed to the red display window in the front panel to ensure maximum brightness. The LEDs used in this power supply are mounted in a similar manner with suitable lengths of solid wire.

When all parts have been fitted onto the PCBs, the supply wiring may be started with reference to Fig. 6. Wires carrying high current must, of course, be of suitable cross-sectional area, whereas normal, thin wire is sufficient for the connection of potentiometers and switches. In general, keep the wires as short as possible.

Transistors T1 and T1' are fitted onto a common heatsink, bolted to the rear panel of the verobox, in which a rectangular clearance has been made to allow direct thermal contact between transistor body and heat sink. Do not forget to insulate the mica washers and a generous amount of heat conducting paste when fitting the power transistors. The aluminium front panel of the verobox is next drilled and deburred. To get the holes in the right places, use the template supplied with the self-adhesive front panel foil.

Before the PCBs are fitted into the box, a support bracket will have to be made from sheet aluminium (2 mm or thicker) — see Fig. 7. This bracket serves to hold the transformer and preregulator PCB, whilst providing a shield between transformer and main PCB, since the bracket is connected to the mains earth line.

The verobox enclosure has a number of guides for PCB mounting, but these will have to be removed with pliers and a file before the PCBs can be fitted snugly. Remember to drill a number of ventilation holes in the box, both in the lid and in the bottom plate to assist in cooling the power transformer, preregulator FET, bridge rectifiers, and other heat dissipating components inside.

The parts Da, Ca, and Cm must be connected direct across the output terminals, and a 100 nF capacitor, C0, between the output minus terminals, while another 100 nF capacitor, C0', must be connected between one of these minus terminals and the aluminium front panel.

It should be noted that both supplies operate completely independently of
Fig. 5 These are the PCBs for the dual power supply. One holds two preregulator sections (Fig. 5b), the other (Fig. 5a) is a double sided type for the regulator and display sections of both power supplies. Note that identical parts in the second unit have been marked with an apostrophe (').

Fig. 6 Wiring plan for the dual power supply. Keep cable lengths to a minimum and use heavy gauge wire where high current flows.

Setting up

The necessary adjustments may be divided into two groups: first, there is the setting of the voltage drop across the series regulator transistors $T_s$ and $T_s'$ ($P_3$, $P_3'$), second, the presets for calibration of the digital readout section ($P_5$, $P_5'$, $P_6$, $P_6'$, $P_7$, $P_7'$).

For a speedy and precise calibration, use a digital multimeter (DMM), set to the 2A DC range. Turn $P_3$ and $P_3'$ fully anti-clockwise to obtain a maximum voltage drop across the series regulator transistors.

Connect the DMM directly to the output terminals of the supply to be calibrated. Now turn the voltage control to a low output voltage. Turn $P_3$ (current limit) fully clockwise and check if the DMM reads a short-circuit current of about 1.25A; when this value needs to be corrected, $R_3$ may be given a different value.

Next, carefully turn $P_3$ clockwise until the output current drops to zero. Turn $P_3$ once more slightly anti-clockwise to restore current flow, which will correspond to a voltage drop of 8V across $T_s$.

Since the other power supply is entirely identical, the same calibration procedure is followed. Note that the setting of $P_3$ is fairly critical, and the outlined calibration method is best repeated several times with both power supplies warmed up and terminated as indicated.

Calibration of the display units is performed as follows. Set $S_2$ to the 'A' position and disconnect the DMM. Set $P_5$ to obtain a zero reading (0.00) on the displays. Connect the DMM again and set the supply to a current of 1A on the DMM. Now turn $P_5$ to obtain a reading of 1.00A on the relevant display unit. The voltage calibration is also quite straightforward.

Set the supply voltage to give a reading of 10.0V on the DMM, switch $S_2$ to 'V', and adjust $P_3$ to obtain the same voltage indication on the displays.
Adjust the other display unit in the same way.
The maximum output voltage may be set to exactly 20.0V by altering the values of voltage dividers R1–R16 and R17–R34, but note that each of these is made of two resistors of equal value.

Fig. 7 This aluminium support bracket acts as a shield between PCB and power transformer.
RF CIRCUIT DESIGN

Third in the series, this article discusses aspects of good VHF preamplifier design, before proposing a practical circuit that enables reception of FM broadcast signals hitherto lost in noise.

VHF PREAMPLIFIER

Some of the important aspects in aerial amplifier design have already been covered in Elektor Electronics, March 1986 issue, along with the prerequisites for successful VHF filter realization. While the points discussed in that article remain fully valid, the present article aims to look at the most important technical characteristic of any VHF preamplifier stage: its noise figure.

While many of today's FM tuners have very sophisticated tuning control systems and excellent stereo demodulation, the design of up-to-date RF amplification and first mixer sections often deplorably lags behind. Since it is certainly not advisable to embark upon a complete reshuffle of the proprietary RF parts in the receiver front end, an add-on preamplifier stage of good design may prove helpful in updating the receiver performance to a considerable degree. Moreover, as the above mentioned article already pointed out, a VHF aerial booster should not be mounted in the receiver, but at the other end of the downlead coax cable, at the one and only place where it is effective; direct at the aerial connections (masthead mounting).

Noise

There are a number of basic considerations to go with design and construction of an RF preamplifier stage, if this is to operate in the very high frequency (VHF) range, generally referred to as 50...300 MHz. A section of this band is of special interest for this article, namely the FM broadcast band, which extends from 88 to 108 MHz; while being quite crowded with local stations in most built-up areas, only few stations may be received in rural districts. This is due to the straight line propagation characteristics of the RF waves at these frequencies, which makes it impossible to receive over-the-horizon stations, except during special weather conditions.

A typical daytime FM-band spectrum (= survey of signal strengths within a certain frequency band) may look very much as sketched in Fig. 1a; there are a number of very strong transmissions, as well as relatively weak and also nearly invisible (i.e. inaudible) ones, sometimes quite close to one another. This spectrum is purely hypothetical, however, since it is a representation of relative signal strengths at the aerial connections, i.e. without noise caused by any active electronic device. Obviously, the spectrum analyser itself would feature a certain amount of self-generated noise, but this has been disregarded for the sake of clarity. The low noise level $N_0$ in Fig. 1a is, however, present at any...
VHF aerial, since this picks up a certain amount of atmospheric noise; the nature of this effect would lead us into theoretical physics, which is beyond the scope of this article. Spectrum analysis of the preamplifier output signal (Fig. 1b) reveals that while all signals have been amplified, a certain amount of additional noise is introduced by the aerial booster, to the effect that some signals have got lost underneath the noise threshold $N_o$ and are, therefore, inaudible in the receiver. Since the amplifier noise output is not caused by amplification of the atmospheric noise level $N_o$ (compare the signal levels of $f_2$ in Fig. la and 1b), level $N_o$ must needs be generated by the amplifier itself; clearly, this is an undesirable effect.

If we consider the effective signal strengths of, for instance, the transmission at $f_1$ in Fig. la as opposed to Fig. 1b, the total noise factor of the amplifier stage may be defined as the overall ratio of the output signal/noise ratio to the input signal/noise ratio, or

$$F = \frac{S_o}{N_o} / \frac{S_i}{N_i}$$

(1)

the noise figure may be calculated from $F$ using

$$F_{DB} = 10 \log_{10} F$$

(2)

Clearly, $S_o/N_o$ for $f_1$ is worse (lower) than the original $S_i/N_i$ and this arises from the extra amount of noise generated by the amplifier. Were this device ideal, then

$$S_o/N_o = S_i/N_i$$

or $F = 1$, or $F_{DB} = 0$ dB

(3)

Unfortunately, no electronic device has been developed as yet for use in the ideal preamplifier, nor will it ever be developed, due to some basic laws of physics. However, modern SHF transistors are now readily available with noise figures as low as 0.15 dB at 1000 MHz, while Gallium Arsenide (Ga-As) FETs have been designed to achieve 2.8 dB at 12 GHz; however, the cost and circuit design complexity of these devices puts them well beyond the reach of the average home constructor. The importance of a low preamplifier noise figure is evident after a comparison of Figures 1b and lc; while its signal gain (amplification factor) is still $10$ dB, the amplifier of Fig. lc has a noise figure improved by 4 dB, which enables reception of signals that were inaudible with the $F=6$ dB amplifier of Fig. 1b. We may, therefore, establish the general rule that reception is improved with a lower preamplifier noise figure. Thus, designing for low noise should be a high priority issue.

So far, only the active device in the preamplifier has been held responsible for the noise addition, but it should be pointed out that this device can only attain its minimum noise contribution when supported by passive components that ensure thermal stability and low signal insertion loss at the amplifier input. It will stand to reason that any mismatch at the booster input will adversely affect (i.e. increase) the transistor noise figure as given in the manufacturer's data sheets.

No preamplifier stage, however low its noise figure, will be capable of reception improvement if the signals at the target frequency have been considerably attenuated before being applied to the first active device, either by downlead cable losses or a severe mismatch at the booster input. As the above mentioned article pointed out, however, the preamplifier input necessarily consists of a low-loss filter, which serves both the function of an out-of-band signal attenuator and signal source to transistor input impedance transformer (source matching). It should be fairly obvious by now that the actual gain of the booster is far less important than its noise figure; if the former is some 10 dB higher than the downlead cable attenuation, adequate results are usually obtained; a gain of 15...20 dB is common for a single-transistor preamplifier stage.

### Practical circuit

The circuit diagram of the present VHF preamplifier is shown in Fig. 2. The RF signal at the input is passed to the base of $T_i$ by a capacitance-tuned, inductive top-coupled, low insertion loss and source matching bandpass input filter with a $-2$ dB bandwidth of 20 MHz (88...108 MHz). This is quite a mouthful for a basically simple filter that performs the functions outlined above. Note the taps on $L_1$ and $L_2$ to obtain impedance matching of the cable and the transistor respectively. Any of the listed transistor types may be used in the circuit, but the Type BFQ69 is preferable because of its extremely low noise figure. Since this transistor has been introduced only quite recently, however, it may prove difficult to get hold of. The amplifier is fed by the receiver power supply over the downlead coax cable; the parts to the right of the dotted line are, therefore, mounted in the FM tuner. Decoupling parts $L_3$ and $C_7$ ensure that no RF signal is lost in the power supply. The amplifier bias setting is effected with $P_1$; depending on the transistor in use, this preset may be adjusted to find the right compromise between
optimum noise figure (low current) or maximum amplification with acceptable intermodulation response (high current). For further details on the bias setting of RF preamplifier transistors, refer to Elektor Electronics, February 1980 issue. Fig. 3 shows three curves relevant to the new BFO69; a collector current of 15 mA appears to be suitable for a minimum noise figure of about 1 dB, which will bring the total noise figure of the present design in the 1...2 dB range with a Type BFQ69 fitted and the filter tuned to optimum input matching. However, the Types BFR34A and BFR96S will also ensure a noise figure that is usually far better than the average FM tuner specification in this respect.

The coils and chokes for the present design are wound as follows:

- $L_1 = 4$ turns 20SWG (ø 1 mm) enamelled wire, close wound on dia. 6 mm, tap at 1.5 turns from earth.
- $L_2 = 11$ turns 20SWG enamelled wire on toroid core Type T50-12 (Amidon).
- $L_3 = 4.5$ turns 30SWG (ø 0.3 mm) enamelled wire through 3 x 3 mm ferrite bead.

For more information on inductor calculations and specifications, refer to last month's issue of Elektor Electronics.

Construction and alignment

The present amplifier is fitted on the universal RF board 85000 as shown in Fig. 4; not shown are the bias setting parts, since these are mounted in the receiver. After completion, the unit may be tested by tuning the receiver to a weak transmission at about 95 MHz and adjusting $C_1$ and $C_3$ for optimum reception. The collector current setting should be fairly un-critical; its precise effect on the amplifier performance can only be judged when a very stable and yet sufficiently weak transmission is being received and the input filter has already been correctly tuned. Finally, the preamplifier may be fitted in a suitable water-resistant case for masthead mounting, equipped with suitable coaxial sockets, and fixed to the aerial mast.
CORRECTIONS

**KITT scanner**  
(March 1985, p. 24)  
In a number of PCBs for this project two connections have been omitted. Check, therefore, whether there are connections between IC2 pin 16 and IC3 pin 16, and between IC3 pin 3 and IC3 pin 4. If not, make them with a short length of wire.

**Active subwoofer**  
(March 1986)  
Owing to a printers' error, Figures 1a and 1b (p.29) have been interchanged.  
The end of paragraph 2 on p.33 should read: (use 68 nF or 0.1 μF)

**RF Circuit Design**  
- 2  
(March 1986)  
The value of f in Fig. 4b (p.53) should read 66.0 MHz, not 66.0 Hz.

**MSX Extensions**  
- 3  
(March 1986)  
The caption to Fig. 5 on p.60 should have read: "For slot signal functions see Infocard 121 on page 81 of this issue". Note that further information on the connector is given in Infocard 122 in this issue (p.81).
MAKE YOUR OWN PCBs
MAKE YOUR OWN PCBs

Real-time clock

Satellite loudspeakers
MAKE YOUR OWN PCBs
Dear Sir—May I first congratulate you on an excellent magazine. I have at present a fully functional 6502 Housekeeper and a functional Rugby Receiver. What I require though is the EPROM for the Rugby receiver in order to be able to combine these two excellent projects. As far as I am aware, the EPROM was never available from yourselves or from Technomatic. Since you have a fully operational Rugby Housekeeper, would it be possible for a copy of the EPROM to be made? I would, of course, pay for the necessary costs incurred.

GEORGE PAVLOU EDGWARE, LONDON

Contrary to your information, the EPROM is available from ourselves or from Technomatic under No. 512. Success with the completion of the project! Ed.

Dear Sir—I must say in all honesty that I am not a regular reader of your magazine, but a friend has suggested that you are always very helpful with queries. I am an amateur botanist of some standing, and I urgently require information, circuits, etc. for a BIO-FEEDBACK machine. None the less, the following may be of interest to you: Electronics and Plant Physiology (EE, July 1983); pH Meter (EE, March 1985); and House Plant Protector. The last title appears in one of our books, Projects for Home and Garden. I hope one or more of these may prove useful to you. Ed.

Dear Sir—I am one of your magazine’s subscribers in Ireland. I decided to make the VDU card board (EE, September 1983), but found that there is no figure of the printed circuit for this board. Also can you please supply the contents of the 2732 memory?

S ALI MIRPOUR TEHRAN

It is very difficult, if not impossible, to make the double-sided board (with plated-through holes) at home, but the complete board is still available through our Readers’ Services (No. 83092). Similarly, the only way of obtaining the contents of the 2732 memory is to buy this EPROM (No. 525) through our Readers’ Services. Ed.

Dear Sir—Thank you for your letter of 22 November last answering my queries on the Wireless Microphone project of June 1984. Unfortunately, I have come up against one further blockage, namely the supply of L3 for the receiver part, rated 0.82 μH, for which I cannot find a supplier. Could you please advise one?

A J BRADLEY AUGHION, ORMSKIRK LANCS

Dear Sir—with reference to the Personal FM (September 1983) I am having difficulty in obtaining the 0.22 μH coils and L3 (=Toko ES26HNA100114). I have tried Cricklewood and Technomatic, but neither of them stock these items. Can you help?

M GULAMHUSEIN PETERBOROUGH

RF inductors from 0.10 μH to 1 μH in ten standard values are available from ElectroValue (limited range) at (0784) 33603 or (061) 432 4945; Maplin (limited range) at (0702) 552911, or STC Electronic Services (full range) at (0279) 26777. Cirkil Holdings PLC at (0992) 444111 is the sole distributor for Toko in this country and they should, therefore, be able to supply the ES26HNA100114. Ed.

Dear Sir—for some time I have been a regular reader of the German Elektor and have recently become a subscriber to Elektor Electronics. I hope to see construction articles for video equipment, e.g. an enhancer with fade facility, or a converter (Mac D to PAL) for use with a small dish antenna in preparation for the future DBS satellite TV transmissions. I have already constructed the video mixer and incorporated a sound mixer to take in the original sound from the video tape plus two further sound inputs: for microphone and music, and it works first class. Incidentally, I built the video colour inverter (October 1984) and I would like to hear from any reader who SUCCESSFULLY built this project as in my case I cannot obtain the change from complementary colours through black/white (where it stays) to normal colour. I would also like to see a construction article for a separate title; I assume it may be a little tricky, but as many video cameras have such a facility, there must be a chip in existence to do it.

FRANK CROXON ÜHLINGEN-BIRKENDORF BRD

Your suggestions for future articles have been passed to our technical boffins who, hopefully, will come up with some sort of answer in the near future. The idea of the Mac D to PAL converter looks particularly promising as we are already thinking along these lines. I have sent a copy of your letter to the designer of the video colour inverter for advice on the difficulties you are experiencing; as soon as I hear from him I will be in touch again. In the mean time, some other readers may come up with helpful suggestions. Ed.

Dear Sir—I am faced with having to build a high-quality audio pre-amp. Any designs applicable in Elektor Electronics publications? Thanks in advance.

G ADAMS POOLE, DORSET

Suitable designs might be: MC/MM Phone Pre-amplifier (April 1983) and/or Dynamic Pre-amplifier (October 1984). Of the two, the first is probably the more suitable for your purposes. Ed.
This mixer is not designed for the occasional party, where one slide control per channel will suffice. Rather, it is intended for the serious electrophonics enthusiast. And quite naturally, therefore, it has all the facilities such users have come to expect.

Professional mixers are expected to meet a long list of special requirements: balanced and unbalanced inputs and outputs; independent control of each channel for driving special effects equipment and monitors; automatic setting of input sensitivity to match the signal level; multiple tone controls per channel; and many more. No wonder that such mixers are, to put it mildly, pretty expensive. It is, however, possible, to build one of comparable quality at much lower cost, as described in the following pages.

Modular construction
The mixer is constructed from four modules. A fifth module provides the power for the entire mixer. The mono input unit is almost certainly the most often used module. Its input sensitivity is adjustable between 0 dB and +60 dB. This enables all sorts of mono signal sources, from microphone to keyboard, to be connected to this module. The unit is provided with a three-way tone control; a peak indicator for possible overloads; a monitor; a multi-track or PFL (pre-fade listening) control; and
a panorama control. Balanced inputs are standard, but any of these can be made unbalanced by connecting one of its terminals to earth.

The stereo input unit is intended for use with a wide variety of signal sources. Its input can be switched between MD (variable-reluctance pick-up), AUX (high-level stereo), and LINE (mono). The latter position is for use in the event the mono module is not available. The balance control functions as panorama control when the input is switched to LINE.

The headphone-monitor module contains a stereo headphone amplifier via which each module may be monitored. Unlike the other modules, this unit is provided with a parametric equalizer instead of a three-way tone control. This is a very useful facility, because it enables any tendency to acoustic feedback between the microphone and monitor loudspeaker to be suppressed effectively. The main controls and output terminals of the special effects channel are also fitted on this module.

The most important unit is the output module. Apart from the main tone control and other refinements, it has a stereo LED VU (volume unit) meter. The output is available as a balanced or as an unbalanced signal.

Power supply

Since any equipment is only as good as its power supply, all the supply lines in the present mixer are stabilized twice: once in the power unit and once in the relevant module. Apart from its mains transformer and on/off switch, the power supply unit shown in Fig. 2 is contained on a separate printed-circuit board. It is suitable for the supply of up to eighteen modules.

Regulators IC1 and IC2 hold the supply voltage, preset with the aid of R3-R4, at +18 V. Transistors T1 and T2 and associated RC networks ensure a sufficiently slow rise of the supply voltage to prevent loudspeaker clicks when the mains is switched on. Resistor Rs is a voltage-dependent resistor that suppresses noise present on the mains.

Switch S2 enables the mains earth to be isolated from the case earth, which may be necessary in certain theatres. If S2 is open, and something goes wrong, neon lamp La breaks down, and the mains fuse blows.

The values of resistors Rs and R3 can be ascertained precisely for any individual power unit by replacing them by two 5 k preset potentiometers. Adjust these presets until the output of the relevant regulator is 18.1 V. Switch off, remove the presets, and carefully measure their values with an ohmmeter. Fixed resistors with values so found should then be soldered in the Rs and R3 positions (this may, of course, entail making up a parallel combination to obtain the correct values). Check that the output voltages of the regulators are still ±18 V.

MIC-LINE module

Although the number of presets may give the impression of complexity, the circuit in Fig. 3 shows that this would be misleading. Operational amplifiers A1, A2, and A3 form an instrument amplifier that provides properly balanced inputs. The sensitivity of the microphone input is about 30 dB higher than that of the line input.

Fig. 1. The front panels of (a) the MIC-LINE module; (b) the stereo module; and (c) the power unit.
To keep the overall noise level down, $A_1$ and $A_2$ are low-noise types, while $R_1$ to $R_{13}$ incl. are high-stability (%) metal film resistors.

Gain control $P_4$, which enables setting the gain between 20 dB and 60 dB, must be a high-quality type, because it is located in a noise- and scratch-sensitive position.

The peak indicator is formed by transistors $T_1$ and $T_2$. The threshold of operation is fixed at $9 \text{ V}_{\text{pp}}$ or $3 \text{ V}_{\text{rms}}$ by voltage divider $R_{14}$-$R_{15}$. These levels correspond to a microphone input of $3 \text{ mV}_{\text{rms}}$ at maximum amplification. Reservoir capacitor $C_3$ ensures that short-duration overloads are also clearly indicated.

Coupling capacitor $C_4$ prevents any DC reaching the potentiometers and connects the amplified input to the three-way active (A4) tone control. Effects control $P_6$ sets the wanted monitor output level.

Stereo slide potentiometer $P_7$ is the fade control.

Since a signal to drive a multi-track recorder is also required, slide control $P_7$ - the fader - is a stereo type to prevent any feedback between the stereo channel and the multi-track outputs. An alternative to this arrangement is to provide each channel with a PFL (pre-fade listening) facility; $C_{11}$-$R_{13}$ can then be omitted. $P_7$ can be a single track control, and $S_1$ and $R_{14}$ are fitted externally.

Stereo input module

The stereo input module -see Fig. 7- has no balanced input: instead, it is provided with an equalizing pre-amplifier, formed by $A_1$ and $A_2$; $A_1'$ and $A_2'$, for use with variable-reluctance pick-ups.

Input selection is effected by $S_1$: position 1 is for variable-reluctance pick-ups; position 2 for high-level inputs, such as from tape recorders; and position 3 for mono signals.

Position 3 is for use when the MIC-LINE module is not available, or, for instance, when more equipment is to be connected than was originally foreseen. Note, however, that only line signal sources can be connected: not microphones. The (unbalanced) signal is then taken from the right-hand AUX input, and amplified in $A_3$ and $A_3'$ by a factor 3. Stereo potentiometer $P_4$ provides a monophone effects signal, but is arranged such that its input and output resistance are equal, whatever the position of the wipers.

The active tone control is followed by the controls for the monitor output ($P_7$), the channel output ($P_{26}$), and the balance ($P_8$). With $S_2$ in position 3 (LINE), the balance control functions as panorama control.

A multi-track output is not necessary in this module, because the unit is normally fed from a multi-track tape machine.

If the MD input is not required, the operation of $A_1$ ($A_1'$) can be made linear by omitting $C_1$ and $C_3$ ($C_3'$ and $C_5'$), and replacing $R_3$ and $R_4$ ($R_4'$ and $R_5'$) by $R_{11}$ ($R_{11}'$). The value of the new resistor may be calculated from:

$$R_{11} = R_3 \frac{1}{1-a} \Omega$$

where $a$ is the amplification of the amplifier. If the amplification is large, $R_{11} = R_3$. 

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**Fig. 2. Circuit diagram of the power unit.**
Parts list

Resistors:
- \( R_1 = 2 \text{M}\Omega \)
- \( R_2 = 220 \Omega \)
- \( R_3 = 3 \text{k}\Omega \)
- \( R_4 = 120 \Omega \)
- \( R_5 = 47 \text{k}\Omega \)
- \( R_6 = \text{voltage-dependent resistor Siemens Type S10V-S10k250} \)
  (may be available from ElectroValue — telephone 0784 33603, or 061 432 4945)

Capacitors:
- \( C_1, \ldots, C_4 = 47 \text{nF} \)
- \( C_5 = 47 \text{nF} / 250 \text{VAC} \)
- \( C_6 = 47 \text{pF} / 40 \text{V} \)
- \( C_7, C_8 = 100 \text{nF} \)
- \( C_9 = 100 \text{nF} / 250 \text{VAC} \)
- \( C_{10} = 10 \text{\uF} / 25 \text{V} \)

Semiconductors:
- \( D_1, \ldots, D_4 = 1N5401 \)
- \( D_5, D_6 = 1N4001 \)
- \( T_1 = BC557B \)
- \( T_2 = BC54713 \)
- \( I_C1 = LM317T \)
- \( I_C2 = L05377 \)

Miscellaneous:
- \( S_1 = \text{SPST mains switch suitable for PCB mounting} \)
- \( S_2 = \text{SPST switch} \)
- \( F = \text{miniature fuse; 1 A; delayed action; complete with PCB type carrier} \)
- \( L_{a1} = \text{neon bulb without bias resistor} \)
- \( L_{a2} = \text{neon bulb with bias resistor} \)
- \( T_n = \text{toroidal mains transformer; 2 x 18 V; 0.83 A secondary} \)
  (e.g., ILP Type 11014)
- \( K_1 = \text{13-pole PCB connector to DIN41617} \)
- \( \text{Heat sinks for } I_C1 \text{ and } I_C2 \)
- \( \text{Front panel foil 86012-4F} \)
- \( \text{PCB Type 86012-4F} \)

Fig. 3. The printed-circuit board for the power unit.
Fig. 4. Circuit diagram of the MIC-LINE module.

Parts list

 Resistors:
 R1 = 100 k* 
 R2 = 1 k* 
 R10; R11 = 1 k* 
 R12; R13 = 10 k* 
 R14 = 100 k* 
 R15 = 6 k* 
 R16 = 2 k* 
 R17 = 47 k* 
 R18 = 1 M* 
 R19 = 25 k* linear potentiometer
 R20 = 25 k* logarithmic potentiometer
 R21 = 100 k* linear potentiometer
 R22 = 10 k* logarithmic potentiometer
 R23 = 10 k* linear potentiometer
 R24 = 10 k* logarithmic potentiometer

Capacitors:
 (Polycarbonate or polystyrene unless otherwise indicated)
 C1; C2 = 15 p
 C3 = 200; 16 V
 electrolytic
 C4; C5 = 10 µ; 40 V
 bipolar electrolytic
 C6 = 47 n
 C7 = 56 n
 C8 = 22 n
 C9 = 470 n
 C10 = 22 n
 C11; C12 = 100 n
 C13; C14 = 100 n
 C15; C16 = 10 p; 16 V
 electrolytic
 C17 = 100 n

Semiconductors:
 D1; D2 = 1N4148
 D3 = LED; ref
 T1; T2 = BC558B
 IC1 = NE5532 or LM833
 IC2 = LF356 or TL071
 IC3 = TL072
 IC4 = XR4195 (see fig. 6)

Fig. 5. The printed-circuit board for the MIC-LINE module.
Capacitor C (C1) may be adapted to match the output impedance of the tape machine used.

**Construction**

Before buying any new components, it is wise to determine how many modules are required. Prepare the printed-circuit boards shown in Fig. 5, Fig. 8, and Fig. 9; note that the board in Fig. 8 consists of two parts, which must be separated before any components are fitted.

The dimensions of the front panels are given in Fig. 10: 10a is that for the MIC-LINE module; 10b that for the stereo module; and 10c that for the power supply. The overall length will, of course, depend on the cases used. The prototype was built in one aluminium case with compartments for the various modules. The construction of this will be described in next month's issue.

In the mean time, the completed modules may be tested by connecting their outputs to the TUNER or

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Fig. 6. Where a Type XR4195 voltage regulator is not available, it may be replaced by a 78L15 and a 79L15 connected as shown here.

Fig. 7. Circuit diagram of the stereo module.
Fig. 8. The printed-circuit board for the stereo module consists of two parts, which must be cut apart before any components are fitted.

Parts list

Resistors:
- $R_1, R_2, R_3 = 100 \text{k}
- $R_4, R_5, R_6 = 390 \text{Q}
- $R_7, R_8 = 16 \text{k}
- $R_9 = 68 \text{k}
- $R_{10}, R_{11} = 47 \text{k}
- $R_{12}, R_{13} = 10 \text{k}
- $R_{14}, R_{15} = 22 \text{k}
- $R_{16}, R_{17} = 1 \text{M}
- $R_{18}, R_{19} = 68 \text{k}
- $R_{20} = 1 \text{k}

- $P_1 = 25 \text{k} \text{linear stereo potentiometer}$
- $P_2, P_3 = 100 \text{k} \text{linear stereo potentiometer}$
- $P_4 = 25 \text{k} \text{logarithmic stereo potentiometer}$
- $P_5 = 10 \text{k} \text{logarithmic stereo slide potentiometer}$
- $P_6 = 10 \text{k} \text{linear stereo potentiometer}$

- 1% metal film type
- with 4 mm spindle for PCB mounting

Capacitors:
(polycarbonate or polystyrene unless otherwise indicated)
- $C_{1}, C_{2} = 100 \text{n}
- $C_{3}, C_{4} = 220 \text{n}
- $C_{5}, C_{6} = 10 \mu \text{F}, 6.3 \text{V}$
- $C_{7}, C_{8} = 4 \mu \text{F}$
- $C_{9}, C_{10} = 47 \text{n}$
- $C_{11}, C_{12} = 10 \mu \text{F}, 40 \text{V}$
- $C_{13} = 15 \text{n}$
- $C_{14}, C_{15} = 22 \text{n}$
- $C_{16}, C_{17} = 10 \text{p}$
- $C_{18}, C_{19} = 10 \text{p}$
- $C_{20}, C_{21} = 100 \text{p}$
- $C_{22}, C_{23} = 10 \mu \text{F}, 16 \text{V}$
- $C_{24} = 2 \mu \text{F}, 16 \text{V}$

- See text
AUX input of a stereo power amplifier, and injecting a suitable signal into the various module inputs. The correct operation of all potentiometer controls can then be checked.

Part 2 of the *Portable Mixer* will appear in the May issue of *Elektor Electronics*.

![Image](image-url)

**Fig. 9.** This illustrates how the boards can be screwed together.

**Semiconductors:**
- D1, D2 = 1N4148
- D3 = LED, red
- T1, T2 = BC557B
- IC1, IC2 = NE5532 or LM333
- IC3 = LM308
- IC4 = XR4195 (see fig. 8)

**Miscellaneous:**
- S1 = 3-pole 3-position rotary switch
- S2 = DPST mini switch
- 3.5 mm insulated stereo chassis socket (6.3 mm dia. mounting hole)
- XLR Cannon-type 3-pin chassis socket
- 13-pole PCB-type connector to DIN41617
- Knobs for potentiometers as required
- Front panel foil
- PCB Type 86012-2

* * available through our Rentors Services. (see p. 82)

**Fig. 10.** Drilling plans for the front panels: (a) the MIC-LINE module; (b) the stereo module; and (c) the power unit.
New catalogues

Note that catalogues listed here may not be free of charge, although most of them are. Furthermore, not all businesses publishing a catalogue are prepared to accept orders from other than professional or business customers.

Texas IC applications book

The first volume of a new series of semiconductor device applications handbooks, Linear and Interface Circuits Applications, dealing with amplifiers, comparators, timers, and voltage regulators, has been announced by Texas Instruments. After a brief introduction, which explains that the selected circuit examples have accrued from customer inquiries and related laboratory simulations, in many cases there are solutions to actual customer design problems. Linear and Interface Circuits Applications: Volume 1 is available at £6.50 per copy plus £1.50 for postage and packing from Texas Instruments Limited P O Box 50 Market Harborough Leicestershire

Three brochures from Lucas NSF

Lucas NSF have recently published technical literature for three new product groups. Subminiature rotary code switches. This switch range gives a wide combination of coded and sequential outputs in a subminiature package. The literature contains details of the switching capabilities, full dimensions, and mechanical and materials specifications. Miniature surface-mount elastomeric pushbuttons. Two sizes, two shapes, and ten colours, plus silicon rubber technology and surface-mount; full details of the Series EAS/M including dimensional and mechanical parameters are contained in this new publication. Keylock rotary security switches. These new switches provide economical and secure access to high-cost facilities. A six-position key-operated mechanism gives 1024 possible combinations in an economical and compact package. The leaflet contains dimensional and design specifications as well as technical data. Lucas NSF Limited Kenigley West Yorkshire BD21 5EF Telephone: (0535) 681144 Telex: 51270 Fax: (0535) 681980

VME-bus capability catalogue

BICC-Vero has published a useful 36-page, full-colour catalogue detailing its flexible range for configuring VME-bus solutions (VME=Versatile Module Europe). The catalogue details the complete spectrum of components necessary for building systems, including accessories, racks, boards, power supplies, systems, and software. A copy of the catalogue is available free on request from BICC-Vero Electronics Unit 5 Industrial Estate Flanders Road Hedge End Southampton SO3 3LG Telephone: (04892) Telex: 477984

Frequency control catalogue

Improved purchasing methods and larger stock holdings have enabled IQD to reduce the prices of many of their standard products. The catalogue also contains several new devices that will be of interest to many engaged in electronics and computers. Extensive stocks, first-class technical assistance, and competitive prices make IQD a leading supplier of crystals, filters, resonators, oscillators, and other frequency control components. IQD Limited North Street Crewkerne Somerset TA18 7AR Telephone: (0460) 74433 Telex: 45283 Fax: CCITT Group II

Crystals and ceramic resonators

An illustrated 6-page brochure illustrating their range of crystals and ceramic resonators is available from Golledge Electronics. The company can also provide crystals made to order. Golledge Electronics Merriott Somerset TA16 5NS Telephone: (0460) 73716 Telex: 46529

New brochure from Powerline

A new brochure giving full technical specifications on their Victor range of power supplies is now available from Powerline Electronics. These new units switch at frequencies of up to 1 MHz and at zero current and are claimed to produce half the heat and an order of magnitude increase in power density over conventional switched-mode regulation units. Powerline Electronics Limited 5 Nimrod Way Elgar Road Reading Berkshire RG2 0EB Telephone: (0734) 868557 Telex: 847973
**Gigadisc Optical Disc**

The considerable user benefits of optical data storage technology over conventional recording techniques are explained in a new 4-page publication from Thorn-EMI Datatech Limited. The brochure describes the performance of the new Gigadisc optical disc drive system, for which the company has the sole UK marketing rights. The laser-based system offers the ability to record 2 Gigabytes of digital data on each double-sided 12 inch disc. Guaranteed storage life is over ten years. The Gigadisc system can be used with virtually any type of computer system and is the first readily available product of its type with a write/read capability.

Copies of the brochure are available free on request from

Marketing Department
Data Products Division
Thorn-EMI Datatech Limited
Spur Road
Feltham
Middlesex TW14 0TD
Telephone: (01) 890 1477
Telex: 23995

**New mains filters**

A F Bulgin & Company PLC has published a new brochure illustrating its broad range of mains inlet filters.

Designed to protect electronic equipment from mains-borne interference and to reduce any similar emission the equipment itself may produce, the Bulgin range of mains filters incorporates models suitable for baseboard, bulkhead, panel, or PCB mounting with current ratings of 1 to 10 amperes.

Complying with inter-
national specifications, with approvals either gained or pending, all Bulgin filters, with the exception of PCB mounting versions, are enclosed in drawn steel casings, with provision for earthing. All versions are encapsulated. Medical filters PS621 exhibit exceptionally low-earth leakage currents of less than 100 μA, while in all other types leakage currents are less than 350 μA.

A F Bulgin & Company PLC
Bypass Road
Barking
Essex IG11 0AZ
Telephone: (01) 594 5588
Telex: 897255

**Friendly programmer**

A six-page colour brochure, Concentrated programming, describes the new ROM 5000D programmer from Micropross, for whom Euro Electronics is the UK distributor. The 5000D is a complete software engineering workstation designed to relieve the user of all tedious effort. It provides the ease of operation that is expected today, and programmes, verifies, and tests PALs, PROMs, EPROMs, IFLs, and embedded-memory microcomputers.

Euro Electronics Limited
Lancaster Gate House
319 Pinner Road
Harrow HA1 4HF
Telephone: (01) 863 0811
Telex: 23848

**Comprehensive fuse catalogue**

Now available from GCA Electronics is the latest 132-page, full colour catalogue Buss Fuses, a comprehensive guide to the range of Bussmann fuses, fuseblocks, and accessories. GCA is the fully franchised UK distributor of the entire range of Bussmann fuses and keeps an extensive selection of these devices in stock.

Reference data and application notes are an integral part of the latest catalogue and a design objective was to enable the engineer to make summary evaluations and time-saving pre-purchase analysis.

GCA Electronics Limited
Unit 2
Great Haseley
Oxfordshire OX9 7PF
Telephone: (08 446) 88612
Telex: 837150

**Weir 150-watt power supplies**

Weir Electronics Limited has published a new illustrated data sheet giving general and technical information on the SMM 150 Series of OEM switched-mode power supply units. The series includes five variants, all rated at 150 watts, and providing either four or five variable-regulated outputs. All models include a fully floating 5V; 20A main output and a -5V; 1A subsidiary output.

The four-page data sheet, printed in colour throughout with a four-colour photograph of the power supply, is available free on request from

Weir Electronics Limited
Durban Road
Bognor Regis
Sussex PO22 9RW
Telephone: (0243) 865991
Telex: 86543

**New Eurostyle cases**

A new brochure from Enclosure Technology Limited outlines the company's Eurostyle range of 19 inch card frame racks, single or double eurocard direct mounting racks, instrument cases, and tower systems illustrated in colour are various configurations of the Eurostyle system to show the adaptability of the system.

The Eurostyle system has a unique two-piece moulded foot that can be fitted in different ways to act as a tilt prop for instruments, as a retainer for stacked systems, and as a stabilizer for tower systems. Eurostyle is a registered trade mark of Enclosure Technology Limited.

Enclosure Technology Limited
Unit G
Southampton Airport
Southampton SO2 2HG
Telephone: (0703) 614533
Telex: 477045

April 1986
REAL-TIME CLOCK

A good many highly interesting computer applications will no doubt have been cancelled for lack of a programmable time keeping device. This article, however, offers a truly up-to-date RTC extension board to program dates with data!

With the presentation of the universal I/O bus in the May 1985 issue of Elektor Electronics, the peripheral handling capabilities of the popular C64 computer, as well as other personal micros, have been considerably enhanced, since the I/O bus board allows a number of extension boards to be inserted in a neat and versatile arrangement.

The present design enables the user to program real-time software drivers without the need for critical and cumbersome machine language wait loops. Time and data can now be read from and written to I/O addresses, in the very same manner as customary with peripheral control ports; the time updating process is autonomously controlled by a dedicated low-power chip: the Type ICM7170 manufactured by Intersil.

In order to be useful for many owners of personal micros currently on the market, the present add-on RTC board has been designed to operate in both 6502- and Z80-based systems equipped with Elektor's universal I/O bus. However, there is one important restriction for use with the Z80 processor: since the I/O bus was originally intended for the 65XX series of microprocessors as used in Commodore machines, no bus line is left over for the Z80 NMI or INT input; this means that the alarm and periodic interrupt facilities offered by the RTC chip can not be put to use in conjunction with the Zilog CPU. None the less, the time and calendar features of the ICM7170 will also be fully functional with the Z80.

Inside the RTC chip

Since the real-time clock controller (RTC) Type ICM7170 is an all-CMOS device with extremely low power consumption, it may conveniently be operated from a back-up battery to keep the internal oscillator and counter sections working when the computer supply voltage is off, or when a mains failure occurs.

The main features of the RTC chip in the proposed circuit may be summarized as follows:
- full compatibility with 8-bit microprocessor types that have either a fully decoded or multiplexed address bus;
- time registers supply binary coded data to simplify software;
- faultless RTC register-to-CPU data transfer thanks to intermediary buffer section;
- calendar with automatic leap year correction;
- chip switches automatically to backup supply;
- chip access time less than 300 ns;
- software selection of one of four crystal frequencies;
- data buffering after any read of 10 millisecond register (1/100th part of a second);
- programmable alarm with memory function;
- CPU interrupt requests generated by alarm section or by one of six selectable periodic signals;
- 2 µA typical standby current at 3V and oscillator frequency of 32 kHz.

The internal organization of the ICM7170 RTC controller is shown in Fig. 1. The chip has a low-power Pierce-type CMOS oscillator which only requires two external capacitors and a quartz crystal to obtain an accurate frequency standard for the present RTC extension board. One of the capacitors is an adjustable type for precise alignment of the crystal frequency, which is divided down to 4 kHz by a programmable prescaler section. By virtue of this prescaler, four crystal frequencies may be used with the on-chip oscil...
Table 1. COMMAND REGISTER ADDRESS (10001b, 11h WRITE-ONLY)

<table>
<thead>
<tr>
<th>D7</th>
<th>D6</th>
<th>D5</th>
<th>D4</th>
<th>D3</th>
<th>D2</th>
<th>D1</th>
<th>D0</th>
</tr>
</thead>
<tbody>
<tr>
<td>n/a</td>
<td>n/a</td>
<td>Test</td>
<td>Int.</td>
<td>Run</td>
<td>12/24</td>
<td>Freq.</td>
<td>Freq.</td>
</tr>
</tbody>
</table>

Table 2. CRYSTAL FREQUENCY 24/12 HOUR FORMAT RUN/STOP INTERRUPT ENABLE TEST BIT

<table>
<thead>
<tr>
<th>D1</th>
<th>D0</th>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
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<tr>
<td>0</td>
<td>1</td>
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<td>0</td>
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<td>1</td>
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Table 3. ADDRESS FUNCTION DATA VALUE

<table>
<thead>
<tr>
<th>A4</th>
<th>A3</th>
<th>A2</th>
<th>A1</th>
<th>A0</th>
<th>HEX</th>
<th>D7</th>
<th>D6</th>
<th>D5</th>
<th>D4</th>
<th>D3</th>
<th>D2</th>
<th>D1</th>
<th>D0</th>
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<tbody>
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<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>12 Hour Mode</td>
<td>Counter-hours</td>
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<td>0</td>
</tr>
</tbody>
</table>

Notes

* = not present in interrupt-mask register, MSB in interrupt-status register.
- = not used.
* = AM/PM in 12-hour indication mode; (AM = 0, PM = 1).
M = alarm time is compared with corresponding counter time when this bit is programmed low (0).

Table 4. INTERRUPT MASK REGISTER ADDRESS (10000b, 10h WRITE-ONLY)

<table>
<thead>
<tr>
<th>D7</th>
<th>D6</th>
<th>D5</th>
<th>D4</th>
<th>D3</th>
<th>D2</th>
<th>D1</th>
<th>D0</th>
</tr>
</thead>
<tbody>
<tr>
<td>n/a</td>
<td>Day</td>
<td>Hour</td>
<td>Min.</td>
<td>Sec.</td>
<td>1/10 sec.</td>
<td>1/100 sec.</td>
<td>Alarm</td>
</tr>
</tbody>
</table>

Interrupts

Table 4. INTERRUPT STATUS REGISTER ADDRESS (10000b, 10h READ-ONLY)

<table>
<thead>
<tr>
<th>D7</th>
<th>D6</th>
<th>D5</th>
<th>D4</th>
<th>D3</th>
<th>D2</th>
<th>D1</th>
<th>D0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int.</td>
<td>Day</td>
<td>Hour</td>
<td>Min.</td>
<td>Sec.</td>
<td>1/10 sec.</td>
<td>1/100 sec.</td>
<td>Alarm</td>
</tr>
</tbody>
</table>

Notes

- = not used.
* = AM/PM in 12-hour indication mode; (AM = 0, PM = 1).
M = alarm time is compared with corresponding counter time when this bit is programmed low (0).

Note that addresses 10010 up to and including 1111 (i.e. 12hex...1Fhex) are not used by the RTC chip.

Table 1. RTC command register organization.

Table 2. Programming functions of bits D6...D0 in the command register at address 11hex.

Table 3. Address organization for the RTC counter sections and their RAM counterparts.

Table 4. Organization of the internal RTC interrupt mask and interrupt status registers at address 10hex.
digital signals: 100 Hz, 10 Hz, 1 pulse/second, 1 pulse/minute, 1 pulse/hour, or 1 pulse/day. Provision has been made for both simultaneous and independent interrupt operation of the alarm and periodic signal circuitry.

Both the alarm and periodic interrupts are under the control of the interrupt-mask register (IMR) and interrupt-status register (ISR), the bit assignments of which are shown in Table 4. Selection of the desired interrupt signal is effected by setting the relevant bit in the IMR. By reading ISR, the CPU is informed about the nature of the interrupt request; ISR is automatically cleared by the falling edge of the CPU read pulse.

Whatever the source of the interrupt request signal, it may or may not be passed to the 6502 IRQ line depending on the logic level of the interrupt enable bit in the RTC command register (see Table 1). This bit controls an on-chip output FET which has its drain connected to the INT terminal (pin 12) and its source to the INTERRUPTSOURCE terminal (pin 11). This arrangement allows the INT output to be used in a wired-OR interrupt request bus configuration, together with other devices that may supply interrupts to the CPU. If an interrupt is generated by the RTC chip, the INT output will be at near interrupt-source potential, since the FET is switched on internally; this may occur both in the standby and in the power-down (battery back-up) mode.

If, as in the proposed circuit, the RTC supply voltage is connected to the Vss and Vdd terminals, and the interrupt-source connection also to Vdd, the INT output can only be active (i.e. logic low with respect to Vdd) in the presence of a sufficiently high chip supply voltage; that is, when the computer has been switched on (RTC fully operational). In case the user wishes to pass interrupts in the power-down mode only, pin 11 should be connected to the negative terminal of the battery at the Vbackup pin. This arrangement may be useful to activate a computer wake-up circuit after a predetermined time has elapsed since system power-down.

When the voltage between the Vbackup and Vdd terminals drops below 1 V, the RTC chip switches to the power-down mode with only the internal clock and interrupt sections active; all other functions are disabled to ensure minimum power consumption from the back-up battery. Chip terminals A7...A0, D0...D7, ALE, WR, RD, and CS are internally connected to Vss with a
single 50kΩ resistor. In case a battery back-up supply voltage can be dispensed with, \(V_{\text{bat}}\) may be connected to \(V_{\text{backup}}\).

**Practical circuit**

The proposed circuit of the real-time clock extension board for the universal I/O bus is shown in Fig. 2. Note that very few components are required to make a functional unit with the ICM7170 RTC chip in a 6502- or 280-based system. To select between these two types of microprocessor, the user need merely fit the appropriate wire links; connection to the I/O bus is through a standard 21-way PCB connector.

The ready-made PCB for this project is fitted with the necessary parts as shown in the mounting plan of Fig. 3. Note that the battery is an integral part of the completed RTC board; it may be charged from the computer +5V supply by means of D1 and 111. Since it was considered a waste of available I/O address space to reserve 17 memory locations or I/O channels for the RTC registers, IC1 and IC2 latch the RTC register number which must be supplied as a databyte with a POKE or OUT instruction to an address within the slot that has a 0 for address line A5; the contents of the RTC chip registers are next read from or written to an address within the same slot with A high (I). Since every slot offers four I/O addresses (see the article on the universal bus, *Elektor Electronics*, May 1985), both the latch and the RTC chip appear two times within the slot occupied by the present extension board. Finally, Z80 programmers are referred to the first article in the series on MSX extensions in the January 1986 issue of *Elektor Electronics* to find details on modification of the universal I/O bus as required for this CPU.

**Setting up**

As can be seen from Table 1, the real-time clock may be stopped and started by programming bit D3 in the command register; this bit controls the 100 Hz clock input to the counter sections. To stop the clock in order to synchronize it with an available time standard, D3 must be set low (0). The desired start time for the RTC is next loaded into the time registers; the correct data is also supplied, and the RTC may be started at the desired time by setting D3 again (I). To enable the CPU to read glitch-free and therefore absolutely stable time data from the RTC chip, time register data are passed through a buffer section before being transferred to the CPU databus during a read cycle. However, this buffer is only loaded when the 10 ms register is read, and programmers are advised to start any time reading from the RTC chip with a read of this latching register to ensure that time data are stable and accurate. The command register comprises a TEST bit (D5) to apply the internal 100 Hz signal to the seconds counter; this will cause the clock to run a hundred times faster than normal, which may be useful for test purposes. It will be evident that the accuracy of the present RTC board depends solely on crystal stability and correct frequency setting of the oscillator. Outlined below is an preferred alignment method using a period counter such as the one featured in *Elektor Electronics*, January 1985. To prevent the RTC INT output from actually generating an interrupt pulse in the computer during the alignment session, temporarily disconnect the wire at pin 12 of IC3.

First, write all zeros to the IMR. Next, load the command register with decimal values 24 or 28 (18 or 1C hexadecimal respectively) to run the clock in either the 12- or 24-hour mode with interrupts enabled. Now set D3 in the IMR to generate periodic interrupts with a frequency of 1 Hz. Adjust capacitor \(C_2\) for an indication of exactly 1.000 second on the period counter which should be connected to the RTC chip INT output (pin 12). For this measurement, the period counter should be set to trigger on the falling edge of the digital input signal. Reset ISR by

---

**Parts list**

- **Resistors:**
  - \(R_1 = 2k\)Ω
  - \(R_2 = 10k\)Ω

- **Capacitors:**
  - \(C_1 = 15p\)
  - \(C_2 = 10-33p\) trimmer
  - \(C_3, C_4 = 100n\)

- **Semiconductors:**
  - \(D_1 = 1N4148\)
  - \(IC_1, IC_2 = 74HC(T)/LS173\)
  - \(IC_3 = ICM7170\) (Intersil)
  - \(IC_4 = 74HC(T)/L500\)
  - \(IC_5 = 74HC(T)/L510\)

- **Miscellaneous:**
  - \(X_1 = 32.768 kHz\) crystal (subminiature type)
  - 21-way DIN41617 connector, angled connections
  - NiCd battery 2.4V or two 1.2V cells connected in series
  - PCB 86017
Listing 1: The essentials of MSX real-time clock programming. Although the present RTC hardware does not support interrupts with the Z80, provision has been made to set the RTC alarm function. For this purpose, the subroutines at lines 1000 and 0M may be called with N=8 and US= ’ALARM’. Note that the register latch is at OUT 113, the RTC proper at INP/OUT 112.

```
5 CLS: PRINT "**** MSX REAL-TIME CLOCK ****"
7 OUT 113,17: OUT 112,4: REM STOP CLOCK
9 REM GO GET TIME DATE INFO
10 N:=8: US:= ’SYNCHRO’: 60SUB 1000
20 CLS: PRINT “SET”;US:” ;DATE =”;A(N+1):” ;TIME =”;A(N+2):” ;HOURS =”;A(N+4):” ;MILLI-SECONDS =”;A(N)
30 PRINT “IF CORRECT PRESS [Y]: INPUT Q: IF Q$ =”’Y’ OR Q$ =”’N’” THEN GOTO 70
50 GOTO 7
55 REM GO LOAD RTC
60 N:=8: GOSUB 2000
70 CLS: PRINT “HIT ANY KEY TO START CLOCK”
75 IF INKEYS =” ” THEN 60 TO 75
80 CLS
84 REM READY TO START CLOCK
85 OUT 113,17: OUT 112,12
90 OUT 113,0: A:= INP(112): REM LATCH
100 OUT 113,3: S:= INP(112)
110 OUT 113,2: M:= INP(112)
120 OUT 113,1: H:= INP(112)
130 LOCATE 0,0: PRINT “TIME =”;H:” ;”:M:” ;”:S
140 IF INKEYS =” ” THEN GOTO 90
150 END: REM OPTION HERE FOR RETURN
1000 REM GET TIME AND DATE
1010 INPUT “YEAR =”;A(N+6)
1020 INPUT “MONTH = (1-12)”;A(N+4)
1030 INPUT “DATE = (1-31)”;A(N-1-5)
1040 INPUT “DAY OF THE WEEK = (0-6)”;A(N-1-7)
1050 INPUT “HOURS = (0-23)”;A(N+1)
1060 INPUT “MINUTES = (0-59)”;A(N+2)
1070 INPUT “SECONDS = (0-59)”;A(N+3)
1080 INPUT “10 MILLI-SECONDS = (0-59)”;A(N)
1090 RETURN
2000 REM LOAD RTC REGISTERS
2005 FOR N:=N TO N+7
2010 OUT 113,N: REM 40ns LATCH
2020 OUT 112, A(N): REM RTC LOAD
2030 NEXT N
2040 RETURN
```

Programmers should be well aware of the essential difference in I/O mapping between the Commodore type of computer and 280-based micros, such as the MSX series. Generally speaking, the former use memory locations for I/O byte transfer, the latter have 256 I/O channels available which are under control of IN and OUT instructions, whereas the 65XX-based computers work with PEEKs and POKEs for this purpose. However, the basic method of RTC control remains the same for both computer types: first the internal RTC register is specified with an appropriate instruction, then data may be read from or written to that register by addressing the RTC proper.

MSX users may key in the program of Listing 1 which displays a digital clock in the top left-hand corner of the screen. Obviously, the screen formatting and graphics features of this computer type allow the user to ‘brush up’ this little program to his heart’s content. Note that line 100 reads the 10 ms register before the actual time reading is performed in a loop. Experienced programmers may have a go at writing a routine that prints time and date on every printer sheet prior to a listing or any other draft copy. Note that, once the clock has been synchronized, time display is simply effected with GOTO 90. However, some provision will have to be made to exit the time display loop and resume the main program.

The sample program listed for the Commodore 64 and 128 model computers is somewhat lengthier than the MSX version, and, therefore, offers more programming functions; among these are selection of video polarity and word-based input of days and months – see Listing 2.

**RTC programming**

Hardware needs software support and vice versa. To complete this article, two sample programs are offered to guide in further programming explorations, which will, no doubt, lead to more complex and sophisticated time-keeping software once the basics of RTC control have been mastered.

reading it; this will also deactivate the INT output (logic 1). The outlined method should be programmed as an instruction loop to obtain maximum clock accuracy.

Where a period counter is not readily available, use may be made of another time reference signal with known accuracy, such as the BBC time signals on radio and TV. Obviously, this method costs more time and requires a good deal of patience before the target accuracy is reached.

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**RTC programming**

Hardware needs software support and vice versa. To complete this article, two sample programs are offered to guide in further programming explorations, which will, no doubt, lead to more complex and sophisticated time-keeping software once the basics of RTC control have been mastered.
10 REM * COMMODORE 64 REAL-TIME CLOCK CONTROL *
20 DIM A$(12), B$(7)
30 RESTORE
40 FOR 0 = 1 TO 12: READ A$(Q): NEXT 0
50 DATA "JANUARY", "FEBRUARY", "MARCH", "APRIL", "MAY", "JUNE", "JULY", "AUGUST"
60 DATA "SEPTEMBER", "OCTOBER", "NOVEMBER", "DECEMBER"
70 FOR 0 = 1 TO 7: READ B$(0): NEXT 0
80 DATA "MONDAY", "TUESDAY", "WEDNESDAY", "THURSDAY", "FRIDAY", "SATURDAY", "SUNDAY"
90 PRINT CHR$(147): PRINT: PRINT "--COMM0D0RE 64 REAL-TIME CLOCK CONTROL--"
100 PRINT: PRINT: PRINT:
110 INPUT "CLOCK SETTING (Y/N)"; V$
120 IF V$ = "N" THEN 365
130 PRINT CHR$(147)
140 REM CLOCK SETTING
150 INPUT ' ENTER HOURS '; H: PRINT: PRINT
160 INPUT ' ENTER MINUTES '; M: PRINT: PRINT
170 INPUT ' ENTER SECONDS '; S: PRINT: PRINT
180 INPUT ' ENTER MONTH '; MS: PRINT: PRINT
190 FOR 0 = 1 TO 12: IF M$ = A$(Q) THEN R = C: NEXT 0
200 INPUT ' ENTER DATE '; D: PRINT: PRINT
210 INPUT ' ENTER YEAR '; F: PRINT: PRINT
220 F1 = INT(F/100): F2 = INT(F1/10): F3 = F1 - 10*F2: Y = F - F1,100
230 INPUT ' ENTER DAY OF THE WEEK '; WS: PRINT: PRINT
240 FOR 0 = 1 TO 7: IF W$ = B$(0) THEN E = Q: NEXT 0
250 PRINT CHR$(147)
260 POKE 56832, 128: REM ACTIVATE CLOCK
COMPUTERS AND HEALTH CARE

by Helena Buswell

When a 38 year old Scottish housewife made an appointment to visit her doctor at the local health centre, she was unaware of the role that computers were about to play in her life.

Mrs Ann Robertson (not her real name) had stomach pains, and, like most people, was nervous when she tried to describe her condition.

Dr Michael Ryan had before him a summary listing his patient’s details produced by the health centre’s own computer ready for Mrs Robertson’s visit. He could see at a glance her age, number of children, occupation, height, weight, blood pressure, previous and current health problems, and other demographic data relevant to her general health.

Almost all of the 56 million population is registered with one of about 50,000 general practitioners (GPs), contracted to work within the National Health Service (NHS). Each GP has a list of several thousand people, and for each and every one he has case notes — most going back to that person’s birth.

At health centres like Howden, near Livingston in central Scotland, these details have been transferred to new computer systems, which produce a summary sheet ready for each patient’s consultation.

Further tests

In Mrs Robertson’s case, Dr Ryan decided to send her to the area hospital — Bangour General Hospital — for further tests. Her appointment there had already been computer generated, and, when she arrived, more details were entered into the computer system by the receptionist.

As Mrs Robertson had been a patient at the hospital some years before, the computer automatically alerted the hospital staff, and her earlier case notes were produced.

Bangour uses the de Dombal system for diagnosing abdominal conditions. Developed by Tim de Dombal, a consultant surgeon at Leeds General Hospital, this computer-based diagnostic system assesses the chances of different causes of acute abdominal pain with a very high degree of accuracy. The system is now used in many British hospitals, and, with fewer unnecessary exploratory operations of the abdomen, more patients are sent home from casualty wards and both lives and money are saved.

The system is also used in submarines of both the US Navy and the Royal Navy. Dr Ryan says: “In these situations, when long periods at sea, acute abdominal complaints are the most critical to diagnose correctly. After all, apart from heart attacks, they are the most likely to kill you.”

A comparable system in use at Glasgow has a dyspepsia program that obtains data on symptoms by directly interviewing the patient. Where direct computer interviewing is also used, the patient is often more relaxed and forthcoming, talking directly to a machine, rather than to another person. The de Dombal interview has already been translated into Swedish and Dutch, and is being tested in other clinics here and overseas.

Possible appendicitis

Mrs Robertson, however, was asked a series of structured questions by the hospital doctor, and her answers keyed into the computer. The computer’s diagnosis showed a 90 per cent chance of appendicitis, with lesser chances of constipation or gynaecological abnormalities.

Admitted to hospital, Mrs Robertson’s subsequent operation and stay were logged from start to finish on the hospital’s computer. Her files, both at the health centre and Bangour, were updated.

Howden Health Centre is one of 50 to have recently installed computer systems in Scotland with the help of the Scottish Home and Health Department. The GPs buy their own British built Apricot computers, but the software and its development and maintenance are provided free by an NHS computer team. Dr Ryan, who is chairman of the project’s steering committee, says: “We expect many more practices to install computers in the near future.” Some of the practices already using computers are in Scotland’s most isolated communities — the outlying islands. As well as holding patient records, the computers are used for repeat prescriptions, and for monitoring continuous conditions like hypertension, diabetes, and thyroid problems.

Under the overall direction of the Department of Health & Social Security, health care in England is provided by regional health authorities, which in turn are divided into administrative districts. The logistics of running such an enormous enterprise is formidable, and it is this, as much as anything, that has encouraged the introduction of computers at all levels.

Management information

The NHS is introducing new management information systems in the next two to three years, and their success will rely heavily on the use of computers. However, computers are not new to the health service. Some were installed nearly 20 years ago, and with this wealth of experience, the NHS is now marketing a range of software in other countries.

Milton Keynes General Hospital is typical of those.
opened in recent years. The new town of Milton Keynes has a population of 145,000 — expected to reach 220,000 by the year 2000. The hospital was planned in three phases. Phase one began in 1978 as a community (mainly geriatric) hospital. Phase two, with 400 beds, was opened in 1984, when the two, with 400 beds, was opened as a community (mainly geriatric) hospital. Phase three is scheduled for 1990, giving space for more beds and a mental health unit. The computer system is based on three interlinked minicomputers — in the event of breakdown or maintenance the system can run on one — and 100 terminals around the hospital, half of which have a printer attached. Terminals are also on-line at outlying clinics. And under a pilot scheme, one GP in an outlying district is on-line to a clinic terminal.

A computer system is used for patient identification; record management; patient location and logging; bed, clinic, and waiting list management; and management information. Each ward has a terminal, as do the casualty, pathology, and radiology departments. A busy hospital has much in common with a large hotel in the comings and goings, catering, cleaning, general maintenance, and payment of wages. Patients have to be booked in and out in the same way as hotel guests. Surprisingly as it may seem, bed management is a permanent problem. At Milton Keynes, tight computer control is kept on the occupancy of beds, where and when beds are available for waiting list patients (there are always beds kept for emergencies), patient movement from ward to ward, and so on. A computer check is maintained 24 hours a day so that all authorized personnel can see at a glance which beds are occupied, and who the patients are. Before computerization, it could take hours for an accurate bed check to be made.

Wider health context

Although computerized bed management has been developed to facilitate the smooth running of hospitals, the accumulated data can provide vital information in a wider health context. At Milton Keynes, a potential minor epidemic was averted after a patient, who had entered hospital for routine treatment and a two week stay, was discovered to have active tuberculosis. From computer data, all his contacts from several wards — staff, patients (most of whom had already been discharged), and even visitors — were located in less than 24 hours. A special ward was set up for screening and immunization the same day. Payrol systems were among the first computer applications introduced by British health authorities. The West Midlands Regional Health Authority uses OMR (Optical Mark Reading) forms and readers to process a complicated payroll for 102,000 people working in a widespread area. As a further complication, about 52 per cent are monthly salaried, with the rest being paid weekly. "People fail to realize that it is a complex payroll structure," says computer operations manager Peter Owen. "We have one of the most complex payroll structures in the country. At least once a month some 200,000 OMR documents are being processed."

The East Anglia Regional Health Authority covers Cambridgeshire, Norfolk, and Suffolk, and has a population of two million. The eight major hospitals, and many of the smaller ones, have computer systems dealing with administration, in-patients and out-patients, radiology, and pathology. Pathology statistics help to analyse the incidence of medical conditions, providing valuable leads to links between such parameters as occupations, social conditions, and the occurrence of illness. As with all regional authorities, East Anglia writes its own software. A recently developed catering program at Peterborough General Hospital has simplified patient menu orders, and has drastically cut costs. Around the area's health community centres, all child health immunization programmes are also computerized.

International Computers Ltd (ICL) has emerged as one of the leading suppliers of computer equipment to the NHS. Formed in 1968, ICL operates in over 70 countries and employs 21,000 people worldwide. It has collaborative agreements with Fujitsu of Japan; PERQ Systems of the United States of America, and Mitel of Canada, and also has a joint research institute in Munich with Bull of France and Siemens of West Germany.

Patient administration

ICL has recently formed the ICL Health Systems Business Unit. It includes the 100 strong team that has been working on the ICI Patient Administration System already ordered by about ten health authorities. The company also runs seminars for NHS personnel and ICL user groups. An idea of the scale of ICL's health computer systems, and of the phenomenal growth of NHS computerization, is evident in just a short selection of recent installations. An ICL supplies information system being installed for the Grampian Health Board in Scotland will handle 6,500 stock items, ranging from staff uniforms and cleaning material to surgical needles and sutures.

The Brighton Health Authority is installing two new networks for district information, replacing and upgrading older hardware. Brighton will also be one of the first districts to install an obstetrics software package developed at St Mary's Hospital in London, where the Princess of Wales had her children. Obstetrics computer systems have helped reduce perinatal death rates. Tender letting control systems have been installed by seven health authorities to help with the administration of the tendering process, including the monitoring of successful contractors.

Real-time systems

A new real-time patient administration system is being used by the West Glamorgan and Gwynedd health authorities. Supplies information systems have been installed by all the districts under the southwest London Regional Health Authority, and by six districts of the Oxford Health Authority. Apart from systems based on orthodox computer hardware, British scientists have developed advanced computer based technology for the specialized diagnosis and treatment of a range of illnesses. The National Hospital for Nervous Diseases in London, for example, is to have a prototype expert system called BRAINS designed to give powerful aid in the analysis of brain scans. The main goals of a team from University College, London, Leicester Polytechnic, and the hospital were to give the radiologist a tool for fast and efficient study of the scan image, and to reduce unnecessary scans. The team decided to
Temperature control is often the key to efficient and economic industrial production. In many process plants, for example, the temperature may need to be held within narrow bounds if the process is to be a success. And the close control of the temperature of production processes and of factory environments can often tip a large chunk from a company's annual energy bill.

A growing number of control equipment suppliers recognize that simply knowing a temperature is of little use. What is needed is the ability to monitor how temperature is changing and adjust it accordingly. These demands are being increasingly satisfied as electronics expands the options of equipment designers and allows low cost solutions to past problems.

**Microprocessor based**

A good example of the great flexibility available with the latest temperature controllers is the microprocessor based digital unit from Control & Readout Ltd, designated the 451. The general purpose 451 is aimed particularly at machine makers and users in the food, plastics, oven and furnace industries, and accepts a range of inputs. But as well as being a proportional, integral or derivative (PID), three term or on/off control unit with a range of common features, the 451 is easily reconfigured to change the basic functions. The measurement range, control algorithm and limit mode, as well as PID terms, output cycle time and limit setting, can be changed as often as wanted.

Because of this, any 451 can serve as the spare for other units, cutting the number of controllers held in stock and minimizing the cash tied up in spares. The 451 can take inputs from K, J and S sensors over the respective temperature ranges 60 to 1200 °C, 60 to 600 °C, and 60 to 1600 °C, as well as from Pt100 sensors over -200 to + 400 °C and 4 to 20 mA; 0 to 50 mV or zero to 20 mA; 0 to 50 mV signals. The controller works on supplies of 115/230 V at 50/60 Hz.

**Hidden button**

For commissioning, an internal security switch is actuated and a hidden button on the front panel operated together with the normal controls. This allows the 451 to be matched to the process needs. Any reconfiguration requires the entry of a special code after the actuation of an internal security switch. As an example of how input and output control functions can be altered, the unit could be changed from a thermocouple input with on/off control to a resistance thermometer sensing instrument with PID control. A non-volatile memory retains the configuration for more than ten years, even without power.

For slow and controlled heating of large structures, the 451 has a soft start or controlled ramp function, with a digitally set rate of 0.1 to 50 °C/minute. An automatic manual option also allows such processes as mixing to be started manually and then switched to automatic control. The device has 5 A relay or logic outputs.

**Self-tuning adjustment**

Another digital indicating temperature controller is the 810 unit, which the manufacturer, Eurotherm Ltd, claims, has carved out a niche for itself in industry only a short while after its introduction. The device won an award from the Design Council in 1984. To expand the market further, the company has introduced a self-tuning control adjustment aimed mainly at the plastics extrusion and continuous furnace markets. The new feature is intended to cut out long, involved manual adjustment.

The 810 is a three term, microprocessor based instrument with a high degree of control accuracy and easy front panel adjustment of all 15 main parameters. It features a new, self-tuning algorithm for such equipment as extruder barrel and die zones, where there is a maximum rate of temperature change under full power of about one unit/second, requiring only 300 bytes of code space. The three easily set operating modes provide self-tuning on start-up as long as the measured value is well below the desired set-point, and self-tuning at set-point if the loop is over-damped or under-damped. In the third mode, self-tuning can be initiated manually during operation.

There is a high or deviation alarm and three set-point and alarm ranges from zero to 500 °C, zero to 1000 °C and zero to 1500 °C. The operator can override all the parameters available from the 810's scroll push-buttons.

**Set-point changed with time**

The flexibility of the latest control equipment is illustrated by the possible uses claimed by Gulton Ltd for its West 2050 programmable controller. The PID, microprocessor based unit is said to be suitable for the heat treatment of metals, kiln control, environmental chambers and cabinets, food and chemical processing, plastic manufacture, textile dyeing and autoclaves, as well as other uses where set-point must be vary.
The 2050, from the Gulton group's control and instrumentation division, is based on the established West Opus 70 temperature and process controller. It has the same mechanical construction and is in a metal case with splash- and dust-proof membrane front panels.

The programmer controls a measured value through a set-point profile which can change with time through up to four stages, each with a ramp and a dwell segment adjustable up to 99 hours 59 minutes. Rate or time programming can also be adopted for the ramps. The 2050 can handle thermocouple, resistance thermometer, direct current linear, and voltage and current inputs. Output forms include relay, logic for solid state relay, direct current linear, voltage and current, thyristor pulse, and valve motor drive.

**Integral lock-out**

The manufacturer claims a 0.25% accuracy and the PID control has an integral lock-out. Typically, control parameters can be retained without power for five years, according to Gulton.

The 2050's optional extras include an RS422 serial interface, a digital (event) output, a remote programme start, and guaranteed soak times. Preliminary trials of FGH Controls' furnace temperature controller, known as the thermal head ratio system, suggest typical fuel cost savings of 15 per cent. Aimed at such sectors as the aluminium industry, with medium sized and large furnaces, the system is claimed to improve the efficiency of heat treatment and to be simply controlled by non-specialist workers.

Present control methods for furnace temperatures typically involve regulating the furnace atmosphere and letting the load warm to this temperature, or controlling the load at a chosen temperature and probably suffering from high atmospheric temperatures and high load skin temperatures.

**Thermocouples**

To eliminate the need for this wasteful system, FGH has come up with a two instrument and two thermocouple design. The thermocouples monitor load and atmosphere temperatures. One instrument compares the load temperature with a load set-point and generates a further set-point, which is led to the second instrument. The second set-point is compared with measured atmosphere temperature which it maintains. To avoid dangerously high atmosphere temperatures, the user can include a further set-point in the atmosphere controller instrument, operating as an upper clamp. A range of control components can be coupled to the system. FGH can also supply suitable thermocouples, and up to three can be used to sense load temperature. In this case, an additional control unit selects the highest temperature and switches this through to the ratio system.

A similar set of three thermocouples can be used for atmosphere temperature sensing.

**Factory heating**

Temperature control can also be applied profitably to the heating system of a factory or other plant. A recent addition to the energy management equipment made by Gent is the microprocessor based 6202 temperature controller. This unit, which is easy to program with a 25 button keyboard, can be used as a stand-alone energy management device or can form part of a more comprehensive control system. It is suitable for both existing and new heating installations. The 6202 can control up to eight zones, three boilers, a main system pump, a hot water circuit and alarms, with up to 14 digital outputs. The unit accepts signals from up to 24 dedicated analogue inputs.

Gent sees as a particular advantage the ability of the 6202 to control energy use in any of three ways. The first, a pulsed power mode, links a zone direct to a boiler and pump operation. By monitoring outside and zone temperatures, the unit calculates the input power each zone needs to maintain the desired space temperature. By monitoring the system flow temperature, the controller also determines the period the zone valve needs to be pulsed open.

**Three way valve**

The modulating valve mode calls for each zone to be controlled by a three way valve and zone circuit pump, with a corresponding zone flow temperature sensor. The valve is modulated in line with the outside and space temperatures.

The third mode, designated on/off, is for a wide range of energy consuming plant such as oil and gas fired air heaters, electric heaters, lighting, and pumps. Independent zone operation allows time and temperature or time-only control.

The 6202 can also be programmed with 99 consecutive shut-downs up to six days in advance, and there is a back-up battery to retain programs for up to 72 hours. The user can also select parameters to be coupled to alarm outputs, and an RS323/242 interface can be used to connect the unit to remote computer equipment. TPS

The 6202 energy management unit from Gent can produce major cost savings when applied to factory temperature control.
While many users of graphics terminals are content with the colour features of their 8- or 16-colour systems, the era of true multi-colour image production on a digital basis has recently been heralded with the availability of colour palette chips which offer up to 4096 possible colours to put the older systems in the shade.

**DIGITAL COLOUR PALETTE**

For a number of centuries, artists have used palettes to obtain a certain target colour by mixing a limited number of basic colours; the mixing process is one that requires skill and precision since any additional spot of paint may spoil the desired colour nuance. Today’s electronics industry offers the digital equivalent of the wooden palette in the form of a chip that incorporates a number of registers for target colour definition; the object colour is ‘mixed’ by programming the relevant colour index code before the register contents are converted to analogue RGB levels.

This article examines two of these devices as offered by different LSI manufacturers: Texas Instruments and Thomson. However, before discussing the technical characteristics of each of the palette chips, their general method of operation in a RGB video system must be sketched.

**Principle of operation**

Graphics terminals and graphics cards such as the one featured in *Elektor Electronics*, issues from September 1985 onwards, generally provide three or four output bits to generate eight or sixteen possible colour shades on a RGB monitor. In a configuration with a palette chip, these bits are ‘intercepted’ and used to address (specify) eight or sixteen registers that hold a higher number of colour definition bits, for example twelve; obviously, the more colour bits, the more colour shades within reach of the programmer.

The register contents are passed to three digital-to-analogue converter (DAC) sections in the chip. The three analogue voltages at the chip output terminals then represent the colour shade as programmed in the addressed palette register. Thus, starting from only four bits (RGBI) to specify one of sixteen pixel colour shades, the palette chip expands the total number of available shades to 4096 if it contains sixteen 12-bit registers for this purpose. This may appear a huge number at first sight, but it should be noted that only 16 of 4096 colour nuances may be used at one time.

It will be readily understood that the essence of the matter lies in the method and timing arrangement relevant to modification, i.e. reading and reloading of the colour conversion registers in the palette chip. Clearly, the faster the register contents can be changed, the more colour nuances will be simultaneously visible on the screen.

To illustrate the possibilities offered by a palette chip, consider a RGBI system with four output bits used to address the 16-by-12 register array in the palette. Suppose that it is only allowed to modify the register contents during the vertical scan retrace time (field or raster blanking). The screen is empty, the background is, say, red; this implies that the four input bits are programmed to address but one of the palette registers, which is loaded with a 12-bit code that specifies red. If nothing is done about the register contents, the image will simply remain red. However, if the colour index code is incremented by one during every field blanking pulse (20 ms), the range of 256 shades of red will be passed from pale to dark (fully saturated) in about five seconds, without any trace of picture disturbance. Likewise, one half of the screen may be pale red and the other half dark blue. If the rel-

![Fig. 1. The basic principle of digital palette chips rests on the use of RGBI pixel information to select registers which hold a higher number of colour definition bits for conversion in DAC sections.](image-url)
event colour conversion registers are simultaneously incremented (red) and decremented (blue), an interesting and attractive effect is obtained on the screen. As already pointed out, palette register reloading should, ideally, be possible as frequent as possible, since the rate of access determines the total number of colour shades simultaneously visible to the human eye; happily, the palette chips examined below offer a high flexibility in this respect; both accept the horizontal blanking pulse as a timing signal for register access, despite the fact that the actual new register contents are obtained quite differently, as will become evident from the detailed descriptions below.

**TMS34070**

Texas Instruments offer a video palette chip to the design outlines given in the functional block diagram of Fig. 2. Identified as TMS34070, the chip features a 16-by-14 register array; each register may hold 12 colour conversion bits and two auxiliary bits for special functions. The register outputs are multiplexed before being applied to three on-chip DACs which supply the relevant voltage levels to the analogue inputs of an RGB monitor. At the left of the diagram are two 4-to-16 decoders for addressing the registers in the array. The internal configuration is completed with the necessary timing and control sections.

Addressing the colour conversion registers in the TMS34070 palette chip is effected by a rather peculiar method. As already explained, every pixel has a four-bit code in the relevant location in video memory (bit map). By virtue of its internal timing, the TMS34070 is capable of loading the four-bit colour codes of a pair of adjacent pixels at its DA3...DA0 and DB3...DB0 inputs, clocked by CLKOUT, which is DOTCLK divided by two. Two-to-one multiplexing and digital-to-analogue conversion is performed at DOTCLK frequency; see Figures 3a and 3b for the timing method of the input clocking process. The even pixel is output as an analogue voltage after 6 CLKOUT periods, the adjacent odd pixel half a period later. Palette inputs DA3...DA0 and DB3...DB0 also give access to the register array to effect definition of colour shade; loading requires two successive CLKOUT periods as shown in Fig. 3b; during the first clock period, four red bits and two auxiliary bits are loaded, the next clock cycle loads the bits for blue and green. At this point, it is necessary to establish the origin of the colour index bits which form the contents of the 16 conversion registers. As visible in the block schematic of the chip, the Texas palette does not feature a microprocessor interface, and can, therefore, not obtain the register data from any area in the computer memory. Instead, the TMS34070 gets its register data from a dedicated 256-bit area located in the pixel bit map. These bits are loaded as outlined above, immediately after the MODE input of the chip is pulled logic low. The user is free to apply either the system raster or line blanking pulse to this input; the raster load mode implies that the TMS34070 loads its registers during the last blanked scan line, just before the picture scan spot lights again in the upper left hand corner of the screen; the transfer of the 256 bits takes 32 clock cycles. The line load method, if used, requires the same amount of cycles, but the horizon-

tal (line) blanking interval is used to allow for the bit transfer to take place before the scanning spot becomes visible again at the beginning (left) of the next lower line on the screen. Irrespective of the mode selected, the 16 registers are loaded with a video memory resident, but invisible, block of 256 bits during the MODE low interval, starting with register 0 and ending with number 15 (0Fhex). Note that two bits are ‘don’t care’ for every register load, since only 14 bits are required to fill any register; 4 red, 4 blue, 4 green, and two auxiliary. Also note that the 256-bit register area in the pixel bit map is not visible on the screen, because this is arranged to ‘disappear from sight’ by the blanking pulse.

**Auxiliary bit functions**

In addition to the three colour definition nibbles, each conversion register in the TMS34070 palette chip may hold two auxiliary bits, the function of which will be briefly examined in the following lines. Whenever a register is addressed, the logic level of
its XAT (external auxiliary) bit is output at the corresponding palette terminal, which may be useful to supply control information for devices external to the TMS34070. A typical use of the XAT function could be the selection of an external RGB source connected to an analogue multiplexer output circuit in order to obtain video overlay effects. Further details of this interesting option will be given in the section on the Thomson chip, later in this article. The REP (repeat) bit has a function internal to the palette chip; when set, it repeats the colour information last clocked into the palette chip. This feature may be put into effect as follows: first, the screen is cleared and given a colour which has an index code with the REP bit set. Next, the desired polygon outlines are drawn and it will be observed that the defined screen areas will be automatically coloured (Fig. 4). Any time the register with REP high is addressed, the previously loaded colour index is repeated, overriding a new latch operation at the DA3...DA0 and DB3...DB0 inputs. So, rather than constantly addressing a register to obtain an even coloured screen area, the REP bit may be programmed to effect fast polygon filling at the time of picture visualization on the screen. Needless to say that this method offers interesting possibilities for real-time video animation on an effective basis.

**EF9369**

As shown in Fig. 5a, the internal configuration of this palette chip by Thomson is roughly identical to that of the TMS34070. The 16-by-12+1 register array is referred to as the colour lookup table, CLUT. The M (marker) bit has basically the same function as the XAT bit in the TI chip. Unlike the TMS34070, the EF9369 has a micropro-

**Fig. 3a.** The TMS34070 may latch the four-bit codes of two adjacent pixels, and convert them sequentially into an RGB signal at DOTCLK frequency.

**Fig. 3b.** Timing diagram illustrating a TMS34070 register load cycle.

**Fig. 4.** In Fig. 4a, all pixels on the screen are black (colour 0), while the REP bit for this colour has been set. Fig. 4b shows how the outlines of an object are drawn in colours 1, 2, and 3, all of which have REP reset. Fig. 4c shows the result; all pixels defined as black automatically colour like the preceding pixel.
be incorporated in systems. In the latter case, the chip may be tied low or high. In the mode interface) terminal of the chip is connected via SMI (select mode, the SMI (select multiplexed 1.4P bus structure). The 9369 can be used with both multiplexed and non-multiplexed µP bus structures, to select the relevant mode, the SMI (select mode interface) terminal is tied low or high. In the latter case, the chip may be incorporated in systems with CPU types such as the 6800, 6808, 6502, or 68008 which have a non-multiplexed address bus. A smart feature offered by the Thomson palette chip in this mode is its automatic address-increment capability, which will be briefly examined below.

The 9369 is memory-mapped at two addresses: one to hold the register number, the other to pass register data for read or write operations. If the AS terminal of the chip is wired to address bus line A2, this will result in the following addressing method:

Address 0: address holds read/write data from/to specified register;
Address 1: address holds register number (write only).

To access a specific colour conversion register, it is first necessary to write its array number (0..15, 0..0Fhex) to an AS=As=0 address within the I/O block, followed by a read or write operation, whichever is required, involving an AS=As=0 address within the same block. Each access to the data register causes the address register to be automatically incremented modulo 32, which obviates the need for the programmer to explicitly address the next register before accessing it. Obviously, this clever auto-point method enables the register array to be loaded efficiently and fast: instead of some 60 cycles, a mere 33 are now required to load the entire array with a 'look-up table and data download loop' programmed in machine language and triggered off during the picture blanking interval.

Towards a practical circuit

The 9369 palette chip merely requires a terminal-generated four-bit pixel data stream at its P4..P1 inputs, a dot clock signal for the DOTCLOCK input, and a picture blanking pulse (BLK) to determine the size of the display window on the screen. Pixel codes are latched into the colour index register at the rising edge of the DOTCLOCK pulse; the index register, in turn, addresses the relevant colour conversion register in CLUT, and the contents of the red, green, and blue registers are passed to the three output DACs, while the logic level of the M bit is passed straight to the chip terminal with the same name. After having been buffered, the RGB signals are applied to the input of an RGB monitor with analogue inputs.

How RGB signal buffering may be put into practice is shown in Fig. 7: either
Fig. 7. Application of the EF9369 palette chip in combination with the Elektor high-resolution graphics card.

Fig. 8. The XAT or M bit allows interesting video overlay applications to be realized with an analogue multiplexer such as the Type TEA5114 connected as indicated.

The RGB signals supplied by the external video source will not be passed in that case. In this way, a high-resolution overlay effect may be produced, e.g. coloured bold letters or other signs illustrating camera-recorded stills. So far, an important aspect of the palette and external video combination has been left unmentioned; it involves the necessary clock-signal synchronization between these video sources to preclude trouble with picture instability and undesirable colour interference; the problem and the method of tackling it will be reverted to in a further article on the subject of up-to-date colour applications.
RFI suppression devices

Now available from Swissinco UK Ltd is a wide range of RFI suppression devices. Products include 2- and 4-terminal capacitors; filters in various sizes and styles; RFI suppression chokes with open and toroidal cores in both moulded and un-moulded versions; and spark suppression devices. VDE approved, the BV series of suppression capacitors has a rated voltage of 250V and a rated current of 4A. Type dependent, the rated capacity is between 0.033 and 0.27 μF.

Swissinco UK Limited
Unit 2
225 Hook Rise South
Surbiton
Surrey KT6 7LD.
Telephone: 01 397 704114
Telex: 924245 (3430:5:F)

Plastic cases for instrumentation purposes

BICC-VERO Electronics now offer the Apollo range of plastic cases in light and mid grey colour combinations for portable or desktop instrumentation applications. The Apollo range comprises six sizes for single PCB mounting up to cases that may hold several boards; all types come complete with self-adhesive pads which, together with the pre-marked grid moulded into the case, offer a simple, yet effective means for board mounting. Alternatively, the cases accept a stick-on pad with a self-tapping boss for more secure board installation. The front and rear panels may be clipped on in a choice of positions and ways, allowing the user to conceal or display connections or controls as desired.

BICC-VERO Electronics Limited
Industrial Estate
Chandlers Ford
Hampshire SO5 3ZR.
Telephone (04215) 60211
Telex 47551 (3430:8:F)

Smart socket cures electronic amnesia

A new memory retention socket for RAMs from MS Components eliminates loss of data due to power failure. Two lithium batteries built into the socket provide dual redundancy back-up in the case of system power failure. A transparent and automatic switching circuitry senses the loss of power when it occurs and selects whichever of the two batteries has the highest potential to supply memory retention voltage. If both of the batteries fall below 2 volts, a battery status warning is initiated. The smart socket accepts either 28-pin 8Kx8 or 24-pin 2Kx8 CMOS static RAMs and provides a 'write protect' signal at switch over to prevent garbled data. Memory chips used with the socket should have a standby current of less than 1 μA; typical types include the Toshiba TOS5564PL and TOS55178PL.

MS Components Limited
Zephyr House
Waring Street
West Norwood
London SE27 9LH.
Telephone: 01 670 4466
Telex: 892425 (3430:1)
Mini printer for portable/compact equipment

Epson OEM Division's new M-180 series miniature shuttle printers combine high print quality and speed with low power consumption. The new range includes the M-180, 181, 182, and 183 printers. The basic 24-column M-180 provides a print speed of 1.5 lines per second (LPS) and 144 dots per line (DPL). The M-181 will give 30 columns, 1.3 LPS and 180 DPL; the M-182 36 columns, 1.1 LPS and 218 DPL; the M-183 42 columns, 0.9 LPS and 252 DPL. The paper width is the same for all types at 57.5 mm, and power consumption is low at 200 mA (typ) from a 5V supply, which makes battery operation feasible.

The printers can operate in text and graphics mode; a compact control board, the BA-180 and single-chip dedicated controller, the LA-180, are available to simplify interfacing to the range. Ideal for use in hand-held terminals, cash registers, calculators and portable data logging systems, the printers measure 91mm x 46.9mm x 15.8mm.

Epson (UK) Limited
Dorland House
388 High Road
Wembley
Middlesex HA9 6UH.
Telephone: 01-902 8892
(3430:3:F)

Top class letter quality printer

Star Micronics have recently introduced a new dot matrix printer, the NB-15. Fitted with a 24-pin head, it is capable of producing draft copy at 300 cps and letter quality print-outs at 100 cps. In addition to the standard ASCII set with international alternatives in both draft and letter quality, up to two additional font modules may be in use at any one time, giving a remarkable degree of flexibility. Standard features of the new LB-15 include both tractor and automatic single sheet feed, easily accessible DIP switches and comprehensive front panel controls, full IBM character set including standard block graphic characters, 16 Kbyte buffer, and easily interchangeable interfaces.

Priced at around £950, the LB-15 is claimed to be significantly better equipped than competitive products, since it offers a true letter quality print-out as compared with the current near letter quality offered in most cases.

Star Micronics UK Limited
Craven House
40 Usbridge Road
Ealing
London W5 2BS.
Telephone: 01 840 1800
Telex: 948501
(3430:4:F)

Single-board controller

New from J.P. Designs is the Gimini 2 hand held controller, ideally suited for real time applications such as lathe control, robotics, etc, where user interaction may be required.

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