MIDI programme changer
50 MHz transverter
P-U converter
Dynamic pick-up preamplifier
AM/FM receiver
Dimmer for halogen lights
AKHER PCs

A range of PCs with high performance/cost ratio. Includes all features on board except a high quality full size case.

All PCs include MS DOS 4.01/CGE Basic, Windows 3.0, IBM 4.01 HD, 3.5" 1.2 Mt D. + 3.5" 1.44 Mb Floppy's, 1 Parallel/2 Serial Ports, 102 key keyboard/14 VGA Colour Monitor, Co-Pro sockets.

<table>
<thead>
<tr>
<th>Model</th>
<th>Price (09.91)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LC286-16</td>
<td>£199.00</td>
</tr>
<tr>
<td>LC386C16</td>
<td>£199.00</td>
</tr>
<tr>
<td>LC386-25</td>
<td>£199.00</td>
</tr>
<tr>
<td>LC386-25SR</td>
<td>£199.00</td>
</tr>
<tr>
<td>LC586-25</td>
<td>£199.00</td>
</tr>
</tbody>
</table>

Memory Upgrades for HPI/IBM

<table>
<thead>
<tr>
<th>Model</th>
<th>Price (09.91)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JeRAM £119(a)</td>
<td>£119.00</td>
</tr>
<tr>
<td>JeRAM £219(b)</td>
<td>£219.00</td>
</tr>
</tbody>
</table>

POSTSCRIPT FOR HPI/IBM

<table>
<thead>
<tr>
<th>Model</th>
<th>Price (09.91)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP 4000S</td>
<td>£599.00</td>
</tr>
<tr>
<td>HP 4100</td>
<td>£799.00</td>
</tr>
</tbody>
</table>

All laser printers include 1 year on site maintenance.

INJECT PRINTERS

<table>
<thead>
<tr>
<th>Model</th>
<th>Price (09.91)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP DeskJet 500</td>
<td>£199.00</td>
</tr>
<tr>
<td>HP DeskJet 510</td>
<td>£199.00</td>
</tr>
<tr>
<td>Canon LPB6 IT/TT/TY</td>
<td>POA</td>
</tr>
</tbody>
</table>

ROLAND PRINTERS

<table>
<thead>
<tr>
<th>Model</th>
<th>Price (09.91)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DXY1100/1200/1300 A3 8 pin phone</td>
<td>£259.00</td>
</tr>
<tr>
<td>DXY2500/3500 A1/A0</td>
<td>£259.00</td>
</tr>
</tbody>
</table>

HEWLETT PACKARD PRINTERS

<table>
<thead>
<tr>
<th>Model</th>
<th>Price (09.91)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP744A</td>
<td>£249.00</td>
</tr>
<tr>
<td>HP7475A</td>
<td>£249.00</td>
</tr>
</tbody>
</table>

CO-PROCESSORS

<table>
<thead>
<tr>
<th>Model</th>
<th>Price (09.91)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8087-9</td>
<td>£76(b)</td>
</tr>
<tr>
<td>8087-10</td>
<td>£110(b)</td>
</tr>
</tbody>
</table>

MEMORY MODULES

<table>
<thead>
<tr>
<th>Model</th>
<th>Price (09.91)</th>
</tr>
</thead>
<tbody>
<tr>
<td>256K RAM Cart for DeskJet+</td>
<td>£120.00</td>
</tr>
<tr>
<td>256K RAM Cart for DeskJet+</td>
<td>£120.00</td>
</tr>
</tbody>
</table>

Panasonic Printers

<table>
<thead>
<tr>
<th>Model</th>
<th>Price (09.91)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KPC1060</td>
<td>£125(a)</td>
</tr>
</tbody>
</table>

STAR PRINTERS

Prices include 1 year on site maintenance.

All software products listed in this ad are for IBM PCs or 100% compatible clone systems.
In our next issue:
- Universal rod antenna
- DC-DC converter
- Speed control of DC motors
- Augmented A-matrices
- Laser - Part 1
- Video D-A and A-D
- Computer-controlled weather station - Part 2

Front cover
Although it has been in use for over ten years in the UK, the 6-metre (50 MHz) band has recently gained a lot of attraction since the PTT (Post, Telephony and Telegraph) authorities of a number of continental European countries, including France, Holland, Belgium and Germany have, after a faltering start, issued the first few hundred 6-metre licences. The author, a Belgian radio amateur, invites you to take an active part in the growing 6-metre activity. The design for a transverter in this issue has a number of distinct advantages over earlier designs that have appeared in the radio amateur press.

**CONTENTS**

<table>
<thead>
<tr>
<th>AUDIO &amp; HI-FI</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 PROJECT: Preamplifier for moving-coil pick-up by T. Giffard</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COMPUTERS &amp; MICROPROCESSORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 PROJECT: 8-bit I/O interface for Atari ST by M. Breuer</td>
</tr>
<tr>
<td>31 Digital Research DOS 5.0 brings back your memory by J. Buiting</td>
</tr>
<tr>
<td>36 Intel/Tektronix-to-hexdump converter program for PCs based on an idea by S. Mitra</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ELECTROPHONICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 PROJECT: MIDI programme changer by R. Degen</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GENERAL INTEREST</th>
</tr>
</thead>
<tbody>
<tr>
<td>54 PROJECT: Dimmer for halogen lights based on an idea by H. Peter</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INTERMEDIATE PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>51 Surf generator from an idea by W. Cazemier</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RADIO, TELEVISION &amp; COMMUNICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>38 PROJECT: 6-metre band transverter by Pedro Wyns, ON4AWQ</td>
</tr>
<tr>
<td>59 PROJECT: AM/FM receiver based on a Philips design</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TEST &amp; MEASUREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 PROJECT: Logic analyser - Part 3 by K. Nischalke and H.J. Schulz</td>
</tr>
<tr>
<td>32 PROJECT: Wattmeter by L. Lemon</td>
</tr>
<tr>
<td>44 PROJECT: PC-controlled semiconductor tester [2] an ELV design</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MISCELLANEOUS INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leader 11; Electronics scene 12, 13; Events 13; New books 62; Switchboard 64; Readers services 63; Terms of business 64; Index of advertisers 74.</td>
</tr>
</tbody>
</table>

**FREE WITH THIS ISSUE**

BULL ELECTRICAL'S NEW 40-PAGE CATALOGUE CONTAINING 1000 ELECTRICAL AND ELECTRONIC BARGAINS!

NOTE: THAT OWING TO POSTAL RESTRICTIONS THE CATALOGUE MAY NOT BE CONTAINED IN YOUR ISSUE. IF SO, WRITE TO US AND WE WILL SEND YOU ONE BY RETURN POST.
### ATN-FILMNET DECODER

**ELEKTOR MARCH 1989**

Anyone in Western Europe in possession of a private reception system for TV satellites must, at some time, have noticed that some channels cannot be watched unless an appropriate decoder is bought or rented. Hence, working on descrambler circuits is a popular and highly interesting pastime with technically inclined owners of satellite TV receiving equipment. This ATN-Filmnet decoder is remarkable for its reliability, selectivity, automatic switch-over capability and low cost. Thanks to its versatile design, the decoder is suitable for use with many commercially available indoor units.

**ATN-Filmnet decoder**

Kit like elektor. £ 59.00

- PLL-based synchronization regenerator
- Automatic encodercode switch-over
- Digital timing used throughout design
- Video processer is transparent to other satellite TV channels
- Decoder retains multi-language Teletext Service
- PLL-based synchronization receiver module for filling in indoor unit
- Simple-to-connect to most types of indoor unit, including Elektor Electronics IDU
- Few alignment points
- No expensive components
- CMOS design ensures low current consumption

### FOR THE SAT-TV-FANS

**Inductor set for Filmnet-decoder:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>7A1S</td>
<td>3893A 110V-220V</td>
<td>£ 45.00</td>
</tr>
<tr>
<td>7A1S</td>
<td>586HM</td>
<td>£ 20.00</td>
</tr>
<tr>
<td>7A1S</td>
<td>3893A 4-586HM</td>
<td>£ 14.00</td>
</tr>
</tbody>
</table>

**Separate parts also available:**

- Mechanical parts set, incl. 3 pen lift solenoids, 2 stepper motors and HPGL software on disk (IBM) £ 169.00
- Stepper motor control board £ 45.00
- Main transformer prim.110-220 Volt £ 14.00
- Pen lift solenoid (each) £ 9.00
- Stepper motor (200 steps) £ 23.00

### MICROPROCESSOR-CONTROLLED FREQUENCY METER

**ELEKTOR ELECTRONICS APRIL 1991**

A professional grade multi-purpose frequency meter, designed by Elektor Electronics, that can be built by many at an affordable cost. Described in Elektor Electronics December 1984 January & February 1985.

- Frequency meter: 0.01 Hz to 1.2 GHz
- Pulse duration meter: 0.1 s to 100 s
- Pulse counter: 0 to 1000 pulses
- Period meter: 10 ns to 1000 ns
- Sensitivity: input A: 10 mV (2.5 nV = 1.9 pA)
- Input B: FTI or CMOS compatible (0 V to 25 kHz)

Kit includes power supply, prescaler and enclosure. £ 169.00

### BASIC COMPUTER

**with Intel 8052AH-BASIC**

£ 89.00

- Analog module £ 11,00
- Digitale module £ 17,00
- Adres dekoder £ 11,00

---

*ELEKTOR ELECTRONICS* APRIL 1991
Bardeen, Cooper and Schrieffer shared the 1972 Nobel Prize in physics. Bardeen thereby became the first person ever to have won two Nobel Prizes in physics. He is also one of only three people who have twice won a Nobel Prize for scientific achievement: Marie-Curie (1903 in physics and 1911 in chemistry) and Frederick Sanger (1958 and 1980, both in chemistry) are the other two.

In memoriam

John Bardeen (1908–1991)

Just after our March 1991 issue had gone to press, we received news of the death, on 30 January, of John Bardeen, the American physicist and co-inventor of the transistor (in 1947, with William Shockley and Walter Houser Brattain, for which the three shared the Nobel prize in physics in 1956). At the time, all three worked at the Bell Telephone Laboratories. Bardeen was the theoretical physicist, Shockley led the group that worked on semiconductor devices, and Brattain was the great experimentalist.

In 1951, Bardeen assumed the chair of physics and electrical engineering at the University of Illinois. It was at that university that he, together with Leon N. Cooper and J. Robert Schrieffer, developed a theory to explain the phenomenon of superconductivity. This theory, which bears their initials—the BCS Theory—has formed the basis for all subsequent theoretical work on the subject.

The phenomenon of superconductivity, in which metals lose all resistance to the passage of an electrical current when they are cooled close to absolute zero (−273.15 °C), was first discovered by Heike Kammerlingh Onnes, the famous Dutch physicist, at Leiden University in 1911. For that discovery, which led to the production of liquid helium, Onnes was awarded the Nobel Prize in physics in 1913.

For their work on the BCS Theory, Bardeen, Cooper and Schrieffer won the 1972 Nobel Prize in physics. Bardeen thereby became the first person ever to have won two Nobel Prizes in physics. He is also one of only three people who have twice won a Nobel Prize for scientific achievement: Marie-Curie (1903 in physics and 1911 in chemistry) and Frederick Sanger (1958 and 1980, both in chemistry) are the other two.

Sir Monty Finniston, FRS (1912–1991)

Sir Monty Finniston, who died a few days after John Bardeen, on 2 February, was not an academic, but one of Britain’s most prominent engineers this century. Although he did not become known to the general public until he was in his late fifties, he had long before then devoted much energy and determination to helping the engineering profession to adapt to the post-World War world. He also exercised great influence on the education and industrial structure of Britain through his serving on a multitude of industrial, scientific, educational and engineering bodies.

In 1969, Harold Montague Finniston was elected a Fellow of the Royal Society; six years later he was knighted for his services to the country.

Sir Monty really became known to the general public when he was appointed to chair a committee of inquiry into the engineering profession. The results of the inquiry, embodied in the Finniston Report (1979), formed a detailed programme for the future of British industry. Sir Monty believed that the report would counter the tendency, then as now fashionable, to write off the manufacturing industry in favour of the services industry. In later years, he continued to maintain and defend his conviction that only the success of the manufacturing industries would generate and sustain the services industries.

Professor Daphne Jackson (1936–1991)

Professor Daphne Jackson, OBE, who died on 8 February, was, after her appointment in 1971 to the chair in physics at Surrey University, for many years the only woman professor in physics in the United Kingdom.

Although she did important work in nuclear, medical and radiation physics, Daphne Jackson will probably be best remembered for her efforts to make science an attractive career for women. She was President of the Women’s Engineering Society from 1983 to 1985.

In memoriam

John Bardeen (1908–1991)

Just after our March 1991 issue had gone to press, we received news of the death, on 30 January, of John Bardeen, the American physicist and co-inventor of the transistor (in 1947, with William Shockley and Walter Houser Brattain, for which the three shared the Nobel prize in physics in 1956). At the time, all three worked at the Bell Telephone Laboratories. Bardeen was the theoretical physicist, Shockley led the group that worked on semiconductor devices, and Brattain was the great experimentalist.

In 1951, Bardeen assumed the chair of physics and electrical engineering at the University of Illinois. It was at that university that he, together with Leon N. Cooper and J. Robert Schrieffer, developed a theory to explain the phenomenon of superconductivity. This theory, which bears their initials—the BCS Theory—has formed the basis for all subsequent theoretical work on the subject.

The phenomenon of superconductivity, in which metals lose all resistance to the passage of an electrical current when they are cooled close to absolute zero (−273.15 °C), was first discovered by Heike Kammerlingh Onnes, the famous Dutch physicist, at Leiden University in 1911. For that discovery, which led to the production of liquid helium, Onnes was awarded the Nobel Prize in physics in 1913.

For their work on the BCS Theory, Bardeen, Cooper and Schrieffer shared the 1972 Nobel Prize in physics. Bardeen thereby became the first person ever to have won two Nobel Prizes in physics. He is also one of only three people who have twice won a Nobel Prize for scientific achievement: Marie-Curie (1903 in physics and 1911 in chemistry) and Frederick Sanger (1958 and 1980, both in chemistry) are the other two.

In memoriam

John Bardeen (1908–1991)

Just after our March 1991 issue had gone to press, we received news of the death, on 30 January, of John Bardeen, the American physicist and co-inventor of the transistor (in 1947, with William Shockley and Walter Houser Brattain, for which the three shared the Nobel prize in physics in 1956). At the time, all three worked at the Bell Telephone Laboratories. Bardeen was the theoretical physicist, Shockley led the group that worked on semiconductor devices, and Brattain was the great experimentalist.

In 1951, Bardeen assumed the chair of physics and electrical engineering at the University of Illinois. It was at that university that he, together with Leon N. Cooper and J. Robert Schrieffer, developed a theory to explain the phenomenon of superconductivity. This theory, which bears their initials—the BCS Theory—has formed the basis for all subsequent theoretical work on the subject.

The phenomenon of superconductivity, in which metals lose all resistance to the passage of an electrical current when they are cooled close to absolute zero (−273.15 °C), was first discovered by Heike Kammerlingh Onnes, the famous Dutch physicist, at Leiden University in 1911. For that discovery, which led to the production of liquid helium, Onnes was awarded the Nobel Prize in physics in 1913.

For their work on the BCS Theory, Bardeen, Cooper and Schrieffer shared the 1972 Nobel Prize in physics. Bardeen thereby became the first person ever to have won two Nobel Prizes in physics. He is also one of only three people who have twice won a Nobel Prize for scientific achievement: Marie-Curie (1903 in physics and 1911 in chemistry) and Frederick Sanger (1958 and 1980, both in chemistry) are the other two.

In memoriam

John Bardeen (1908–1991)

Just after our March 1991 issue had gone to press, we received news of the death, on 30 January, of John Bardeen, the American physicist and co-inventor of the transistor (in 1947, with William Shockley and Walter Houser Brattain, for which the three shared the Nobel prize in physics in 1956). At the time, all three worked at the Bell Telephone Laboratories. Bardeen was the theoretical physicist, Shockley led the group that worked on semiconductor devices, and Brattain was the great experimentalist.

In 1951, Bardeen assumed the chair of physics and electrical engineering at the University of Illinois. It was at that university that he, together with Leon N. Cooper and J. Robert Schrieffer, developed a theory to explain the phenomenon of superconductivity. This theory, which bears their initials—the BCS Theory—has formed the basis for all subsequent theoretical work on the subject.

The phenomenon of superconductivity, in which metals lose all resistance to the passage of an electrical current when they are cooled close to absolute zero (−273.15 °C), was first discovered by Heike Kammerlingh Onnes, the famous Dutch physicist, at Leiden University in 1911. For that discovery, which led to the production of liquid helium, Onnes was awarded the Nobel Prize in physics in 1913.

For their work on the BCS Theory, Bardeen, Cooper and Schrieffer shared the 1972 Nobel Prize in physics. Bardeen thereby became the first person ever to have won two Nobel Prizes in physics. He is also one of only three people who have twice won a Nobel Prize for scientific achievement: Marie-Curie (1903 in physics and 1911 in chemistry) and Frederick Sanger (1958 and 1980, both in chemistry) are the other two.

In memoriam

John Bardeen (1908–1991)

Just after our March 1991 issue had gone to press, we received news of the death, on 30 January, of John Bardeen, the American physicist and co-inventor of the transistor (in 1947, with William Shockley and Walter Houser Brattain, for which the three shared the Nobel prize in physics in 1956). At the time, all three worked at the Bell Telephone Laboratories. Bardeen was the theoretical physicist, Shockley led the group that worked on semiconductor devices, and Brattain was the great experimentalist.

In 1951, Bardeen assumed the chair of physics and electrical engineering at the University of Illinois. It was at that university that he, together with Leon N. Cooper and J. Robert Schrieffer, developed a theory to explain the phenomenon of superconductivity. This theory, which bears their initials—the BCS Theory—has formed the basis for all subsequent theoretical work on the subject.

The phenomenon of superconductivity, in which metals lose all resistance to the passage of an electrical current when they are cooled close to absolute zero (−273.15 °C), was first discovered by Heike Kammerlingh Onnes, the famous Dutch physicist, at Leiden University in 1911. For that discovery, which led to the production of liquid helium, Onnes was awarded the Nobel Prize in physics in 1913.

For their work on the BCS Theory, Bardeen, Cooper and Schrieffer shared the 1972 Nobel Prize in physics. Bardeen thereby became the first person ever to have won two Nobel Prizes in physics. He is also one of only three people who have twice won a Nobel Prize for scientific achievement: Marie-Curie (1903 in physics and 1911 in chemistry) and Frederick Sanger (1958 and 1980, both in chemistry) are the other two.
WORLD DEMAND FOR ELECTRONICS TO INCREASE BY TWO THIRDS BY 1995

World demand for electronics equipment is expected to increase by over 66 per cent between now and 1995, reaching well over $500 billion and making the electronics industry the largest single branch of industry in many countries in the 1990s, according to The International Electronics Industry: Corporate Strategies and Government Policies, a Special Report published by the Economist Intelligence Unit.

The structure of the international electronics market by end user in 1990 is broken down as follows:

- Computers: 33.3 per cent
- Industrial equipment: 30.0 per cent
- Consumer electronics: 20.0 per cent
- Telecommunications: 17.6 per cent

The computer sector is expected to continue to dominate the market throughout the 1990s.

In the 1980s, the industry was transformed by major advances in semiconductor technology, further improvements in production processes and a growing reliance on the semi-skilled, low-cost labour of East Asia. It is already the largest single industry in Japan, South Korea, and Taiwan, where government policy fostered its development in the 1980s. In these countries, it is likely to contribute 7 per cent of GDP by the year 2000, compared with 5 per cent in Germany and 3 per cent in the USA.

Japan's increasing dominance of the world market is traced back to strategic government support from the 1960s onwards. This was based on a clear vision of evolving electronics technology and a coherent policy to focus on key areas such as optoelectronics and microchips and bringing products to the market much faster than the US or European industries. By 1988, the result of this strategy led to an $30 billion surplus in electronics equipment and components with the rest of the world.

The electronics industry in the USA remains the largest in the world with substantial exports of computers, peripheral equipment and components. However, it faces the 1990s with a heavy reliance on imports of consumer electronics and is no longer in control of the semiconductor device production equipment industry that US companies first invented.

In western Europe, the electronics industry's strength lies in telecommunications, industrial and medical equipment. Government support for research and development was varied, but generally lacked the coherence and focus of the Japanese programme, being particularly weak in semiconductor component technology, and slow to switch to digital technology.

This gap in Europe's industrial base will be filled in the early 1990s as a result of a reorientation of the strategy of the few remaining European owned diversified electronics companies and plans by Japanese and American companies to manufacture locally for the largest single market in the world.

ELECTRONICS SCENE

The report concludes that, despite a reorientation strategy in Europe and the USA, Japan will continue to produce more than half the world's output of consumer electronics and increase its share in computer and industrial electronics.

The Economist Intelligence Unit
40 Duke Street, London W1A 1DW

BRITISH EMC MEASURING EQUIPMENT FOR EUROPE

CHASE Electrics and Advantes, two significant companies in the field of electromagnetic compatibility (EMC) test instrumentation, have joined forces in a bid to supply Europe with a range of EMC emission measurement packages. The picture shows a radiated emission measurement system from the combined companies. Chase EMC Ltd, St Leonard's House, St Leonard's Road, Mortlake, London SW14 7LY.

THE SETMAKERS

To CELEBRATE one of the century's most remarkable and far-reaching inventions, Radio and Television, the British Radio and Electronic Equipment Manufacturers Association-BREMA—has published The Setmakers. This book charts the British history of companies and people who powered one of the greatest engines for social change the world has seen since the invention of the printing press.

The Setmakers, written by Keith Geddes in collaboration with Gordon Bussey, recalls some of the great brand names of the past, like Ekco, Vidor, HMV, and contains a mass of archival material much of which has never previously been made public.

The book is available from BREMA, Landseer House, 19 Charing Cross Road, London WC2H 0ES.

ENGINEERING INSTITUTIONS A STEP NEARER MERGER

The COUNCIL of the Institution of Electrical Engineers (EEE) has approved a document proposing a merger on 1 October 1991 with the Institution of Production Engineers (IProdE). If the IProdE Council gives a similar approval, the proposal will be voted on by corporate members of the Institutions next month.

The Institution of Electrical Engineers, Savoy Place, London WC2R 0BL

WORLD'S SMALLEST GLOBAL MOBILE SATCOM SYSTEM BEGINS COMMERCIAL OPERATION

INMARSAT-C, the world's smallest two-way global mobile satellite communications system, has started commercial operation in the Pacific Ocean Region (POR) with the opening of the Perth, Australia, earth station operated by OTC Ltd, Australia's worldwide communications company. Inmarsat, 40 Melton St., London NW1 2EQ.

MICHELLE RICHMOND IS YOUNG WOMAN ENGINEER OF 1990

TWENTY-five-year-old Michelle Richmond, Senior Engineer with Siemens Plessey Radar, Isle of Wight, has become the 1990 holder of the coveted title "Young Woman Engineer of the Year". The Award, now in its thirteenth year, is sponsored jointly by the Institution of Electronics and Electrical Incorporated Engineers (IEEE) and the Caroline Haslet Memorial Trust (see Elektronik Electronic, September 1990, p. 61).

Second prize was awarded to Engineering Assistant, Helen Sumbler, from Bristol. Helen, aged 25, was the first woman to be appointed to a technical management post in the Signalling and Telecoms Department of British Rail's Western Region.

Third prize went to Melanie Stephenson, a Sales Engineer with Brush Electrical Machines in Manchester.

The Mary George Memorial Prize, given to a young entrant showing particular promise as an Incorporated Engineer, was awarded to twenty-one-year-old Brenda Napier from Harrow. Brenda is a Database Controller with Marconi Defence Systems at Stanmore. The Institution of Electronics and Electrical Incorporated Engineers, Savoy Hill House, Savoy Hill, London WC2R 0BS.

TRUE SIMULTANEOUS AND SYNCHRONOUS SAMPLING

CAMBRIDGE Research Systems has developed a true simultaneous and synchronous computer sampling system that has wide applications in process monitoring and control, vibrational and stress analysis, materials testing, and, indeed, in any field that can benefit from multi-channel sampling of analogue signals.

The system, type-coded AS-16, is an intelligent PC board that incorporates up to 16 analogue inputs and an integral processor. Up to five boards can normally be installed in one IBM PC or compatible computer, and an expansion box is available if more channels are needed. Each board has a 12-bit sample-and-hold facility and can provide maximum sampling rates of 10, 20, or 50 kHz per channel to give an aggregate frequency of up to 800 kHz per card. Any number
Controller, the device looks like a common 550-type asynchronous UART. But, to a device communicating with the PC, the 650 can emulate virtually anything, including an 8530-type synchronous UART. With Manchester encode/decode capability, the 650 can even be used with fibre-optic communication links.

Silicon Systems, 14351 Myford Road, Tustin, CA 92680, USA.

INFRA-RED REMOTE-CONTROL TESTER

The infra-red remote-control units widely used with television sets, video cassette recorders and hi-fi system can be tested quickly and easily with the aid of a pocket-sized instrument developed by J.P. Micro Services. Called the RXT-2, the instrument measures only 75x50x25 mm and is designed for use by both bench and field engineers. It detects infra-red beam, tests continuity and includes a self-test mode to check the state of its internal batteries.

In its infra-red mode, the instrument will detect both passive and modulated beams. Modulated infra-red produces a clicking or chirping sound on the RXT-2's speaker and also causes a LED to flash.

J.P. Micro Services, Unit 5, Church Ward Estate, Barrs Court Road, Hereford HR1 1EN.

DOT-MATRIX PRINTER OFFERS LINE-PRINTER SPEEDS

Newbury Data Recording has developed a computer printer that combines the flexibility and low cost of dot-matrix technology with the speed of a line printer. Called the ND-825, the printer can be easily programmed to create a comprehensive choice of type-faces, sizes and spacing. Sizes can range from 5 to 20 characters per inch, and eight- and nine-needle Epson compatible graphics can also be produced, as can DEC SIXEL and a wide selection of print modes and international character sets.

Newbury Data Recording, Hawthorn House, Staines TW18 3BJ.
MIDI PROGRAMME CHANGER

by R. Degen

Since virtually all electronic musical instruments are now fitted with a Musical Instrument Digital Interface (MIDI), it has become possible to control a whole array of such instruments from a small keyboard. The MIDI programme changer described in this article is based on that concept and enables a number of electrophonic instruments to be accessed quickly and efficiently.

THANKS to the MIDI (Musical Instrument Digital Interface), it is now possible for all performances of a musician to be recorded digitally and stored on floppy disks. When the stored music is replayed, it sounds as natural as when it was recorded. Also, by performing a number of pieces in succession and storing them in a sequencer, the musician can simulate an entire orchestra. Furthermore, integration of the interface with a personal computer gives several new possibilities, such as the noting down of complete musical scores with the aid of a keyboard, and the transposing of pieces of music at the touch of a button.

The strength of the MIDI is its ability to exchange information rapidly in real time with the aid of a serial connection. Not only the key impressions, and the force with which these are carried out, can be transmitted via the MIDI, but also information about the tempo, the chosen preset, synchronizing pulses and complete samples. This is the reason that nowadays keyboards are frequently offered for sale together with an expander.

In principle, an expander is a complete musical instrument, the keyboard of which has been replaced by a MIDI input. It receives all the required control signals via the serial connection. In general, it offers more facilities for a smaller outlay: the money that would otherwise have been spent on a keyboard is now available for sale together with an expander.

A disadvantage of the expander is that it requires a separate (MIDI-master) keyboard or sequencer to make full use of all its facilities. In particular, the changing of a preset can create problems, since most keyboards cannot generate a programme change instruction without altering its own settings.

Also, there are differences in the counters fitted to the keyboards: on some these operate in the decimal system, while others use the octal system.

The present programme changer enables the choosing of a different preset in the musical instrument via the MIDI. This is done by keying the desired programme change code (a decimal number of more than three digits) on the keyboard of the changer and confirming it with 'ent' (enter). Corrections may be made with the 'clear' key. Once the code has been confirmed, the unit transmits the hexadecimal code CXII and the associated data to the appropriate musical instrument.

The programme change command is made up of two bytes. The first of these is 1100nnn, where nnn is the binary coded number of the MIDI channel. The second is 0ppppppp, where ppppppp is the binary form of the decimal number keyed in. This number lies between 0 and 127, because the MIDI protocol has reserved seven bits for it.

Circuit description

The MIDI programme changer is a small, but complete, microcomputer system. The Type 8031 microcontroller, IC1, processes the incoming MIDI data and scans the keyboard. The control program is contained in a Type 2764 EPROM, IC4. The demultiplexing of the microcontroller's data/address bus is carried out by IC2.

The microcontroller confirms that the data at gate 0 are valid address data via pin 30 (ALE/17). This information is stored by IC3 and placed on address lines A0-A7 of IC4. The remaining address lines, A8-A12, are connected to gate 2 of the microcontroller.

The data bus of the EPROM is connected to gate 0 of IC1. The microcontroller reads the data from IC4 via the PSEN signal.

The RD output of IC1 is used to read the contents of DIP switches S1A-S1D. Diodes D1-D4 ensure that the DIP switches can not adversely affect the operation of the keyboard. As soon as the RD line is high, they form a sort of three-state input.

The setting of the switches determines which MIDI channel is selected for transmission of the data. When all switches are closed, that is, on (equivalent to logic 0), channel 0 is selected; when they are all open

<table>
<thead>
<tr>
<th>Table 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1A</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>
Table 1. When the setting of a switch is altered, resistors are not necessary. Provided with a pull-up resistance, external next power-on reset. The change becomes effective only after the

Fig. 1. Circuit diagram of the MIDI programme changer.

(0ff = logic 1), channel 15 is selected—see Table 1. When the setting of a switch is altered, the change becomes effective only after the next power-on reset.

Since the outputs of gate 1 are internally provided with a pull-up resistance, external resistors are not necessary.

All twelve keys on the keyboard are connected to a common earth on connector K1. The microcontroller is reset via network R1-C1. Every time the power is switched on, pin 9 of IC1 goes high for an instant and the microcontroller starts processing the data in the EPROM. At the same time, the settings of the DIP switches are read.

Crystal X1 is connected directly to the X-pin of the controller and oscillates at 6 MHz. Diode D2 has two functions: it lights briefly when one of the keys is pressed and it flashes when the programme mode is active. The LED is controlled by the WR output via IC3a. As soon as the level at this output goes high, the diode lights.

Since the MIDI operates with a current loop and must be electrically isolated from the equipment connected to it, its input is formed by an optoisolator, IC5. The light-emitting diode in this device is operated by the current flowing in the loop. The serial data output of the CNY17 is fed directly to the receive data input (RXD) of IC1 for further processing.

The transmit data output, TXD, of the microprocessor is connected to two series-connected gates, IC3d and IC3, that, with the aid of resistors R4 and R3, provide the necessary current drive.

The power supply is kept simple and uses a Type 7805 voltage regulator, IC4. Diode D7 serves to prevent damage should the polarity of the supply voltage be reversed. The supply is best derived from a mains adapter with an output voltage of 9–15 V. Since the current drain is small, cooling of the regulator is not necessary.

**Construction**

With the exception of the keyboard, all components are housed on the printed-circuit board shown in Fig. 2. Since the design is fairly simple and there is no alignment required, nothing can go seriously wrong.

The programmed EPROM is available through our Readers' services shown further on in this magazine, but you may do the programming yourself with the help of the hexdump given in Table 3.

The MIDI input is via connector K3, while the output is transmitted via K5.

Connector K1 may be a 13-way single-row header, but many readers may find it more convenient to make the connection between the unit and the keyboard with a length of 13-way flat cable.

The keyboard may be any simple membrane type, but it should not have a matrix. Each key must be individually connected to the relevant pin of K1, or if this is not used,
to the relevant pin of IC₁. A sturdy keyboard may be constructed from twelve miniature push-button switches fitted on to a piece of vero- or other prototyping board. In many cases, the digit keys can be bought ready-made; different colour keys can then be used for the 'ent' and 'clear' keys. Table 2 shows the layout of the keyboard and the correlation between keys, function and pins.

Once the keyboard has been completed, it may be mounted above the PCB with the aid of suitable spacers, after which the unit can be mounted in an appropriate enclosure.

### Table 2

<table>
<thead>
<tr>
<th>Key</th>
<th>IC₁ pin</th>
<th>Function</th>
<th>K₁ pin</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>P1.0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>P1.1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>P1.2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>P1.3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>P1.4</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>P1.5</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>P1.6</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>P1.7</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>INTO</td>
<td>9</td>
</tr>
<tr>
<td>9</td>
<td>13</td>
<td>INT1</td>
<td>10</td>
</tr>
<tr>
<td>Clear</td>
<td>14</td>
<td>T0</td>
<td>11</td>
</tr>
<tr>
<td>Enter</td>
<td>15</td>
<td>T1</td>
<td>12</td>
</tr>
</tbody>
</table>

### Parts List

**Resistors:**
- R₁ = 1x47 kΩ
- R₂ = 1x1k8
- R₃-R₆ = 4x200k

**Capacitors:**
- C₁ = 1x10 µF, 25 V
- C₂ = 2x22 µF
- C₃ = 1x100 µF, 25 V
- C₄-C₅ = 4x100 nF

**Semiconductors:**
- IC₁ = 1x8031
- IC₂ = 1x74HC573
- IC₃ = 1x74HC00
- IC₄ = 1x2764
- IC₅ = 1xCNY17

**Miscellaneous:**
- K₁ = 1x13-pin header
- K₂-K₅ = 5-pin DIN connector, 180°
- S₁ = 1xquadruple DIP switch
- X₁ = 1xcrystal, 6 MHz
- 1xkeyboard with 12 keys and common earth or 12xmini push-button switches
- 1xconnector for mains adapter

**PCB**
- PCB 900138

**IC₆ = 1x7805**
- D₁-D₄,D₅ = 5x1N4148
- D₆ = 1xLED (red)
- D₇ = 1x1N4001

**Taking the unit into use**

- Switch on the supply.
- Depress each key in turn, whereupon the LED should light briefly.
- Choose the wanted MIDI channel; the setting of the relevant DIP switches is shown in Table 1.

- If a different MIDI channel is to be selected during operation, press down and hold the 'clear' key.
- Press the 'ent' key, whereupon the LED should begin to flash.
- Select the wanted channel with the aid of the DIP switches and press the 'ent' key.
Table 3. Hexdump of the contents of the EPROM. A ready programmed EPROM is available through our Readers’ services.

<table>
<thead>
<tr>
<th>0000</th>
<th>00 01 02 03</th>
<th>04 05 06 07</th>
<th>08 09 0A 0B</th>
<th>0C 0D 0E 0F</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000</td>
<td>80 4E FF FF</td>
<td>FF FF FF FF</td>
<td>FF FF FF FF</td>
<td>FF FF FF FF</td>
</tr>
<tr>
<td>0010</td>
<td>FF FF FF FF</td>
<td>FF FF FF FF</td>
<td>FF FF FF FF</td>
<td>FF FF FF FF</td>
</tr>
<tr>
<td>0020</td>
<td>FF FF FF 10</td>
<td>98 05 C2 99</td>
<td>C2 01 32 C0</td>
<td>D0 C0 E0 E5</td>
</tr>
<tr>
<td>0030</td>
<td>99 B4 F8 0E</td>
<td>30 01 03 30</td>
<td>99 FA C2 99</td>
<td>D2 01 F5 99</td>
</tr>
<tr>
<td>0040</td>
<td>80 09 50 F0</td>
<td>F6 18 B8 40</td>
<td>02 78 70 D0</td>
<td>E0 D0 D0 32</td>
</tr>
<tr>
<td>0050</td>
<td>78 70 79 70</td>
<td>75 87 80 75</td>
<td>89 20 75 8D</td>
<td>FF D2 8E 75</td>
</tr>
<tr>
<td>0060</td>
<td>98 50 C2 01</td>
<td>D2 AC D2 AF</td>
<td>75 81 28 C2</td>
<td>00 C2 02 C2</td>
</tr>
<tr>
<td>0070</td>
<td>03 75 7A 00</td>
<td>75 90 FF 75</td>
<td>FF FF CF 04</td>
<td>C2 B6 C2 B7</td>
</tr>
<tr>
<td>0080</td>
<td>E5 90 F4 44</td>
<td>CO F5 7C D2</td>
<td>B7 7D 80 75</td>
<td>7F 00 75 7E</td>
</tr>
<tr>
<td>0090</td>
<td>00 75 7D 00</td>
<td>E8 B5 01 11</td>
<td>12 00 DA 30</td>
<td>03 F6 E5 7C</td>
</tr>
<tr>
<td>00A0</td>
<td>12 00 D2 E5</td>
<td>7A 12 00 D2</td>
<td>C2 03 D2 02</td>
<td>80 E6 E7 19</td>
</tr>
<tr>
<td>00B0</td>
<td>B9 40 02 79</td>
<td>20 70 E7 12</td>
<td>30 02 09 FA</td>
<td>74 7B 12 00</td>
</tr>
<tr>
<td>00C0</td>
<td>D2 C2 02 EA</td>
<td>12 00 D2 02</td>
<td>00 94 F5 7B</td>
<td>12 00 D2 02</td>
</tr>
<tr>
<td>00D0</td>
<td>00 94 20 01</td>
<td>FD F5 99 D2</td>
<td>01 22 30 04</td>
<td>03 02 01 EA</td>
</tr>
<tr>
<td>00E0</td>
<td>20 90 04 74</td>
<td>00 80 59 20</td>
<td>91 04 74 01</td>
<td>80 52 20 92</td>
</tr>
<tr>
<td>00F0</td>
<td>04 74 02 80</td>
<td>4B 20 93 04</td>
<td>74 03 80 44</td>
<td>20 94 04 74</td>
</tr>
<tr>
<td>0100</td>
<td>04 80 3D 20</td>
<td>95 04 74 05</td>
<td>80 36 20 96</td>
<td>04 74 06 80</td>
</tr>
<tr>
<td>0110</td>
<td>20 F0 97 04</td>
<td>74 07 80 28</td>
<td>20 B2 04 74</td>
<td>08 80 21 20</td>
</tr>
<tr>
<td>0120</td>
<td>B3 04 79 09</td>
<td>80 1A 20 B5</td>
<td>04 74 0B 80</td>
<td>13 20 B4 04</td>
</tr>
<tr>
<td>0130</td>
<td>74 0A 80 C3</td>
<td>30 00 08 DC</td>
<td>06 C2 00 7C</td>
<td>FF 7B FF 22</td>
</tr>
<tr>
<td>0140</td>
<td>30 00 2A B4</td>
<td>0B 26 BB 0A</td>
<td>23 D2 04 7C</td>
<td>FF 7B FF 7D</td>
</tr>
<tr>
<td>0150</td>
<td>80 75 7F 00</td>
<td>75 7E 00 75</td>
<td>7D 00 43 89</td>
<td>01 75 8C 00</td>
</tr>
<tr>
<td>0160</td>
<td>75 8A 00 D2</td>
<td>8C 75 79 03</td>
<td>D2 B6 D2 00</td>
<td>22 B5 03 09</td>
</tr>
<tr>
<td>0170</td>
<td>DC 1B C2 B6</td>
<td>04 B0 17 80</td>
<td>3D B4 0A 02</td>
<td>80 0A 4B 08</td>
</tr>
<tr>
<td>0180</td>
<td>02 80 05 BD</td>
<td>7D 02 80 05</td>
<td>D2 B6 7C FF</td>
<td>FB 22 B4 0A</td>
</tr>
<tr>
<td>0190</td>
<td>0E 7D 80 75</td>
<td>7F 00 75 7E</td>
<td>00 75 7D 00</td>
<td>D2 00 22 D2</td>
</tr>
<tr>
<td>01A0</td>
<td>00 1D BD 7F</td>
<td>04 F5 7F 80</td>
<td>0C BD 7E 04</td>
<td>F5 7E 80 05</td>
</tr>
<tr>
<td>01B0</td>
<td>BD 7D 02 F5</td>
<td>7D 22 C0 01</td>
<td>A9 05 B9 80</td>
<td>02 80 20 87</td>
</tr>
<tr>
<td>01C0</td>
<td>7A 09 B9 80</td>
<td>02 80 18 E7</td>
<td>75 F0 0A A4</td>
<td>25 7A F5 7A</td>
</tr>
<tr>
<td>01D0</td>
<td>09 B9 80 02</td>
<td>80 09 E7 75</td>
<td>F0 64 A4 25</td>
<td>7A F5 7A D2</td>
</tr>
<tr>
<td>01E0</td>
<td>03 D2 00 79</td>
<td>80 AD 01 D0</td>
<td>01 22 30 8D</td>
<td>14 D5 79 05</td>
</tr>
<tr>
<td>01F0</td>
<td>B2 6B 75 79</td>
<td>03 C2 8C C2</td>
<td>8D 75 8C 00</td>
<td>75 8A 00 D2</td>
</tr>
<tr>
<td>0200</td>
<td>8C 20 90 04</td>
<td>74 00 80 59</td>
<td>20 04 80 AD</td>
<td>01 80 52 20</td>
</tr>
<tr>
<td>0210</td>
<td>92 04 74 02</td>
<td>80 4B 20 93</td>
<td>04 74 03 80</td>
<td>44 20 94 04</td>
</tr>
<tr>
<td>0220</td>
<td>74 04 80 3D</td>
<td>20 95 04 74</td>
<td>05 80 36 20</td>
<td>96 04 74 06</td>
</tr>
<tr>
<td>0230</td>
<td>80 2F 20 97</td>
<td>04 74 07 80</td>
<td>28 20 B2 04</td>
<td>74 08 80 21</td>
</tr>
<tr>
<td>0240</td>
<td>20 B3 04 74</td>
<td>09 80 1A 20</td>
<td>B5 04 74 0B</td>
<td>80 13 20 B4</td>
</tr>
<tr>
<td>0250</td>
<td>04 74 0A 08</td>
<td>0C 30 00 08</td>
<td>DC 06 C2 00</td>
<td>7C FF 7B FF</td>
</tr>
<tr>
<td>0260</td>
<td>22 30 00 01</td>
<td>22 B5 03 07</td>
<td>DC 17 B4 0B</td>
<td>15 80 31 B4</td>
</tr>
<tr>
<td>0270</td>
<td>0A 02 80 0A</td>
<td>B4 0B 28 70</td>
<td>05 BD 7D 02</td>
<td>80 03 7C FF</td>
</tr>
<tr>
<td>0280</td>
<td>FB 22 B4 0A</td>
<td>0B 7D 80 75</td>
<td>7F 00 75 7E</td>
<td>00 D2 00 22</td>
</tr>
<tr>
<td>0290</td>
<td>D2 00 1D BD</td>
<td>7F 04 F5 7F</td>
<td>80 05 BD 7E</td>
<td>02 F5 7E 22</td>
</tr>
<tr>
<td>02A0</td>
<td>C0 01 99 05</td>
<td>B9 80 02 80</td>
<td>12 87 78 09</td>
<td>B9 80 02 80</td>
</tr>
<tr>
<td>02B0</td>
<td>0A E7 75 F0</td>
<td>0A 4A 25 78</td>
<td>F5 78 09 E5</td>
<td>78 44 C0 F5</td>
</tr>
<tr>
<td>02C0</td>
<td>7C D2 00 79</td>
<td>80 AD 01 D0</td>
<td>01 C2 8C C2</td>
<td>B6 C2 04 22</td>
</tr>
<tr>
<td>02D0</td>
<td>28 43 29 20</td>
<td>50 52 4F 47</td>
<td>52 41 4D 4D</td>
<td>2D 43 48 41</td>
</tr>
<tr>
<td>02E0</td>
<td>4E 59 45 52</td>
<td>20 56 32 2E</td>
<td>30 20 20 20</td>
<td>20 20 52 6F</td>
</tr>
<tr>
<td>02F0</td>
<td>6C 66 20 44</td>
<td>65 67 65 6E</td>
<td>20 32 33 2E</td>
<td>38 2E 39 30</td>
</tr>
</tbody>
</table>

Table 3. Hexdump of the contents of the EPROM. A ready programmed EPROM is available through our Readers’ services.
PREAMPLIFIER FOR MOVING-COIL PICK-UP

by T. Giffard

Although the analogue record player (as it is now often called) was written off by many some years ago, well-known manufacturers like Thorens, Dual and Linn continue to design and produce new models. And no wonder, because long-playing records are still widely available, in spite of the forecasts in the mid-eighties by experts that this type of record would not be seen in the nineties except in museums and personal collections. As long as these record players remain available, there will be a need of special preamplifiers. The one described here has been designed specifically for the processing of signals from high-quality moving-coil pick-up cartridges.

The case for a new preamplifier for moving-coil pick-ups rests on two important considerations. First, vinyl long-playing records are still being produced (and, of course, there are millions of people who have large collections of them). Second, the reproduction quality of analogue records is of the highest order and, many hi-fi enthusiasts maintain, far superior to that of the compact disk.

Design considerations

It is clear that those who have a need of a preamplifier for a pick-up put quality at the top of their list of requirements. In the design it is assumed that by far the greater majority of serious listeners use a moving-coil pick-up since this now seems to have ousted most other types.

Also, it was thought desirable for the preamplifier not to be dependent on the RIAA correction network in the main amplifier. For those readers who are not conversant with this, a short explanation. A pick-up cartridge is a velocity-to-voltage converter. During the recording, the response of the cutting stylus is constant velocity, which means that its velocity is the same for all frequencies. In the absence of any correction, the amplitude would therefore increase as the frequency drops, at the rate of 6 dB/octave: that would make it about 16 times greater at 30 Hz than at 15 kHz. Large low-frequency stylus excursions are avoided by attenuating base frequencies below 500 Hz at a rate of 6 dB/octave and boosting treble frequencies above 2120 Hz at a rate of 6 dB/octave to improve the signal-to-noise ratio. The contours roll off either side of a short flat region centred on 1 kHz, to form the RIAA (Record Industries Association of America) recording characteristic. The preamplifier needs a correction network to convert the recording characteristic back to a straight line. Both characteristics are given in Fig. 2.

The filters required to obtain the desired playback characteristic are prominent in the block diagram of the preamplifier in Fig. 3. Note that since passive filters would give rise to amplifier overdrive and higher noise and hum levels, active ones are used, except for that providing a high-pass response below 20 Hz. That filter serves to counter the effect of the IEC standard that requires the recording signal below 20 Hz to be amplified at 6 dB/octave to eliminate any adverse effects of rumbble filters in playback systems.

As usual in this type of preamplifier, it needs a large voltage amplification factor, coupled with a very low hum and noise level. These requirements cannot be met by inexpensive components.

Some readers may wonder why the block diagram is more complex than one might expect. Indeed, if the preamplifier was intended for frequency correction only, its design would probably consist of a single opamp with a suitable correction network in its feed-
back loop. However, since signals of only 250 µV (average output level of a moving-coil cartridge) have to be raised to line level, a voltage amplification factor of about 800 is required. That means at least one more amplifier and then it becomes logical to split the correction network over the two stages. The input stage serves primarily to keep the noise and hum level as low as feasible.

Note, by the way, that the filter curves in Fig. 3 are the mirror images of the playback characteristic in Fig. 2, since the correcting networks are located in the feedback loop of the amplifiers.

Circuit description

The diagram in Fig. 4 shows only one channel of the stereo amplifier circuit.

The input stage is formed by differential amplifier T1, which is a very-low-noise double opamp Type MAT03. At very low signal levels, this p-n-p type gives an even better noise performance than its n-p-n counterpart, the MAT02. The use of this excellent opamp also means that IC1 and IC2 need not be super high-quality types. This stage will be discussed in more detail later on.

The first amplifier is formed by T1 and IC1. The feedback network, located between the output of IC1 and the emitters of T1a-T1b, contains the first part of the RIAA correction filter. For that reason, C5-C7 and R3-R6 must be high-stability types. More about that later on.

The passive 20 Hz high-pass filter is formed by R17-C9. With values as specified, its cut-off frequency is exactly 20.037 Hz.

The second amplifier is formed by IC2, the feedback network of which, R10-C10, gives a cut-off frequency of 2120 Hz. With values of these components as specified, the theoretical deviation from this frequency is only 0.05%. The printed-circuit board allows for C10 to consist of two MKT type capacitors should the specified 1% polystyrene type prove difficult to obtain.

The last item in the preamplifier, R19, looks insignificant, but is not, since it prevents any tendency to instability when the load is capacitive. This would be the case if the cable between preamplifier and main equipment were very long.

The symmetrical ±15 V power supply is fairly straightforward. Additional ceramic capacitors across the electrolytic types and the rectifier diodes improve the HF performance.

The input stage

The most important part of the preamplifier is the input stage. This provides a symmetrical input and has been designed to allow the pick-up cartridge to be direct-coupled. This obviates the nasty large input capacitor found in so many preamplifiers.

These facilities meant that the differential amplifier had to be designed very carefully. This is borne out by the additional filters in the supply lines, T4 and T5 and associated components, to reduce the hum and noise on these lines to an absolute minimum.

A stable d.c. operating point for T1 is ensured by current source T2. This source derives its reference voltage from D1, the current through which is kept constant by a second current source, T3.

The symmetrical input meant that the feedback loop of the input stage had to be symmetrical. To ensure good common-mode
Fig. 5. Printed-circuit board for the stereo amplifier. Note that this consists of three sections, which may be separated before construction begins. Two of the sections are for the left-hand and right-hand channel preamplifiers and the third is for the common power supply.

### PARTS LIST (Amplifier - one channel)

**Resistors:**
- R1, R2 = 560Ω; 0.1%
- R3, R4 = 3kΩ; 0.1%
- R5, R6 = 33kΩ; 0.1%
- R7, R8-R11 = 1kΩ; 0.1%
- R12 = 1kΩ; 1%
- R13, R14 = 22Ω; 1%
- R15 = 24Ω; 1%
- R16 = 10kΩ; 1%
- R17 = 1kΩ; 1%
- R18 = 14kΩ; 1%
- R20, R21 = 5kΩ; 0.1%

**Capacitors:**
- C1, C2, C3, C4 = 270μF; polystyrene
- C5, C6 = 470μF; MKT or MKP
- C7, C8 = 15μF; polystyrene
- C9 = 10μF; 0.1% preset
- C10 = 5μF; 1% preset
- C11 = 100μF; 10V; radial
- C12-C15 = 47μF; ceramic
- C16 = 22μF; tantalum
- C17, C18 = 47μF; tantalum
- C19, C20 = 100μF

**Semiconductors:**
- R19, R22 = 12kΩ; 1%
- T1, T3 = BC550C
- T2, T5 = BC560C
- IC1, IC2 = 741C
- IC3 = OP27
- LED = red

**Other:**
- C1, C2 = 2μF; polystyrene
- C3 = 22μF; 0.1% preset
- C4 = 47μF; radial
- C5 = 100μF; 0.1% preset
Preamplifier for Moving-Coil Pick-Up

Preamplifier for Moving-Coil Pick-Up

Fig. 6. Finished amplifier board (one channel).

Fig. 7. Finished power supply board.

PARTS LIST (PSU)

Capacitors:
- C21, C22, C23 = 47 nF; ceramic
- C24, C25, C26 = 470 nF; 40 V; radial
- C27, C28, C29, C30, C31 = 47 µF; 25 V; radial

Semiconductors:
- D2-D5 = 1N4001
- IC3 = 7815
- IC4 = 7915

Miscellaneous:
- K1, K2, K3 = 3-way PCB terminal block
- PCB Type 910016

SOME TECHNICAL DATA

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input sensitivity</td>
<td>250 µV</td>
</tr>
<tr>
<td>Input impedance</td>
<td>100 Ω</td>
</tr>
<tr>
<td>Output level</td>
<td>200 mV</td>
</tr>
<tr>
<td>Terminating impedance</td>
<td>&gt;2 kΩ</td>
</tr>
<tr>
<td>Signal-to-noise ratio</td>
<td>75 dB (A-weighted)</td>
</tr>
<tr>
<td>Accuracy of RIAA curve</td>
<td>±0.4 dB</td>
</tr>
<tr>
<td>Distortion</td>
<td>&lt;0.006%</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>±15 V</td>
</tr>
<tr>
<td>Current drain</td>
<td>Abt 24 mA</td>
</tr>
</tbody>
</table>

Construction

The printed-circuit board—see Fig. 5—consists of three sections, which may be separated from one another before construction begins. The middle section is for the two amplifiers (left-hand channel and right-hand channel) and the third is for the symmetrical power supply. If you do not separate the sections, note that the power lines on the three sections are not inter-connected.

The amplifier boards allow C10 to consist of two capacitors and also the use of either polyester (MKT) or polypropylene (MKP) types in the C2, C3, C5, C6, and C9 positions. The MKP types (which are slightly larger) are for those who want the very best.

The mechanical rounding off and building in of the amplifier are left to the constructor's taste and specific requirements. If the record player has the space, it is worthwhile considering building the amplifier and power supply in that space. Another solution is, of course, a stand-alone enclosure. In either case, use a separate mains adapter to power the supply: this will prevent annoying mains hum in the amplifier.

With some record players the symmetrical input may give a problem. If their pick-up cartridge is provided with an asymmetrical output, the signal return and earth connections are usually linked. In the present preamplifier, however, these must be separate. Normally, this problem is easily overcome, because in the cable running through the pick-up arm the signal return and earth connections are always separate.

It is advisable to provide the record player with separate two-core screened audio cables for the left-hand and right-hand channels. Each of the preamplifier channel outputs can then be taken via two phono sockets, of which the central pins are used for the "+" and "-" signal paths. The outer case of the four sockets can then serve as a common earth. That arrangement worked very well in our prototype.

The output of the preamplifier is asymmetrical, so one phono socket per channel will suffice.
The control board

Although the operating instructions for the logic analyser come from the computer, the commands are processed entirely by the control board. How the analyser is controlled has already been discussed in Part 1 with reference to Fig. 2. What has not yet been discussed is how the controller is driven by the computer and this will be done now with reference to Fig. 12.

Communication between computer and control board is via an interface that serves not only as a staging post for the data but also as a detector of differences between Atari and IBM or compatible computers.

The data from the computer are stored in the four eight-bit registers on the control board. Registers 1 and 4 are used exclusively to provide data to the two trigger-counters, while registers 2 and 3 provide data to the window-counter and the logic circuits. Note, however, that when the window-counter is active in the MHz mode, the logic functions controlled by register 2 are not active and vice versa.

Control logic

Although the control logic circuit consists of only one GAL (gate array logic) IC, it is involved in all operations of the logic board. The use of a GAL circuit reduces the parasitic capacitances, which is particularly important when the clock frequency is MHz. It is, of course, true that the MHz signal does not pass through the GAL circuit, but the edges of the signals processed and output by that circuit must remain in step with the clock.

Another advantage of a GAL circuit is that it may be reprogrammed electrically: ultraviolet erasing is not required.

The GAL, clock-select and post-trigger-counter circuits are shown diagrammatically in Fig. 13. Internally, the GAL resembles a PAL (programmable array logic). It has a similar matrix on to which the desired functions are programmed. In addition, however, the function of each output (OLMC = output logic macro cell) may be programmed as an input, output or register output, either inverting or non-inverting or three-state. In the control board most OLMCs are used as inputs and only four as output.

The internal MHz clock is connected to pin 1. The reason that the other two internal clocks, 25 MHz and MHz, are not connected to the GAL is that this has not enough inputs and outputs. By passing these signals first through a clock-select circuit (IC55), a larger (and more expensive) GAL is not needed. If three internal clocks are not sufficient, an external clock may be connected to pin 2.

The two qualifier inputs are connected to pins 3 and 4. These inputs form a kind of external start/stop line, which enable the analyser to accept data only when the level at them corresponds to the set logic level (high, low or don't care). This makes it possible to restrict the read data to those that are of interest to the user.

The signals at pins 2, 3 and 4 can be switched on and off by means of the enable inputs at pins 5, 6 and 7. This is not sufficient, however, because it is also necessary to indicate whether these input signals are active high or low. That is made possible by the polarity inputs at pins 8, 9 and 11. The enable and polarity inputs are controlled directly by the computer, that is, via the registers on the control board and the computer interface.

There is one more input that is under direct control of the computer: the single-step input. Via this input, the computer controls the reading of data from the RAM cards. Since the computer software determines the reading rate via this input, there are no problems with the timing (that is, the speed of the computer is irrelevant).

The remaining three inputs and four outputs are associated directly with the operation of the analyser.

Trigger-counter 1 indicates via pin 16 that triggering has taken place. The GAL circuit then starts passing clock pulses to the post-trigger counter via pin 12. The counter signals to the GAL circuit when the second half of the RAM is full. When that happens, the outputs of IC55 are made low and the clock-pulse, the read/write-control, and the data-clock-outputs are disabled via the ready-input (pin 15).

The function of the data clock becomes clearer when the various states of the clock-select circuit, IC55, are considered. The circuit has four sequential states: off (as shown in Fig. 13); MHz mode; MHz mode; and the MHz / external clock mode. The state is determined by two lines (mode and MHz) that are controlled by the computer. When the clock-select circuit is off, the computer reads the RAM-ICs byte by byte. The single-step signal enables the GAL circuit to pass appropriate pulses to the data-clock output that clocks the address counter of the RAM-ICs and to hold the R/WCTRL line high (the RAM-ICs are read).

When the clock-select circuit is in the MHz state, the MHz signal is passed directly to the shift registers on the RAM card. Writing data into the memory and the counting of the post-trigger counter takes place at MHz, however. The lower half of the IC55 therefore sends a signal at that frequency to the clock input (pin 13) of the GAL-IC. That circuit thereupon produces appropriate sig-

![Fig. 12. Block diagram showing the connections between the control card and the computer.](image-url)
nals for the post-trigger counter (clock pulse);  
the address counter of the memory (data  
clock); and the RAM -ICs (read/write control).  
When the clock-select circuit is in the 25 MHz  
state, a 25 MHz signal is again applied to the  
clock input of the GAL -IC. Since the shift  
registers are then used in the parallel-load  
mode, they can be clocked at that frequency,  
and are therefore connected to the data clock  
of the GAL -IC. A similar arrangement exists  
for the 1 MHz internal clock and the exter-  
nal clock, which are connected to the the  
parallel-load circuit via the clock output (pin  
17), depending on the signal at the external  
clock enable input (pin 5). Whatever clock sig-  
nal has been selected, it is fed to the clock input  
(pin 13) via the clock-select circuit so that  
the GAL circuit can ensure that the signals  
at pins 12, 18 and 19 remain in step with it.  

Circuit description  
The clock generator is formed by T2 and T3 - 
see Fig. 14. The output of the generator is  
buffered by T3, after which it is converted to  
TTL level and buffered again by R25, C39,  
IC50a-d and D1. The 100 MHz signal at the  
output of IC50 is processed in IC55 (clock  
select) and two frequency dividers, IC51 and  
IC52. These dividers provide clocks of 1 MHz,  
25 MHz and 50 MHz. The 50 MHz signal is  
used only for locking trigger counters IC36-  
IC37 and IC44-IC45. The period that can be  
counted by these circuits may be set from  
between 20 ns and 5.1 μs in 20 ns steps.  
The window-counter, IC40-IC42, which  
is used only in the 100 MHz mode, is provided  
with a 25 MHz clock via IC55. That circuit also  
provides a clock to the RAM cards (of which  
there may be up to four). Each RAM card  
gets its own clock, which is first buffered by  
the gates in IC57, via a short length of coax-  
ial cable. Note that the 100 MHz indications  
at the connections is for guidance only: the  
real frequency there is the set clock.  
The resistors between the gates and the  
outputs suppress any reflections in the lines.  
The three external inputs of the control  
board are taken to external circuits via con-  
nector K19, whose layout is identical to that  
of the input connectors on the RAM cards.  
This arrangement makes it possible to use  
the probes for the cards also to control ex-  
ternal inputs to the control board. As with  
the RAM cards, these probes obviate prob-  
lems caused by parasitic capacitances and  
relections.  
To drive the control board, the computer  
has available lines card select (CRDSL), write  
(WR), register address (RA0, RA1); data (D0-  
D7) and, in the case of the Atari, single step  
(SNGL step). If the computer is not an Atari,  
that line is driven indirectly via a register  
and the data lines.  
Via the card select, write and the register  
address lines, the computer indicates whether  
the data are destined for the control board  
and, if so, for which register (IC34, IC38,  
IC39, IC43). These lines are taken to address  
decoder IC35, which converts the computer  
signals into control signals for the registers.  
The data written into IC34 and IC43 are fed  
direct to trigger counters IC36-IC37 and IC44-  
IC45 respectively.  
The outputs of IC38 and IC39 are split be-  
tween IC53 and window counter IC40-IC42.  
To that end, outputs Q0-Q5 of IC38 have a dou-  
ble function: they drive either IC53 or the  
window counter. This is possible, because  
the counter is active in the 100 MHz mode only,  
when it is not possible to operate with an ex-  
ternal clock and qualifiers. The associated drive  
inputs of IC53 are then disabled and they  
may therefore be used for the window counter.  
In all other modes, the situation is reversed:  
the window counter is inactive and the lines  
are used to control IC53.
Fig. 14. Circuit diagram of the control board.
Resistors:
- $R_{21}, R_{33}, R_{31} = 1 \, \text{k} \Omega$
- $R_{22} = 33 \, \Omega$
- $R_{23} = 22 \, \Omega$
- $R_{24} = 220 \, \Omega$
- $R_{25} = 470 \, \Omega$
- $R_{26} - R_{29} = 27 \, \Omega$

Capacitors:
- $C_{35} = 15 \, \text{pF}$
- $C_{36} = 22 \, \text{pF}$
- $C_{37} = 390 \, \text{pF}$
- $C_{38}, C_{101}, C_{102} = 100 \, \text{nF}$
- $C_{29} = 33 \, \text{pF}$
- $C_{40} - C_{62}, C_{101}, C_{102} = 100 \, \text{nF}$
- $C_{63} = 100 \, \mu\text{F}; 25 \, \text{V}$

Inductors:
- $L_1 = \text{air-cored; 10 turns enamelled copper wire 0.5 mm; inside diameter 3 mm}$
- $L_2 = \text{air-cored; 25 turns enamelled copper wire 0.5 mm; inside diameter 3 mm}$

Semiconductors:
- $D_1 = \text{1N4148}$
- $T_1 = \text{BC547B}$
- $T_2 = \text{BF494}$
- $T_3 = \text{BF982}$
- $IC_{34} - IC_{38}, IC_{39} , IC_{43} = \text{74HCT574}$
- $IC_{35} = \text{74HCT138}$
- $IC_{36} - IC_{39}, IC_{40} - IC_{43}, IC_{44} - IC_{48}, IC_{51} = \text{74F161}$
- $IC_{49} = \text{74F74}$
- $IC_{50} - IC_{52} = \text{74AS00}$
- $IC_{52} = \text{74HCT390}$
- $IC_{53} = \text{programmed 16V8-10}$ (not yet available)
- $IC_{54} = \text{74HCT4020}$
- $IC_{55} = \text{74AS153}$
- $IC_{56} = \text{74F02}$
- $IC_{58} = \text{74AS02}$
- $IC_{100} = \text{74121}$

Miscellaneous:
- $K_{18} = 64\text{-way male PCB connector; 90° (DIN41612)}$
- $K_{19} = 34\text{-way male PCB header; 90°}$
- $X_1 = 5\text{th overtone crystal}, 100 \, \text{MHz}; \text{Series HC49}$
- PCB Type 90094-5
**Measurement cycle**

Before a measurement can be made, the control card must be set to a certain mode: 100 MHz, 25 MHz, 1 MHz, or external clock, of which the last three are identical but for the clock frequency. Therefore, if reference is made in the following to the 25 MHz mode, the 1 MHz mode and the external clock mode are included. For instance in the line indication "100 MHz/25 MHz" (Q5 of IC39), the "25 MHz" really means "not 100 MHz".

Apart from line 100 MHz/25 MHz, the line mode (Q4 of IC39) co-determines which clock frequency is selected. Once the mode has been selected, the controller is put on standby by a reset (Q7 of IC39). After the reset, the control card sends clock pulses to the shift registers at the inputs of the RAM cards and write pulses (via R/W-CNTRL) to the RAM ICs. After each write pulse, the address counter, IC46-IC48, is increased by one so that data read to the RAM cards at the subsequent clock pulse are stored in the next memory location.

This cycle of writing and storing data goes on continuously. When all memory locations have been filled, the oldest data are replaced by new data. This continues until the word recognizers on the RAM cards recognize the trigger conditions. In the 100 MHz mode, there are two trigger lines, TRIG and ARM, each of which has its own function. In the other modes, these two lines are inter-
linked via T1 (possible because they are driven from open-collector outputs).

When a non-100 MHz mode is selected, the load inputs of trigger counter IC36-IC37 go high, whereupon the counter begins counting from the position written in register IC34. If the trigger signal is of sufficient duration, the counter counts to the maximum position, whereupon bistable (flip-flop) IC56b-IC56c is set. If, however, the trigger signal goes low before the maximum position is reached, the counter is loaded again with the value in the register and the trigger pulse is not accepted as valid.

Assuming that the bistable is set, IC53 receives the signal 'trigger acceptable'. The writing of data then continues and when IC53 also starts the post-trigger counter, IC54. This circuit ensures that writing stops when the number of data samples written into the memory after the trigger pulse is exactly half the available memory locations. The memory then contains a block of data that indicates what happened before the trigger pulse and another block that indicates what happened after the trigger pulse.

The operation stops when output Q10 of IC54 goes high, whereupon IC53 gets the signal 'ready', IC55 is switched off (its outputs go low) and the computer interface gets a ready signal via the IRQ line. The control board is then completely under the control of the computer, which reads all the data in the RAM cards. This is done via the single-step line, which is provided by a signal in a slightly different way if an Atari is used than if an IBM or compatible is used. For each pulse on this line, the address counter is increased by one. Since this counter stopped at the last addressed sample with the newest data, the next address is that of the sample with the oldest data. From there, all 2048 memory locations can be read byte by byte from the RAM ICs. Once all data have been read and processed, the analyser may be started again with a reset.

Basically, operation of the controller in the 100 MHz mode is different from that in the other modes: only the triggering is slightly more complex. The TRIG and ARM lines are separated and have their own function. A sort of warning signal is given via the ARM line, whereupon the trigger circuit is put on standby for a short time. The real trigger signal, TRIG, must arrive within that time to ensure that the triggering is accepted. The triggering process thus starts with the signal ARM. When this goes high, trigger counter 2, IC41-IC42, starts counting. If this counter can count to the maximum position (like counter 1), the ARM triggering is accepted and the window counter starts. This counter checks the time during which a valid triggering signal must be given via the ARM line and trigger counter 1. If that does not happen, bistable IC49a is reset, whereupon trigger counter 1 is disabled, and the window counter is reset in anticipation of a new ARM trigger. However, as long as the window counter counts, triggering is possible. If the TRIG pulse is long enough, the start bistable (flip-flop), IC56b-IC56c, is set and the analyser can start sampling again.

Finally

The printed-circuit board for the controller is shown in Fig. 15. Populating it is straightforward, although it is even more important than with other projects that the work is carried out very carefully, interspersed with frequent checks. It is better to check too often than once too seldom, because faultfinding at a later stage is not easy.

Note that IC50 is better not mounted in a socket, since that will result in additional parasitic capacitances in the oscillator circuit. In the prototype, all other ICs are fitted in a socket: this has not resulted in any noticeable deterioration. One of the prime benefits of sockets is that it reduces the likelihood of damage to the ICs, some of which are not cheap.

The inductors are best wound around a 3mm drill bit from enamelled copper wire as specified in the parts list.

It is advisable to screen the oscillator circuit, not so much to improve its operation as to prevent its radiating outside the analyser. It is also advisable, again in view of radiation outwards, to fit the entire analyser in a metal enclosure.

Forthcoming instalments of this article will deal with the power supply, an interface for IBM or compatible, an interface for the Atari ST, an overview of the various interconnections and building the analyser into an appropriate enclosure and software. It is the intention to make the software available together with a programmed GAL IC.
The Atari ST series computers have their strong and weak points. For instance, these machines have a powerful graphics interface, but lack a parallel I/O port. The latter deficiency is a spot of bother when it comes to connecting certain non-Atari peripherals and, of course, home-made extensions. The circuit presented here solves this problem elegantly by means of music! A handful of standard, inexpensive components and a small control program written in BASIC, C or assembler language turn the MIDI channel of the Atari ST into an 8-bit I/O port that achieves a maximum data rate of 1 kBit/s. No modifications are required in the computer.

M. Breuer

In principle, the MIDI (Musical Instrument Digital Interface) on a computer works just like any other serial communication port. Each databyte is transmitted on a bit-by-bit basis via a serial connection. According to the MIDI standard, a logic high bit corresponds to no current through the serial link, while a logic low bit corresponds to a current of about 5 mA. In the receiver, this current is passed through an opto-coupler that ensures electrical insulation between the transmitter and the receiver. This insulation allows MIDI equipment with different supply voltages and ground potentials to be interconnected without problems.

The serial data format used on a MIDI port equals that specified in the RS-232C protocol. Each transmission starts with a start bit, which is always a 0. Then follow the eight databits, headed by the LSB (least significant bit). The transmission is terminated with a stop bit, which is always a 1. When the dataline is not in use, it carries no current, so that a logic high level is produced in the receiver.

The data rate on a MIDI channel is standardized at 31.250 bits per second (31.25 kBaud). Although the conversion of serial data into parallel form is fairly simple to realize with a UART (Universal Asynchronous Receiver/Transmitter), the present interface uses a less expensive alternative to accomplish this function. The circuit we have in mind is based on a couple of standard CMOS ICs that perform the parallel-to-series and series-to-parallel conversions at reasonable speed.

Circuit description

The circuit diagram of the interface is given in Fig. 1. The heart of the circuit is formed by IC6, a Type 4060 14-bit counter with an onboard oscillator. The clock signal divided by 128 is present at pin 6 of the 4060. From there, the signal is fed to three shift registers IC3, IC1 and IC5, and a decimal counter, IC7. Since the oscillator on board the 4060 operates with a 4-MHz quartz crystal, the shift registers and the counter are clocked at 31.250 Hz, which equals the bit rate on the MIDI channel.

A 5-way DIN socket, K1, is connected to the MIDI output of the computer via a cable. The serial data arrive at the interface via optocoupler IC1. After being cleaned and shaped by two logic gates, IC2a and IC2b, the data arrives at the D (data-) input of IC3. The falling edge of the start bit is used to generate a needle pulse that serves to reset IC6 and IC7. This pulse is supplied by diode D2, gate IC2c and capacitor C2. The reset pulse ensures that all counters are in a predefined state at the start of a data transmission. Output Q9 of IC7 is low after a reset pulse, and blocks any further reset pulses with the aid of diode D3. Output Q9 does not go high until after the tenth clock pulse, when the start bit of a new dataword causes the next reset. The rising edge of the pulse at Q9 charges C1 and causes a strobe pulse at the STR input of IC3. As a result, the received data is fed to the parallel data outputs of this IC. To protect the IC inputs, diodes D1 and D3 limit the negative pulses supplied by the differentiators to a voltage of -0.6 V. The digital data at outputs Q0 to Q7 of IC3 are applied direct to the user interface connector, K3.

The timing diagram in Fig. 2 illustrates the operation of the circuit by showing the time relation between the most important signals. The measuring points are found back as letter codes in the circuit diagram. When the first databit appears on the serial channel, decade counter IC7 supplies a high level at output Q1. This results in the signals at inputs I0 to I7 of K3 being read into
the parallel register of IC4. On the first falling edge of the clock pulse, the P/S input of IC4 goes low again, and the IC starts to shift out the bits that make up the parallel dataword. The shift-out operation is timed by the clock signal, and the serial bits appear at the QH output of IC4. The serial data is accepted by IC3 at its J and K inputs. Meanwhile, the low level at the QI output of IC7 has been read at the P0 input of IC5. This low level is placed before the data, and thus serves as the start bit.

The serial output data that appears at the Q0 output of IC3 are applied to buffer IC6. This in turn drives IC8, which forms a current source together with resistor R7. In this way, we have created a standard MIDI output.

Following the start bit, the eight databits are shifted out and fed to the current source. The LSB is transmitted first. Since the serial input of IC4 is connected to the positive supply voltage, the eighth databit is followed by a series of logic Is. This is done to keep the MIDI channel 'off', with no current flow through the cable.

The MIDI data produced by the interface is fed to the computer via a second 5-way DIN connector, K2. As you will have gathered from the circuit diagram, two cables are required to connect the interface to the Atari computer.

**Control software**

Although the interface can be used with any computer sporting a MIDI connection, the control software discussed below was designed specifically for the Atari ST. Fortu-
nately, the BIOS ROM in this computer offers a simple way of controlling its internal MIDI. Since most compilers for the ST support the use of the available BIOS routines, higher-language control software is relatively simple to write.

The present interface is tested in three steps. First, data is transmitted for the output on the I/O bus. Next, the program performs a number of status requests on the input register of the ST's MIDI. If reading back data from the I/O card is not successful after a certain period, you are likely to have made an error of some kind in the construction or connection of the interface. The listing in Fig. 5 shows the outline of a routine written in C for the control of the I/O interface.

An example of the screen graphics presented by a test and debugging program for the I/O interface is shown in Fig. 4. The window shows the status of each input and output bit. In the ‘auto’ (automatic) mode, a software counter increases the output value on the I/O bus by one every four seconds. In the ‘manual’ mode, the mouse may be used to toggle the logic level of each individual bit. When the I/O interface is not connected, the text in the input boxes is grey instead of black.

The programs on the diskette supplied for this project should help you on the way in developing a more extensive quasi-multiprocessing control utility which runs in the background. An interesting application is realized by using the interrupt from timer A in the 68001 to transmit a byte via the MIDI every millisecond. Provided the MIDI buffer in the ST is given its maximum size of 32 kBytes, it is even possible to create relatively long intervals (say, several tens of seconds) between the updating of the buffer content.

Users of computers other than the Atari ST may use the structure of the program described here as a starting point to write control routines geared to their machines.

**Construction**

No problems here, even for those with relatively little experience in building electronic

**COMPONENTS LIST**

<table>
<thead>
<tr>
<th>Resistor Values</th>
<th>Identifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>220Ω</td>
<td>R1, R7, R8</td>
</tr>
<tr>
<td>47kΩ</td>
<td>R2</td>
</tr>
<tr>
<td>10MΩ</td>
<td>R6</td>
</tr>
<tr>
<td>8x10kΩ SIL</td>
<td>R9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacitors</th>
<th>Identifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>15pF</td>
<td>C3, C4</td>
</tr>
<tr>
<td>100pF</td>
<td>C1, C2</td>
</tr>
<tr>
<td>100nF</td>
<td>C6-C12</td>
</tr>
<tr>
<td>10µF 25 V</td>
<td>C5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semiconductors</th>
<th>Identifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1N4148</td>
<td>D1-D5</td>
</tr>
<tr>
<td>4014</td>
<td>IC4</td>
</tr>
<tr>
<td>4017</td>
<td>IC7</td>
</tr>
<tr>
<td>4035</td>
<td>IC5</td>
</tr>
<tr>
<td>4060</td>
<td>IC6</td>
</tr>
<tr>
<td>4094</td>
<td>IC3</td>
</tr>
<tr>
<td>74HC04</td>
<td>IC2</td>
</tr>
<tr>
<td>74HCT5</td>
<td>IC9</td>
</tr>
<tr>
<td>CN17</td>
<td>IC9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Miscellaneous</th>
<th>Identifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-way PCB-mount. DIN socket</td>
<td>K1, K2</td>
</tr>
<tr>
<td>20-way PCB box header</td>
<td>K3</td>
</tr>
<tr>
<td>4 MHz quartz crystal</td>
<td>X1</td>
</tr>
<tr>
<td>printed-circuit board</td>
<td>910005</td>
</tr>
</tbody>
</table>
The project described here is supported by a control program which is available on an Atari-format diskette as order code ESS 1571. The diskette also contains the source code listing written in C, and the machine language listing, including the graphics support. For details on cost and ordering of this diskette please refer to the Readers Services page elsewhere in this issue. This item is available exclusively for Atari ST computers.

**SOFTWARE SERVICE**

**Fig. 4.** Screendump of the test program.

```c
bios(3, 3, outvalue);
i = 10;
while (1 > 0 && bios (1, 3) != -1) {
    i = 1 - i;
} 
if (i > 0)
    invalue = bios (2, 3);
else
    printf("MIDI 8-bit I/O-interface not found\n");
```

**Fig. 5.** Use this routine written in C to check the basic function of the interface.

---

**DIGITAL RESEARCH DOS 5.0 BRINGS BACK YOUR MEMORY**

Digital Research has recently introduced what can safely be called the most memory-efficient operating system for PCs. Apart from being a very powerful and simple to use operating system, DR DOS 5.0 ends the hassle with TSRs and drivers eating up large portions of the PC's base 640 kByte memory. If you, like this reviewer, use two or three TSRs, and a less than usual system configuration file, you may well have over 620 kByte of free memory and the hard disk.

Every new IBM DOS and MSDOS release has seen an increase in used up base memory. True, the performance of these systems has increased significantly, and from MSDOS 4.0 on it is possible to select a 'minimum' DOS configuration during the installation. Unfortunately, this minimum system still eats up more than 100 KByte, and slows the computer down considerably by swapping large data blocks between the main memory and the hard disk.

DR DOS 5.0, unlike any operating system I have seen before (with or without fancy 'memory managers'), runs almost entirely outside of the valuable 640 KByte memory area. By virtue of MemoryMAX™, DR DOS is capable of moving TSRs and drivers into high memory, the 384 KByte area between the top of the main memory (640 KByte) and the start of upper memory (1024 KByte).

In my case, I was pleased to see that I had 595 KByte of available memory area installing DR DOS plus my network driver, a really large display driver and all of my system configuration stuff. I upgraded from MSDOS 4.01, which left me a frustrating 420 KByte, just under the minimum required to run my DTP package, Ventura 2.0.

The installation of DR DOS 5.0 is straightforward, although it must be said that to fine-tune the performance you will need to be familiar with quite a few internal specifications of the PC you are using. In particular, the use of high memory and extended memory must be known in detail. Fortunately, the default selections presented during the installation are in most cases perfectly acceptable to achieve good results, even if you do not understand the meaning of all available options. A superb feature of DR DOS is that it can be re-installed from hard disk.

J. Buiting

More information on DR DOS 5.0 from Digital Research (UK) Ltd., Oxford House, Oxford street, Newbury, Berkshire RG13 1JB. Telephone: (0635) 35304. Fax: (0635) 35834.
WATTMETER

It is an unfortunate but well-known fact that measuring the active power of a mains-powered apparatus can be quite tricky. While non-reactive loads such as bulbs are mostly plain sailing, appliances that present inductive or capacitive loads force us to brush up our knowledge of waveform theory. Unless...

L. Lemon

SINCE inductive and capacitive loads cause a phase shift between current and voltage, their real active power can not be measured by multiplying the applied voltage with the measured current. Such a measurement yields reliable results only when the phase shift angle is known and included in the calculation of the active power. A similar problem arises with non-sinusoidal waveforms. These are often supplied by dimmers, whose output voltages seem to take almost any shape except that of a pure sine-wave. Although an oscilloscope could be used to establish the active power of a load powered by a dimmer, this type of measurement is cumbersome and inaccurate.

A much simpler way of measuring a.c. active power is to use a four-quadrant multiplier. This analogue calculation device is capable of measuring the current through a load, and the instantaneous voltage across it, simultaneously. Next, the two values are multiplied, and the result is shown on a display. If this sounds like a complex set of functions, we are fortunate to have these multipliers available in the form of integrated circuits. What's more, a four-quadrant multiplier is almost all we require for the instrument we intend to build. Add a power supply, a potential divider, two opamps, a few presets, and you have your wattmeter with a measuring capability of up to 3.5 kW.

The circuit

The circuit diagram of the wattmeter is simple and readily analysed. It consists of two parts—the meter circuit proper, and the display circuit.

The schematic in Fig. 1 is that of the power-voltage (P-U) converter, while Fig. 2 shows the liquid crystal display (LCD) section. In the top left-hand corner of Fig. 1 we see a load resistor, $R_L$, which is connected to $K_2$. This is where the mains-powered load, for instance, a motor, a bulb, a TV set, etc., is connected. Two parallel-connected shunt resistors, $R_s$ and $R_y$, pass the current drawn by the load. The effective resistance and power rating of the shunt are 0.05 $\Omega$ and 10 W respectively. The two resistors turn the current flow into a proportional voltage, which is amplified about 6 times by opamp IC3 before it is applied to the input of the four-quadrant multiplier, IC4. Switch S1 at the input of the opamp forms a range selector.

A potential divider (p.d.) formed by $R_s$, $R_a$, and $R_s$ is connected in parallel with the load. Resistor $R_s$ feeds the output voltage of this p.d. to the $V_{xx}$ input of the multiplier, IC4. Two series-connected resistors are used in the upper branch of the p.d. to stay well below the maximum voltage that may be applied to a 0.125 W resistor. Since this voltage is usually specified at about 200 $V$, it is safer to use two identical resistors in series considering that the mains voltage may rise to 250 $V$. With two identical resistors in series, the voltage across each of them is unlikely to exceed the maximum permissible value.

Diodes D1 to D4 protect the opamp and multiplier inputs by diverting positive and negative voltage surges to the supply lines.

The basic operation of the analogue multiplier, a Type MC1495L from Motorola, is apparent from the internal structure shown in Fig. 3. The IC uses the input voltages, $V_x$ and $V_y$, to supply an output voltage, $V_o$, that is described by

$$V_o = k V_x V_y$$  \[1\]

In this equation, the constant, $k$, is determined by external components:

$$k = \frac{2 R_s}{R_x R_y}$$  \[2\]

In the present circuit, $R_s$ is composed of two 150-0 $\Omega$ resistors, $R_{12}$ and $R_{24}$, at the output of the multiplier IC, while $R_x$ and $R_y$ are formed by the resistors connected to IC pins 10-11 and 5-6. The current $I_3$ in equation [2] flows from pin 3 of IC4 into the ground line, and can be adjusted with the SCALE FACTOR preset, $P_6$. Presets $P_4$ and $P_5$ each supply an off-set compensation voltage at the $V_{xx}$ and $V_{yy}$ inputs. These voltages serve to set the differential voltage at the relevant multiplier input.

The second opamp in the circuit, IC8b, amplifies the multiplier output signal before this is applied to the display driver.

The circuit diagram of the LCD section based on the ICL7106 is shown in Fig. 2. Preset $P_7$ in the multiplier circuit is used for off-set compensation. The ICL7106 contains an analogue-to-digital converter (ADC) and a liquid crystal display driver. The chip is used in a standard application circuit, which requires a handful of external components for the on-board oscillator (R2-C2), the auto-zero function (R3-C3), and the capacitive reference (C3).

### MAIN SPECIFICATIONS

- **Accurate a.c. active power indication**
- **Four-quadrant multiplier handles ohmic and reactive loads**
- **3½-digit LCD**
- **Simple to connect**
- **Two ranges; resolution 1 W or 10 W**
- **Measures up to 3,500 W**
Fig. 1. The main meter circuit is a power-to-voltage converter based on a four-quadrant multiplier Type MC1495L from Motorola.

Returning to Fig. 1, the power supply is based on two adjustable precision voltage regulators Type LM317/LM337. Fixed voltage regulators are not suitable here in view of the required stability of the supply voltages. Also, the ±7.5 V supply voltage must be exactly symmetrical, which requires the voltage regulators to have an adjustment facility. In the present circuit, the supply voltages are matched with the aid of presets P1 and P2.

Construction: safety first

Since the circuit is connected direct to the mains, the construction demands great care and attention to prevent any risk of electrical shock. With this in mind, it is not surprising that the wiring of the instrument requires much more attention than the construction of the two printed-circuit board, which are relatively simple designs (see Figs. 4 and 5). Although it is possible to use a fixed mains input cord inserted through a rubber grommet and fitted with a strain relief at the inside of the enclosure, it is safer to use a mains appliance socket rated at 13 A. The output of the circuit is connected to a mains socket fitted on the front panel of the enclosure.
This connection must be made with wire with a cross-sectional area of 2.5 mm² or greater. For the sake of safety, cover each solder joint between a wire and a connector or terminal in heat-shrink sleeving or insulating tape. All metal parts of the wattmeter enclosure must be connected to earth.

The front panel is cut and drilled to accept the mains socket, the display, the on/off switch and the range switch. Note that although an IEC-style earthed mains socket is shown fitted on the front panel of the prototype, the actual type of mains socket used depends on local regulations. There should be no problem fitting an U.S. or U.K. style mains socket. A ready-made self-adhesive two-colour foil is available to give the wattmeter a finished appearance. The layout of this front panel is apparent from the introductory photograph.

Finally, fit a 3-mm thick plastic or ABS plate between the display PCB and the front panel of the enclosure. This plate functions as an insulator, and must be at least 3 mm longer and wider than the display PCB.

### Adjustment

The wattmeter is adjusted with the aid of a digital multimeter (DMM) and a sine-wave generator.

First, adjust presets P₁ and P₂ until the circuit supply voltages are exactly +7.5 V and -7.5 V. Next, connect the sine-wave generator to pin 3 of IC₃. Set the generator to an output voltage of 3 V, and a frequency between 50 Hz and 200 Hz. If applicable, set the DC-offset at the generator output to 0 V.

### COMPONENTS LIST

#### METER BOARD

**Resistors:**

<table>
<thead>
<tr>
<th>Value</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>220Ω</td>
<td>R1, R2</td>
</tr>
<tr>
<td>100Ω</td>
<td>R3, R4</td>
</tr>
<tr>
<td>1kΩ</td>
<td>R5</td>
</tr>
<tr>
<td>5.1kΩ</td>
<td>R6, R7</td>
</tr>
<tr>
<td>1kΩ</td>
<td>R8, R9, R10</td>
</tr>
<tr>
<td>3kΩ</td>
<td>R11</td>
</tr>
<tr>
<td>1.2kΩ</td>
<td>R12</td>
</tr>
<tr>
<td>2kΩ</td>
<td>R13-R16</td>
</tr>
<tr>
<td>8kΩ</td>
<td>R17, R18, R20, R23</td>
</tr>
<tr>
<td>5kΩ</td>
<td>R19</td>
</tr>
<tr>
<td>15Ω</td>
<td>R21</td>
</tr>
<tr>
<td>270Ω</td>
<td>R22, R24</td>
</tr>
<tr>
<td>5kΩ preset H</td>
<td>R25</td>
</tr>
<tr>
<td>2kΩ preset H</td>
<td>R26, R27</td>
</tr>
<tr>
<td>25kΩ preset H</td>
<td>R28, R29</td>
</tr>
</tbody>
</table>

**Capacitors:**

<table>
<thead>
<tr>
<th>Value</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>100μF</td>
<td>C1, C2</td>
</tr>
<tr>
<td>1μF</td>
<td>C3, C4</td>
</tr>
</tbody>
</table>

**Semiconductors:**

<table>
<thead>
<tr>
<th>Type</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1N4001</td>
<td>D1-D4</td>
</tr>
<tr>
<td>LM317</td>
<td>IC1</td>
</tr>
<tr>
<td>LM337</td>
<td>IC2</td>
</tr>
<tr>
<td>TL082</td>
<td>IC3</td>
</tr>
<tr>
<td>MC1495L</td>
<td>IC4</td>
</tr>
<tr>
<td>B80C1500</td>
<td>B1</td>
</tr>
</tbody>
</table>

**Miscellaneous:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-way PCB-mount screw terminal block</td>
<td>K1, K2, K3</td>
</tr>
<tr>
<td>SPST switch</td>
<td>S1</td>
</tr>
<tr>
<td>fuse 200mA slow</td>
<td>F1</td>
</tr>
<tr>
<td>mains transformer 230V @ 1.66A</td>
<td>T1</td>
</tr>
<tr>
<td>DPDT mains-rated switch</td>
<td>S2</td>
</tr>
<tr>
<td>printed-circuit board</td>
<td>910011-13</td>
</tr>
</tbody>
</table>
If you do not have a sine-wave generator, use a small mains transformer with a 3-V secondary.

Short out R10, the feedback resistor of IC3a, Connect pin 9 of IC4 to ground, and open switch S1. Adjust preset P4 (Vx offset) for minimum alternating voltage at output A of the main meter board (all voltages are measured with respect to ground).

Connect the generator output to pin 9 of IC4. Connect pin 3 of IC3a to ground, Adjust preset P5 (VV offset) for minimum alternating voltage at output 'A' of the main meter board. Next, minimize the d.c. component at the output terminal, 'A', by adjusting preset P7.

Connect a non-reactive load, e.g., a 100-W bulb, to the output of the wattmeter. Measure the voltage across the bulb, and the alternating current. This measurement is preferably carried out with a true-RMS meter. Calculate the active power of the bulb. The direct voltage at terminal 'A' should be about 100 mV, corresponding to a sensitivity of 1 mV/watt. If necessary, correct the setting of P6. Next, adjust P1 on the display board until the calculated active power appears on the display.

The last adjustment involves the second measurement range. Close S1, and adjust preset P3 until the voltage at terminal 'A' is one tenth of the previously measured value. This completes the adjustment of the wattmeter.

You are now ready to test the wattmeter with 'real' loads whose active power you want to check against the manufacturer's specification. You can measure up to 3.5 kW. The accuracy of the instrument is about 5% even under less favourable conditions, for example, when a heavily capacitive or inductive load is connected, or when the mains voltage is distorted by a dimmer circuit.

Fig. 6. Completed boards, interconnected and ready for adjustment.
Those of you who run assemblers capable of producing Tektronix or Intel format output files have a problem when an available EPROM programmer is not 'intelligent', or when a simple hexdump is required of the object code. Here is a BASIC program to end your misery.

from an idea by S. Mitra

During system software development, it is often required to generate a hexadecimal dump listing from the Intel/Tektronix format for documentation or debugging. Doing such a conversion manually takes a lot of

Fig. 1. Listing of HD.BAS, the file format converter, written in BASIC.

ELEKTOR ELECTRONICS APRIL 1991
The listing of the file converter, HD.BAS, is given in Fig. 1. The program has quite a few error trapping routines, and will handle almost any type of error without crashing your PC. On being run from GWBASIC, the program asks you to enter the input and output file names. Next, it verifies the file format type. If a wrong format is detected, the program terminates with an error message. If the file format is correct, the conversion is started, and you can see the hex dump listing scrolling on your PC screen, while the output file is written to the disk. After each screenful of data, the program will stop and prompt you to press a key to continue.

Two examples of the use of HD.BAS are given in Figs. 2 (Intel format) and 3 (Tektronix format). As you can see, the program is capable of turning what many of you will regard as a cluttered block of data into a neatly formatted hexadecimal dump.

**The program**

The listing of the file converter, HD.BAS, is given in Fig. 1. The program has quite a few error trapping routines, and will handle almost any type of error without crashing your PC. On being run from GWBASIC, the program asks you to enter the input and output file names. Next, it verifies the file format type. If a wrong format is detected, the program terminates with an error message. If the file format is correct, the conversion is started, and you can see the hex dump listing scrolling on your PC screen, while the output file is written to the disk. After each screenful of data, the program will stop and prompt you to press a key to continue.

Two examples of the use of HD.BAS are given in Figs. 2 (Intel format) and 3 (Tektronix format). As you can see, the program is capable of turning what many of you will regard as a cluttered block of data into a neatly formatted hexadecimal dump.

---

**SOFTWARE-SERVICE**

The program described here is available on a 5¼-inch 360 KB MS-DOS formatted floppy disk under order number ESS1551. For details on price and ordering, please refer to the Readers Services page elsewhere in this issue.
Although it has been in use for over ten years in the UK, the 6-metre (50 MHz) band has recently gained a lot of attraction since the PTT authorities of a number of continental European countries including France, Holland, Belgium and Germany have, after a faltering start, issued the first few hundred 6-metre licenses to die-hard home brewers. The author invites you to partake actively in the growing 6-m activity. As shown in the ‘specs’ box on this page, the present transverter has quite a few distinct advantage over earlier designs that have appeared in the radio amateur press.

Pedro Wyns, ON4AWQ

**MAIN SPECIFICATIONS**

- P-I-N-diode Rx/Tx switching; no relays
- Packet/AmTOR compatible
- Output power approx. 1.5 W at 2 W input power (peak effective levels)
- Sensitivity approx. 0.2 µV for 20 dB SINAD
- VOX/ALC output
- Tx ‘hang’ time set by user
- Ready-made inductors for easy construction and adjustment
- Eurocard-size PCB (10x16 cm)

**SITUATED** at the low end of the VHF band, the amateur radio frequency segment between 50 and 52 MHz has some very exciting propagation characteristics. Thanks to atmospheric reflection, transcontinental radio contacts using very low powers have been made ‘on six’. Radio amateurs working on the VHF and UHF bands know that the reception quality of signals from VHF Band-1 (48-68 MHz) TV transmitters can rise within minutes from very poor to quite acceptable. This often happens in the summer and early autumn, when there are temperature inversions in certain layers of the atmosphere. In the UK, where the VHF-1 band is no longer used for TV broadcast services, it is common practice among VHF radio amateurs to monitor the field strength of certain Dutch and Spanish TV transmitters. First, the syncs are audible, then the pictures seem to arise from the noise. The next thing to do is get the logbook out and the rig ready since it is often only a matter of hours before long periods of sporadic-E reflection enable contacts to be made over distances of hundreds of miles in the 2-m band.

A quite different type of propagation, TEP (trans-equatorial propagation), carries 6-m signals across the oceans, reaching stations thousands of miles away. Contacts have been made between European radio amateurs and stations in Rhodesia, South Africa, Namibia and Brazil, using CW on six metres.

In Europe, equipment for the 6-m band is mostly of the home-brew type, although Japanese ‘black box’ transceivers are starting to become available. The 6-m band is not crowded, and equipment being mostly experimental with modest transmit power there is a certain distinction in being QRV on six.

**From two to six and vice versa**

The word transverter is an acronym for transmitter-converter. The circuit described here transposes received signals in the 6-m band to the 2-m band (144-146 MHz; in the USA: 144-148 MHz), while the transmit signal of the 2-m rig is transposed to the 6-m band (50-52 MHz; in the USA: 50-54 MHz). Basically, a transverter is a linear bidirectional mixer connected to an RF input stage and an RF power amplifier. Take a look at the block diagram in Fig. 1. When the transverter is in the receive mode, signals picked up by the 6-m antenna are passed through a filter before they are amplified by T4 via an electronic RF switch based on p-i-n diodes. The up-converted 2-m signal is taken from the RF connection, and fed to the 2-m transceiver.

When the 2-m transceiver is switched to transmission, its RF output signal is rectified to control an electronic Tx/Rx (transmit/receive) switch based on T7-T10. The Tx LED lights, and the transverter is switched to...
transmit mode. The 2-m signal is first attenuated before it is mixed with the 94 MHz LO signal. The mixer output frequency, 50 MHz (with the 2-m rig tuned to 144 MHz), is fed to the input of an amplifier, T5. Then follow the RF power stage and the antenna filter. A signal rectifier in the output filter provides an ALC function or a simple RF signal level meter that may be used to monitor the transverter's output power. The 'hang' time of the Rx/Tx switcher may be adapted by the user to individual requirements.

The input and output impedance of the transverter are 50 Ω. The circuit is powered from a 12-V supply, which makes it suitable for mobile use.

**Look: no relays!**

The circuit diagram of the transverter, Fig. 2, follows the block schematic quite closely. At the heart of the circuit is a Type SBL-1 double-balanced mixer (DBM) from Mini Circuits Laboratories. This is a 7-dBm-LO, 1-dB-RF DBM for use up to 500 MHz. The SBL-1 is familiar to most VHF radio amateurs as it is used in many home made converters and transverters. An equivalent of the SBL-1, the 1ESO0, may also be used in this circuit. An excellent discussion of DBM operation and selection criteria is given in Ref. 1.

**Receive mode**

Let's assume that the transverter is in the receive mode, and start the description of the circuit diagram with the 94-MHz local oscillator chain. In the lower left-hand corner of the diagram we see a Colpitts-type quartz oscillator based on T1 and a 10.44 MHz quartz crystal, X1. The oscillator operates with the crystal resonating at its fundamental frequency. An overtone oscillator running at 94 MHz was found less suitable here in view of the required stability and tuning capability. The output signal of the oscillator is multiplied by three to give 31.32 MHz at the collector of T2. Further tripling, T3, supplies the LO end frequency of 94 MHz at a power of about 10 mW. Via a short length of 50-Ω coax, the LO signal is fed to the SBL-1 (Mixi) which mixes it with the 50 MHz signal supplied by the receive amplifier, MOSFET T4.

Since the Rx supply line is at about +11 V, diode D4 is forward biased, while its Tx counterpart, D5, blocks. This 2-way p-i-n switch provides a high degree of RF isolation between the output of the receive amplifier, T4, and the output of the transmit amplifier, T3, ensuring that the switched-off circuit does not load the active circuit.

The RF signal picked up by the 6-m antenna is taken through a 50 MHz bandpass filter before it arrives at the G1 (gate-1) terminal of T4. The two anti-parallel diodes, D1 and D2, form a clamping circuit that protects the MOSFET input and at the same time functions in the Tx/Rx switching (remember, the RF power transistor, T6, is switched off because the +Tx supply line is at virtually 0 V). The amplifier based on T4 guarantees excellent sensitivity in the 6-m band, and has ample gain to compensate the mixing loss in the DBM. At the output of the receive amplifier, C50 forms part of a matching network that works in both the transmit and the receive mode, while components R21 and C30 are used to bias the p-i-n diode.

The 94 MHz LO signal mixed with the amplified 50 MHz signal yields 144 MHz at the RF connection of the DBM. The 144 MHz signal is filtered by a series L-C network, C96-C97-L1 to bypass the transmit attenuator, before it is fed to the input of the 2-m transceiver.

**Transmit mode**

When the 2-m transceiver is switched to transmit, its RF output signal is rectified by D9-D10-C11. Consequently, transistor T8 is turned off so that T6 is turned on. The Tx LED lights, and the Tx supply line in the circuit is at about 11 V, while the +Rx line is at about 0 V. The +Tx voltage causes p-i-n diode D1 to conduct, which detunes the L-C series network and causes it to act as a 50-MHz notch. The 144-MHz CW or SSB signal is applied to a 50-Ω dummy load and attenuated by R31-R32 to give a suitable driving level for the DBM. Since the LO signal is permanently present, the IF connection of the DBM supplies the heterodyne frequency of 50 MHz. Diode D6 conducts, and the mixer output signal is applied to an amplifier stage based on MOSFET T5. This driver supplies an output power of about 40 mW to the RF power transistor, T6. The MR237 used in this position is a VHF power transistor from Motorola. To ensure that the device operates linearly, its quiescent current is set to about 75 mA. The RF stage has an output power of up to 1.5 W, depending on cooling and the transistor characteristics. The quiescent current can be measured as a voltage across the 10-Ω supply resistor, R25. The typical voltage on R25 will be around 1 V.

A twelve-pole pi-type elliptical low-pass filter based on adjustable inductors is inserted between the RF amplifiers and the antenna connection. This filter has an additional notch, L14-C60, to trap the second harmonic (100 MHz).

The diode detector based on D7 and D8 may be used for output power level monitoring, adjustments or ALC (automatic level control) applications. The latter function however requires the two diodes to be reversed. The output may also be used to provide a basic RF power indication. The transverter has ample output power to drive a 6-m linear amplifier. The use of high power in the 6-m band is not advocated, however.

---

**Fig. 1.** Block diagram of the 6-m transverter. Not shown here for the sake of clarity is an L-C filter at the transceiver side of the DBM. In receive mode, this section forms a series filter tuned to 144 MHz. In transmit mode, it forms a 50 MHz notch. The switching is effectuated with a VHF p-i-n diode.
and constructors should observe the maximum permissible EIRP level stated in their license. In practice, the 1.5 to 2 watts or so furnished by the transverter will scrape the EIRP limits when a directional antenna is used, say, a five-element yagi with 10 dB gain. Do not spoil the experimental character of the 6 m band by using excessively high power levels. QRP is much more fun!

Tx/Rx switching

It will be noted that the circuit is totally solid-state, i.e., the dreaded transmit/receive relay does not come into play. All Tx/Rx switching is performed by p-i-n diodes, whose short response time allows the transverter to be used for Packet Radio and AmTOR, where Tx/Rx switching is computer-controlled. Note, however, that your licence may not allow these communication modes on six. The 'hang time' of the electronic Tx/Rx switch is determined by the 2.2 µF capacitor, C47. You may want to change this value to meet your individual requirements.

Construction

The transverter is best built on the double-sided printed circuit board shown in Fig. 3. The complete circuit is accommodated on this Eurocard-size (10x16 cm) board which has a pre-tinned copper ground plane at the component side to ensure screening and decoupling of the RF signals. Since ready-made inductors are used, the construction is really quite straightforward. A few points must be noted, though.

Start by fitting the capacitors, resistors and diodes. All parts must be fitted with the shortest possible terminal length. Grounded component terminals must be soldered to the ground plane at the component side of the PCB. Proceed with mounting the RF power transistor, T6. Experienced constructors may solder the case of this transistor firmly on the PCB surface, and solder the three terminals at the track side only. Remember that the case of the MRF237 is connected to the emitter, so that any direct contact between it and the ground plane is perfectly all right. Soldering the MRF237 to the board makes for minimum stray capacitance and optimum cooling, which helps to ensure the stability of the RF power stage. Carefully remove the solder resist mask locally with a sharp knife. Next, preheat the area. Remove excess solder and solder resin with the aid of desoldering braid and alcohol. Push the transistor firmly in place, and solder the rim on the case to the pre-tinned area. Solder as quickly as you can, and go all around the case. The solder joints should be smooth. If you have reason to believe that your solder iron is not powerful enough to do this job quickly, pre-heat the transistor with the solder bit until it is so hot that you can just pick it up and fit it on the board. The MRF237 must be fitted with a heatsink, preferably of the type shown in the photograph of the prototype. Never test the transverter without a heatsink fitted on the MRF237: the destruction of this fairly expensive device will be imminent.

Fit the mixer on the board, noting its orientation from the circuit diagram and the indication on the component overlay. Push the device flat on the PCB surface, and solder all eight pins at the track side.

Next, mount the inductors. There are quite a few, and the type numbers can be confusing, so make sure you fit each of them in the right position. The screening cans are soldered to ground.

The last components to be mounted are...
Fig. 3a. Double-sided printed-circuit board for the transverter.
Ceramic capacitors:
1 10pF C3
8 100pF C5,C6,C7,C21
16 10nF C6,C9,C11,C12;

Capacitors:
1 22pF 25V tantalum C2
1 22pF 63V radial C1
1 22pF 16V radial C47
1 68pF trimmer C4

Resistors:
5 27Ω R1,R2,R3,R6,R8,
4 27Ω 0.5W R34,R37
3 1kΩ R4,R20,R21,R24,
3 100Ω R5,R9,R11
3 12Ω R7,R10,R22
2 5kΩ 1% R12,R19
2 10kΩ R13,R17
3 150Ω 1W R27,R32,R29
2 47Ω R15,R30
1 10kΩ R18
1 10Ω R25
3 12kΩ R26,R30,R35
1 16Ω R14
1 2kΩ R32
2 47Ω R36,R38

Inductors:
2 301KN0100 (white) L1,L2
2 301KN0500 (green) L3,L4
1 113KN2K305HM L5,L6
2 10µH choke L7,L10
2 113CNK1370HM L8,L9
1 E526HNA100079 L11
1 E526HNA100073 L12
4 E526HNA100077 L13,L14,L15,L17
1 E526HNA100075 L16
1 301KN0300 (orange) L18

Semiconductors:
1 8V2.0 4W zener diode D1
6 1N4148 D2,D3,D7,D10

Miscellaneous:
1 10.444 MHz quartz crystal X1
1 heatsink TO-39 style for T6; length 25mm
1 printed-circuit board 910010
1 Coax cable RG174/U

The author can supply a number of components for the transverter, including the DBM (E5050 or SBL-1), the 10.444 MHz quartz crystal and all inductors. For further information, contact Pedro Wyns ON4AWQ, Mecheleesteenweg 13, 2220 Heist-op-den-Berg, Belgium.

The majority of components for the transverter are available from Bonex Ltd, 12 Etcher Way, Langley Business Park, Slough, Berkshire SL3 6EP, Telephone: (0753) 49502, fax: (0753) 43612.

Fig. 3b. Component mounting plan.
the transistors. While the BF199s, BC517s and BD139s will pose little problems, pay attention to the MOSFETs. Do not remove the BF961s from their protective packaging until they are due for mounting. Aluminium kitchen foil is fine for storing these devices. Leave them on the foil while you run a thin, chen foil is fine for storing these devices.

The ALC output is optional, and since there appears to be no standard for this connection, any suitable combination of a plug and a socket may be used to carry the signal to other equipment.

Adjustment
The transverter is adjusted in steps as described below. First, however, build the RF signal detector shown in Fig. 6. This circuit is used to probe the RF signal levels at various locations in the circuit. The moving-coil meter may, of course, be formed by your multimeter set to the most sensitive current range. The preset in the detector, Pt, is adjusted depending on the signal level measured. To adjust the inductor cores, you will also require a gate dip meter and a plastic Allen key. Never use a screwdriver or a metal Allen key to adjust the inductor cores.

Local oscillator chain adjustment
1. Connect the probe to the hot side of R4 (1 kΩ), and check for oscillator activity.
2. Tune the gate dipper to 31 MHz, hold it close to L3, and adjust L2 and L3 for maximum reading.
3. Repeat steps 2 and 3.
4. Connect the RF probe to the hot side of R11 (100 Ω).
5. Adjust L3 and L4 for maximum reading.
6. Connect the RF probe to the hot side of R11 (100 Ω).
8. Connect a dummy load/power meter or an antenna to the 6-m output. Apply a continuous power of 100 to 500 mW to the 2-m input.
9. Adjust inductor L5 for maximum output power.
10. Adjust inductors L11, L12, L13, L14, L16 and L17 for maximum output power. Repeat steps 9 and 10.
11. Adjust inductor L15 for minimum signal at 94 MHz (use an FM radio for this adjustment).
12. Remove the short at the collector of T7.

Rx chain adjustment
1. Remove the short to the collector of T7.
2. Connect an RF signal source to the 6-m input. Alternatively, ask a nearby ham to transmit a test signal on six. Tune the 2-m receiver to the test signal. Adjust L5, L6 and L18 for best reception. If necessary, gradually reduce the level of the test signal.

This completes the adjustment of the 6-m converter. The absolute maximum 2-m input power to the transverter is 5 W. In most cases, however, the maximum output power of about 2 W will be achieved with 2.5 W or less on 2 m. Switch the 2-m transceiver to SSB or CW, connect your 6-m antenna, and away you go. You are now QRV on six! International calling frequency: 50.110 MHz.

Reference:
1. RF/IF signal processing handbook. Published by Mini Circuits Laboratories, P.O. Box 166, Brooklyn, New York, U.S.A.
On-board power supply

The circuit diagram of the power supply, Fig. 19, shows that the semiconductor tester has an on-board step-up voltage converter that is powered from the 12-V supply in the PC. The 5-V supply of the PC is also used to power certain parts of the circuit. The 12-V supply of the PC is connected to a step-up converter via a 4-way connector as used for floppy disks and hard disks. The current requirement of the 12-V input is about 2.2 A. If this current is not available in your PC, it is still possible to use the semiconductor tester with a correspondingly reduced maximum collector current for the device under test.

The input current of the voltage doubler in the power supply is about 2.2 times the output current. Hence the 2.2 A input current requirement if a maximum collector current of 1 A is to be achieved. The quiescent current drawn by the power supply is about 150 mA.

The power supply is essentially a switch-mode circuit based on a dedicated controller Type UC3524A, 10, and two power MOSFETs, T1 and T2. The MOSFETs are connected to a ferrite transformer, Tri, which doubles the input voltage to 24 V, and in addition provides a floating 15-V output. The 15-V output of the transformer is rectified and smoothed by diodes D4-D5 and capacitor C8. Next, the rectified voltage is stabilized at 15 V by a Type 7815 fixed voltage regulator. The floating 15-V supply is used for the base voltage generator, which must operate potential-free, that is, at a potential that can not be measured with respect to ground. Finally, capacitors C11-C24 are included for stabilization, decoupling and noise suppression.

Main circuit

Figure 20 shows the circuit diagram of the main digital and analogue sections of the semiconductor tester. The PC bus interface is shown in the top left-hand corner of the diagram. Data lines D0 to D7 (bus contacts A02 to A09) are connected to bidirectional bus driver IC10, a 74LS245, which forms the data link between the PC and the insertion card. Address lines A0 and A1 (bus contacts A30 and A31) drive inputs A and B of the two binary-to-decimal decoders contained in IC9b. These two decoders control the operation of the various bus drivers. Bus signals IOWC and IORC (bus contacts 513 and 514) drive the enable inputs of IC9b via IC9c and IC9d. The RESET line (bus contact B02) has an important function in the circuit because it ensures that all relays are de-actuated when the PC is switched on, preventing undefined switch configurations and short-circuits on power-up.

Address lines A2 to A9 (bus contacts A22 to A29), together with the address enable line, AEN (bus contact A11), are connected to an address decoder based on IC7a, a Type 74LS688. The insertion card is normally addressed at I/O location 300h, but may be given a different address by changing the setting of the 8-way DIL switch. Details on
the address setting of the card are given in the READ.ME documentation file on the floppy disk supplied with the kit.

The digital control information supplied by the PC is latched and distributed by IC14, IC15 and IC16. Circuits IC14 and IC15 have direct control over relays Rei to Rei8, while IC14 additionally controls the switch for the range selection in the current measurement circuit. IC16 forms the interface between the PC and optocouplers IC18 to IC21.

The input data of bus driver IC13 is supplied by outputs Q6, Q7 and Q8 of IC6, by R35, which provides the current protection information supplied by IC6c, and by the INTR output of the A-to-D converter.

As already noted in the introductory installment of this article, the collector-emitter voltage of a device under test rises in the range 0 to 20 V. This voltage is supplied by Ts, a power transistor Type BD250C, which is driven via transistor T4 and opamp IC6A. The output voltage is applied to the input of the opamp, pin 3, via a potential divider consisting of R30, R31 and IC6B. In this arrangement, IC6B merely forms a differential amplifier that serves to shift the reference potential from output terminal ST5 to ground.

The set (i.e. required) output voltage is applied to pin 2 of IC6A via R35 and electronic switch IC17A. The PC supplies the set voltage in digital form to inputs D0 to D7 of DAC (digital-to-analogue converter) IC6.

Depending on the value of the dataword sent to the DAC via the PC interface, a voltage between 0 and -2.55 V is available at pin 6 of buffer opamp IC6B.

With switch IC17A set to the position shown in the circuit diagram, R25 feeds the ADC (analogue-to-digital converter) output voltage to the voltage control opamp, IC6A. The subsequent voltage amplifier based on transistors T3 and T4 supplies an output voltage of 0 to 20.45 V at terminals ST3-ST5. When IC17A is set to the other position, the control voltage is reduced by potential divider R27-R28. This is done to increase the resolution of the output voltage in the lower range. A control voltage of -2.55 V at pin 6 of IC5 results in an output voltage of +3.6 V at ST3-ST5.

The collector current of the device under test is measured with the aid of series resistor R54 inserted into the supply line. Resistor R3 supplies the voltage drop across R54 to pin 3 of a low-drift opamp Type TLC271, IC7. In the feedback circuit of this opamp we find resistor R41, while the ground path consists of switch IC8 and either one or two of 11 resistors R4 to R5 plus R16. The resistor selection is accomplished by IC8, whose internal resistance may be ignored as it is very small with respect to the resistor values. In this setup, the amplification of IC7 can be set to a number of fixed values between 2 and 200. The control information required for the gain selection is supplied by latch IC14 to the

control inputs, A, B and C, of IC6.

At the maximum output current of 1 A, R41 drops exactly 1 V. This results in 2 V at the output, pin 5, of IC6. In the most sensitive measurement range, 10 mA, R41 drops a maximum of 10 mV. This also results in a maximum of 2.0 V at the output of IC6 because the gain of IC7 is then set to 200.

The measured and subsequently amplified voltage is fed to the input, pin 6, of the 8-bit ADC, which converts the input voltage range of 0 to 2 V into a corresponding digital value that can be processed by the PC.

The reference voltages used in the circuit are derived from a Type 7805 fixed voltage regulator, IC9. Resistors R14-R17 and R18 supply a reference of 2.55 V for the DAC, and 1.0 V for the ADC.

The current measurement circuit has a built-in electronic fuse based on IC6c. Pin 13 of this opamp is held at a reference level of 2.25 V, while the other input, pin 12, is at a voltage proportional to the measured current. Since this voltage is supplied by IC7, the full-scale value is 2 V. When this value is exceeded by about 10%, the output of IC6c changes from high to low, causing transistor T5 to conduct. As a result, T4 switches off the current amplifier, IC7, so that the output current is interrupted, preventing damage to the device under test. Diode D7 provides a hold function for the actuated electronic fuse. The output current remains off until the PC clears the hold condition by opening

Fig. 19. Circuit diagram of the power supply section.
Fig. 20. Circuit diagram of the PC I/O interface, the relay control logic, and the variable-gain measurement amplifier.
switch IC7B. The overcurrent condition is signalled to the PC via potential divider R34-R35 and opamp IC13A.

The base current supply

Since the base current of the device under test is either positive or negative, it is supplied with reference to the positive collector-emitter voltage terminal, ST3, or to the negative terminal, ST5. This means that the base current supply must float with respect to ground—hence the separate 15-V section in the power supply discussed earlier.

As shown in the circuit diagram in Fig. 21, an electronic regulator based on IC22, IC5 and IC7 supplies an output voltage between 0 and 15 V, adjustable in 10 steps of 1.5 V. The required output voltage of the regulator is supplied by a DAC based on IC23 and a resistor ladder network, R71-R81. The clock input of IC23 receives the required output voltage in digital form via optocoupler IC21. Following a reset (via pin 11 and IC9), the first clock pulse that arrives via the optocoupler sets an output voltage of 1.5 V. Every clock pulse increases the output voltage of the regulator network by 1.5 V, until the maximum value of 15 V is reached.

Relay Re3 takes the required output voltage (at the collector of T7) to the switches contained in IC25 and IC26, and to the contacts of relays Re1, Re2 and Re3. Next, resistors R22-R99 convert the output voltage of the regulator into a proportional base current for the device under test. When, for example, the contact of Re1 is closed, a regulator output voltage of 15 V corresponds to a base current of 100 mA, and one of 1.5 V to 10 mA. Smaller base currents, starting at 1 µA and up to 10 µA, are generated in a similar manner. The total number of available base currents is 130.

The previously mentioned reference terminal, ST3 or ST5, is selected with the aid of two relay clusters, Re3-Re5 and Re4-Re6.

The base current supply is also capable of generating a gate voltage for the testing of FETs. This is achieved by opening the contact of Re4, so that the collector voltage of T7, reduced by R108-R109, is fed to the relevant test terminal via electronic switch IC26 (from pin 2 or pin 4 to pin 3) and relay Re1.

The PC determines which switch, IC25 or IC26, is actuated. This selection is effected via optocouplers to ensure that the base current supply floats with respect to ground. The actual selection is carried out by means of clock pulses. Five pulses are applied to the two inputs of 8-bit shift register IC22, a Type 4015. Each clock pulse causes the relevant data level to be loaded. After the fifth clock pulse, IC26 receives a latch pulse from IC18. This pulse enables IC24 to copy the 5-bit wide dataword supplied by IC22. The outputs of IC24, pins 2, 5, 7, 10, and 12, then drive the output multiplexers, IC25 and IC26.
Construction

All circuits discussed so far are accommodated on a single, double-sided and through-plated printed-circuit board. The size of this board is approximately 337 x 100 mm, to which 8 mm must be added for the bus contact area.

Before assembling the kit, it is recommended to read this entire section. This will help you keep a few points in mind that require special attention.

The construction of the printed-circuit board follows the component mounting plan printed on the PCB and shown separately in Fig. 22. Start with fitting the low-profile components, followed by the higher parts, and solder each of these at the solder side of the board. Soldering at the component side is not required since the board is through-plated. During the construction, pay attention to the following points:

1. Transistors T1 and T3, and voltage regulator IC9 are fitted horizontally on the board, without heatsinks, and without screws to secure them.

2. The output transistor, T3 (a BD250C) and the positive voltage regulator IC2 (a 7815) are also fitted horizontally. Both components are however, secured to the board by means of an M3x6 mm screw and a single M3 nut. The timed copper PCB surface underneath these components has no solder resist mask, and assists in cooling the devices.

3. The ferrite transformer, T11, is fitted with the side with terminals 1 and 5 on it pointing to transistors T1 and T2. The terminals marked 6 to 10 point to capacitor C7. Note that although the symmetrical arrangement of its connecting terminals allows the transformer to be fitted the other way around from indicated, this must not be done for electrical reasons.

4. Electrolytic capacitors C6 and C10 must be fitted horizontally.

5. Inductors L1 and L2 are mounted as close as possible to the PCB surface.

6. A total of five wire links must be fitted on the board. The first is about 30 mm long and runs underneath IC13 (a 74HC244) as shown on the component overlay. Use the insulated wire supplied with the kit, and take care to avoid short-circuits with the nearby IC pins. The remaining four wire links have a length between 180 mm and 210 mm. As shown on the photograph of the assembled board, one wire connects the two points marked A, one the two points marked B, one the two points marked C, and one the two points marked D.

7. A part of the circuit has a metal screening box around it. This screening serves to ensure the noise margin of the preamplifier, and surrounds the circuit sections that take care of the voltage setting, the current measurement, and the amplifier gain selection. These functions involve IC6, IC7, ICs and

<table>
<thead>
<tr>
<th>COMPONENTS LIST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Resistors:</strong></td>
</tr>
<tr>
<td>1  82Ω 3W</td>
</tr>
<tr>
<td>1  1kΩ 0.5% 1W</td>
</tr>
<tr>
<td>1  56kΩ</td>
</tr>
<tr>
<td>2  330Ω</td>
</tr>
<tr>
<td>1  39Ω</td>
</tr>
<tr>
<td>1  56kΩ</td>
</tr>
<tr>
<td>1  100Ω</td>
</tr>
<tr>
<td>2  120Ω</td>
</tr>
<tr>
<td>1  150Ω</td>
</tr>
<tr>
<td>2  220Ω</td>
</tr>
<tr>
<td>1  270Ω</td>
</tr>
<tr>
<td>1  330Ω</td>
</tr>
<tr>
<td>4  470Ω</td>
</tr>
<tr>
<td>1  680Ω</td>
</tr>
<tr>
<td>2  820Ω</td>
</tr>
<tr>
<td>8  1kΩ</td>
</tr>
<tr>
<td>4  1kΩ</td>
</tr>
<tr>
<td>1  1kΩ</td>
</tr>
<tr>
<td>1  1kΩ</td>
</tr>
<tr>
<td>2  2kΩ</td>
</tr>
<tr>
<td>7  2kΩ</td>
</tr>
<tr>
<td>1  4kΩ</td>
</tr>
<tr>
<td>1  8kΩ</td>
</tr>
<tr>
<td>24  10kΩ</td>
</tr>
<tr>
<td>3  12kΩ</td>
</tr>
<tr>
<td>6  15kΩ</td>
</tr>
<tr>
<td>1  18kΩ</td>
</tr>
<tr>
<td>6  22kΩ</td>
</tr>
<tr>
<td>1  27kΩ</td>
</tr>
<tr>
<td>2  33kΩ</td>
</tr>
<tr>
<td>4  47kΩ</td>
</tr>
<tr>
<td>1  56kΩ</td>
</tr>
<tr>
<td>6  68kΩ</td>
</tr>
<tr>
<td>1  82kΩ</td>
</tr>
<tr>
<td>2  100kΩ</td>
</tr>
<tr>
<td>1  120kΩ</td>
</tr>
<tr>
<td>1  150Ω</td>
</tr>
<tr>
<td>1  220kΩ</td>
</tr>
<tr>
<td>1  270kΩ</td>
</tr>
<tr>
<td>1  330kΩ</td>
</tr>
<tr>
<td>1  680Ω</td>
</tr>
<tr>
<td>2  1kΩ</td>
</tr>
<tr>
<td>1  1MΩ</td>
</tr>
<tr>
<td>1  500Ω preset V</td>
</tr>
<tr>
<td>5  5kΩ preset V</td>
</tr>
<tr>
<td>1  25kΩ preset V</td>
</tr>
<tr>
<td>1  10pF</td>
</tr>
<tr>
<td>3  100pF</td>
</tr>
<tr>
<td>1  1nF</td>
</tr>
<tr>
<td>1  2nF</td>
</tr>
<tr>
<td>1  4nF</td>
</tr>
<tr>
<td>1  10nF</td>
</tr>
<tr>
<td>2  47nF</td>
</tr>
<tr>
<td>1  56nF</td>
</tr>
<tr>
<td>7  100nF</td>
</tr>
<tr>
<td>15  100nF ceramic</td>
</tr>
<tr>
<td>6  100μF-16V</td>
</tr>
<tr>
<td>2  10μF-40V</td>
</tr>
<tr>
<td>1  47μF-40V</td>
</tr>
<tr>
<td>2  1,000μF-40V</td>
</tr>
<tr>
<td><strong>Capacitors:</strong></td>
</tr>
<tr>
<td><strong>Semiconductors:</strong></td>
</tr>
<tr>
<td>1  ADC0804</td>
</tr>
<tr>
<td>1  AD7524</td>
</tr>
<tr>
<td>1  UC3524A</td>
</tr>
<tr>
<td>1  74LS04</td>
</tr>
<tr>
<td>1  74LS32</td>
</tr>
<tr>
<td>1  74HC139</td>
</tr>
<tr>
<td>1  74HC244</td>
</tr>
<tr>
<td>1  74LS245</td>
</tr>
<tr>
<td>1  74LS273</td>
</tr>
<tr>
<td>1  74LS374</td>
</tr>
<tr>
<td>1  74LS688</td>
</tr>
<tr>
<td>1  CD4015</td>
</tr>
<tr>
<td>1  CD4040</td>
</tr>
<tr>
<td>2  CD4051</td>
</tr>
<tr>
<td>1  CD4025</td>
</tr>
<tr>
<td>1  CD4053</td>
</tr>
<tr>
<td>1  CD4093</td>
</tr>
<tr>
<td>1  CD40174</td>
</tr>
<tr>
<td>1  TLC271</td>
</tr>
<tr>
<td>1  LM358</td>
</tr>
<tr>
<td>1  TLO31</td>
</tr>
<tr>
<td>1  TLO64</td>
</tr>
<tr>
<td>4  CD4171</td>
</tr>
<tr>
<td>1  7505</td>
</tr>
<tr>
<td>1  7815</td>
</tr>
<tr>
<td>1  2N3019</td>
</tr>
<tr>
<td>1  BD250C</td>
</tr>
<tr>
<td>2  BUZ71</td>
</tr>
<tr>
<td>1  BC327</td>
</tr>
<tr>
<td>1  BC337</td>
</tr>
<tr>
<td>1  BC548</td>
</tr>
<tr>
<td>2  BV555</td>
</tr>
<tr>
<td>1  1N5822</td>
</tr>
<tr>
<td>12  1N4148</td>
</tr>
</tbody>
</table>

**Miscellaneous:**

10  PCB-mount readout panel
1  15UH inductor
1  0.1μF ceramic
2  4-way DIP switch
1  0.1μF ceramic
6  screw M3x6
4  nut M3
1  screening box
1  PC card fixing bracket
2  aluminum bracket
1  rubber grommet dia. 4mm
3  solder pin
3  crocodile clip
1m insulated wire, red, 1mm²
1m insulated wire, blue, 1mm²
1m insulated wire, yellow, 1mm²
85cm insulated wire, 0.22 mm²

**Release note:**
R117-R120 new in circuit diagram; components R17, R101, R105-R107, R112, C28, C29, C33, C40, IC4, T7 and T8 changed with respect to circuit diagram.
Fig. 22. Double-sided through-plated printed circuit board for the semiconductor tester. PCB layout and component mounting plan shown at 80% of true size.
IC7. The screening around these sections is fitted at the component side as well as at the solder side of the board. A cover is fitted on both screens.

First, bend the metal plate to give the box the required shape, and join the ends of the plate by soldering them where they meet. Next, place the 15-mm high screen on to the component side of the board. The small slots in the plate are to clear some parts on the component side of the board. The inner sides of the screening box, and adjust preset R18 until the reference voltage of the ADC, IC4, is 1.000 V.

Finally, twist the three 1-m flexible wires to make the cable used for connecting the testable devices to the circuit. Insert the cable through the rubber grommet in the PCB plate, and make a knot at the inside to create a strain relief. Connect the red wire to ST3, the yellow wire to ST4, and the blue wire to ST5. The other ends of the wires are fitted with miniature insulated crocodile clips.

Adjustment and first run

Switch off the PC, open it and remove a fixing bracket associated with a free slot. Fit the completed card into this slot, and bolt the fixing bracket to the rear casing of the PC. Connect an unused disk supply cable in the PC to the connector below capacitor C9 on the PCB. This connection carries the high current (2.2 A max.) 12-V supply voltage required for the on-board switch-mode power supply.

Switch on the PC, but do not yet run the software for the semiconductor tester. At power-on the hardware on the insertion card automatically switches to the most sensitive measurement range, in which the three adjustments described below are to be carried out.

All measurements are carried out with a multimeter, with reference to AG1 (analogue ground). Connect the positive terminal of the multimeter to pin 9 of IC4. Next, adjust preset R18 until the reference voltage of the ADC, IC4, is 15 AH.

Next, adjust preset R16 until the reference voltage at pin 15 of IC3 is +2.55 V.

To adjust the off-set of the measurement amplifier, connect the positive lead of the multimeter to pin 6 of the ADC, IC4. Insert the trimming tool through the hole in the cover of the screening box, and adjust preset R18 for a multimeter reading of 0.00 V. A tolerance of ±10 mV is acceptable here. This completes the adjustment of the insertion card.

The software supplied with the kit provides semi-automatic tests of the most essential parts of the circuit. The installation of the control software is straightforward, and requires no further detailing at this point. The hardware address setting of the card is accomplished with the two 4-way DIP switch blocks at either side of IC2, a 74LS688. The right-hand switch block corresponds to the contacts marked 2 to 5, and the left-hand switch block to contacts 6 to 9.

In cases where the default address, 300H, can not be used, the DIP switches are set to the required address. More information on how to do this in hardware and software may be found in the README file on the distribution diskette supplied with the kit. Ready-assembled semiconductor tester cards supplied by ELV are set to operate at address 300H.

Reference:
INTERMEDIATE PROJECT

A series of projects for the not-so-experienced constructor. Although each article will describe in detail the operation, use, construction and, where relevant, the underlying theory of the project, constructors will, none the less, require an elementary knowledge of electronic engineering. Each project in the series will be based on inexpensive and commonly available parts.

SURF GENERATOR

Those of you who have ever spent a summer's day at the beach will affirm that the sun, the wind, the sand and the water can have a reposing effect (we're not talking about the bikinis here). Interestingly, the sound of surf alone is reported to evoke impressions of the ocean, so that it can be used as a perfectly healthy and non-addictive 'tranquilizer' in these hectic modern days. We do not know if the sound of waves rustling to the shore can help you feel relaxed, or fall asleep quicker. We are pretty sure, however, that the electronic circuit presented here provides a quite convincing imitation of the sound of ocean surf.

from an idea by W. Cazemier

Fig. 1. Block diagram of the surf generator.
Amplifier with sufficient output power to drive a small loudspeaker.

The VCF/VCA control voltage is generated with the aid of three pulse generators, whose output signals are mixed. A filter at the output of the mixer provides some smoothing of the control voltage. The result is a quasi-random control voltage, whose erratic character is just what we need to imitate the sound of surf.

**Three pulse generators**

The circuit diagram in Fig. 2 shows the three pulse generators based on opamps IC1a, IC1b, and IC1c. Each pulse generator is derived from the 'classic' square-wave generator, whose basic layout is shown in Fig. 3a. The duty factor (pulse on/off ratio) of this generator is 0.5. By changing the duty factor, the square-wave generator is turned into a pulse generator. Usually, the duty factor is changed by making the charge time of capacitor C different from its discharge time. Figure 3b shows how this can be achieved. Capacitor C is charged by R1+R2, and discharged by R1 alone.

Returning to the circuit diagram, the inputs of the three pulse generator opamps are held at half the supply voltage with the aid of a 5-V regulator, IC2, and resistors R3, R8 and R14. The output signals of the opamps are mixed by resistors Rs, Rn and R16. The previously mentioned smoothing function is realized by R6 and C16. The 'random' control voltage is pulled to the +10 V supply line by R6.

**Noise generator and filter**

Applying an wrongly polarized voltage to a base-emitter junction of a transistor causes a zener effect in the diode junction. This effect is known to cause a considerable amount of noise. In the circuit diagram, the noise generator is formed by transistor T1 and current limiting resistor R17.

Coupling capacitor C4 feeds the noise voltage supplied by T1 to opamp IC1d, which provides an amplification of about 15 times. This amplification can be increased if desired by making R9 larger (the maximum value is 560 kΩ).

The first circuit section at the output of the noise amplifier is the VCF. The practical realization of the VCF is extremely simple, as illustrated by the basic schematic in Fig. 4a. Components R20 and C6 form an R-C low-pass filter, in which diode D4 acts as a resistor whose value is controlled by $U_{ctrl}$. The diode conducts when $U_{ctrl}$ is lower than $V_{th}-0.7$ V, with the internal resistance of D4 decreasing with the control voltage. As illustrated by the equivalent circuit in Fig. 4b, the control voltage determines the response of the filter with the aid of a variable resistance. The filter is most effective when the resistance is low. Thus, we can set the high-frequency content of the noise signal by varying $U_{ctrl}$.

In the circuit proper, the control voltage consists of two voltages: one is applied to the VCF via R21 to provide the basic filter setting, and another is applied via R22 to set the con-
The output signal of the circuit is available at terminal 'A', and can be fed to any suitable AF amplifier. Capacitor C10 shunts the generator output to limit the high-frequency content of the signal.

A small AF amplifier is provided in the circuit to enable an 8 Ohm low-power loudspeaker to be driven. This amplifier is based on ICs, the well-known LM386. If you want to use the output amplifier, fit a wire link between points A and A' on the PCB.

Power supply and construction

To make sure that the noise generator functions properly, a minimum supply voltage of 10 V must be observed. Unfortunately, the circuit will not work on a 9-V battery. The half supply potential, $\frac{1}{2}U_b$, is supplied by a 5 V fixed voltage regulator Type 78L05 (IC2). The 10 V supply line is decoupled by C11 at the input of the regulator, and by C12-C13 at the AF power amplifier.

The circuit draws about 20 mA at a supply voltage of 10 V. The supply voltage may be furnished by a mains adapter with a regulated 10 to 12 V d.c. output, or by seven 1.5-V penlight batteries fitted in one holder for four batteries, and one holder for three batteries. Whatever power supply is used, make sure that its connecting wires are as short as possible. This is a must to prevent oscillation which unfortunately occurs readily in the circuit.

Finally, the photograph in this article show a suggested construction of the surf generator in an ABS enclosure of dimensions 125x49x50 mm. The prototype has a built-in loudspeaker and operates from a 9-V PP3 battery with one 1.5-V penlight battery in series.

Component List

<table>
<thead>
<tr>
<th>Resistors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 68kΩ</td>
</tr>
<tr>
<td>1 270kΩ</td>
</tr>
<tr>
<td>3 56kΩ</td>
</tr>
<tr>
<td>3 100kΩ</td>
</tr>
<tr>
<td>3 22kΩ</td>
</tr>
<tr>
<td>3 33kΩ</td>
</tr>
<tr>
<td>1 220kΩ</td>
</tr>
<tr>
<td>3 10kΩ</td>
</tr>
<tr>
<td>1 680kΩ</td>
</tr>
<tr>
<td>1 150kΩ</td>
</tr>
<tr>
<td>1 1kΩ</td>
</tr>
<tr>
<td>3 47kΩ</td>
</tr>
<tr>
<td>3 39kΩ</td>
</tr>
<tr>
<td>2 10Ω</td>
</tr>
<tr>
<td>2 50kΩ preset H</td>
</tr>
<tr>
<td>1 10kΩ preset H</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacitors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 47μF 16V radial</td>
</tr>
<tr>
<td>3 10μF 16V radial</td>
</tr>
<tr>
<td>1 10μF 16V radial</td>
</tr>
<tr>
<td>2 220μF</td>
</tr>
<tr>
<td>1 12μF</td>
</tr>
<tr>
<td>1 1000μF 16V radial</td>
</tr>
<tr>
<td>2 220μF 16V radial</td>
</tr>
<tr>
<td>1 47μF 16V radial</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semiconductors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 BC107</td>
</tr>
<tr>
<td>1 1N4148</td>
</tr>
<tr>
<td>1 LM324</td>
</tr>
<tr>
<td>1 78L05</td>
</tr>
<tr>
<td>1 LM386N-4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Miscellaneous:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 8Ω 0.3W loudspeaker</td>
</tr>
</tbody>
</table>
Low-voltage halogen lights are becoming fashionable, which is not surprising when one considers the advantages of these small units. They offer low colour temperature, relatively low heat radiation, low operating voltage, wide-angle light emission, illumination that is two to three times brighter than that of conventional lamps for the same energy consumption and far better efficiency than traditional light sources.

Many commercial lighting controls operate at the primary side of a transformer and this means that all lights in a circuit are switched or dimmed simultaneously. When a room contains a number of lights, that is a distinct disadvantage. The dimmer described in this article is based on the concept that each individual light in a two-wire system can be remotely controlled without any effect on the other lights in the system. A hand-held infra-red remote controller provides four functions:

- light on;
- light off;
- light brighter;
- light less bright.

Each light is connected across the 12-V secondary of a mains transformer. To enable it being operated individually, it is fitted with its own infra-red receiver. To enable the lights being switched on from the entrance to a room, an additional, fixed infra-red controller is fitted beside the door opening.

Each remote controller has six operating channels, so that six lights or groups of lights can be controlled. The cost of the small receiver fitted in the lights is about equal to the cost of two traditional light bulbs.

All switching of the lights takes place at the zero crossing, which ensures a long life.

Remote control transmitter

The remote control transmitter is based on Plessey's Type MV500 IC, the block diagram of which is shown in Fig. 1. Apart from a keyboard, an oscillator and a driver for the infra-red diodes, this IC contains all that is necessary for a 32-channel infra-red transmitter. Since the receiver board must of necessity be kept small (about 50x40 mm), the present transmitter is restricted to six channels: see Fig. 2. Because of the need to keep the receiver board small, the circuit of the transmitter is rather larger than Plessey's standard application circuit.

The MV500 IC is a CMOS type that, thanks to the power control block, which automatically switches the transmitter on or off, draws an almost negligible current during quiescent operation. When one of the keys is pressed, the current drain from a 9-V battery is only a few milliamperes even though the (pulsed)
current through the infra-red diodes is of the order of amperes. However, the duration of the current pulses, because of the pulse-spacing modulation, is only about 15µs. Moreover, the transmitter remains operational even when the battery voltage has dropped to just below 4 V.

During quiescent operation, the greater part of the MV500 is switched off. When one of the keys is depressed, the power control switches the supply voltage to all stages of the IC that were off before then. This causes the oscillator, consisting of crystal X1 and capacitors C3 and C4, to generate a 455 kHz signal.

The voltage from the keyboard is applied as a five-bit signal to the row and column decoders. In these, it is converted into a serial signal which, after being pulse-spacing modulated, is available at the output, pin 1. From there, it is applied to T1, amplified, converted to an infra-red signal by diodes D1 and D2, and then transmitted in the direction of a receiver.

In pulse-spacing modulation, also called pulse-interval modulation, the spacing between the pulses, rather than the pulses themselves, is modulated. This type of modulation ensures low current drain from the battery and also greater invulnerability to noise and hum.

The 455 kHz signal from the oscillator is converted to 17 µs long needle pulses. The spacing between the pulses varies according to the modulating information. The divider in the MMV500 arranges for a logic 1 to be given a duration of 9 ms, and a logic 0, a duration of 13.5 ms. The intervals are thus relatively long compared with the pulses. The data stream continues for as long as the key is pressed. When it is released, the power control removes the power supply from most of the IC again.

The rate control outputs enable the frequency of the transmission to be altered. This is effected by a logic 1 at either of these pins, which results in transmission rate A at...
Table 1

<table>
<thead>
<tr>
<th>Key</th>
<th>Bit</th>
<th>J1</th>
<th>J2</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>Yes</td>
<td>A</td>
<td>A+B</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>Yes</td>
<td>B</td>
<td>A+B</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>Yes</td>
<td>C</td>
<td>A+B</td>
</tr>
<tr>
<td>4</td>
<td>A</td>
<td>No</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>5</td>
<td>B</td>
<td>No</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>6</td>
<td>C</td>
<td>No</td>
<td>C</td>
<td>B</td>
</tr>
</tbody>
</table>

pin 15 or transmission rate B at pin 14. The pulse-pause ratio remains unchanged, however. The durations stated earlier pertain to rate A; they are halved with rate B. Note that the transmitter and receiver(s) must be set to the same transmission rate. There is the possibility of a third rate (A+B), which is obtained when a logic high is applied to pins 14 and 15 simultaneously.

Keys S1-S6 provide the channel information to the row decoder; the column decoder is not used. This atypical configuration was chosen because the channel information is not decoded in the receiver(s) owing to space considerations.

The present system uses rate B and rate A+B. Pin 14 is permanently connected to the positive supply line via R1. Pin 15 is kept low via R2 as long as no key is pressed. When one of the keys S1-S5 is pressed, pin 15 also goes high via the OR gate formed by D6-D8. The transmitter then operates at rate A+B. When, however, one of keys S1-S5 is pressed, pin 15 remains low and the transmit rate is B. In this way, it is possible by adding six inexpensive diodes to obtain operation in 2x3 channels without it being necessary for any decoding in the receiver(s).

Infra-red receiver

Circuit IC1 in Fig. 4 prepares the received signals. IC2 decodes them, and IC3 undertakes the dim function.

Circuit IC1 is an infra-red preamplifier, which is quite complex, because it must provide a clean, usable electrical signal from a light signal that is full of spikes and constantly varies in intensity. A number of automatically operating amplifier stages raise the current of the receive diode from as low as just below 1 µA by 68 dB. A clean PPM (pulse period modulated) signal is provided at the output, pin 9.

Circuit IC2 decodes the serial information into the same five-bit data word that was coded in the transmitter. Since all signals must be processed at the transmit frequency, the oscillator based on X1 is identical to that used in the transmitter. Resistor R4 ensures that the crystal oscillates at its fundamental frequency. The decoded data is available at pin 13 (bit A), pin 14 (bit B) and pin 15 (bit C).

It is, of course, imperative that each receiver responds only to the corresponding transmit key. The selection of the appropriate signal is effected by wire links J1 and J2. When J1 is used, the transmission rate is A+B; when it is omitted, the rate is B. The transmit keys, data bits, use or omission of J1, and position of J2 are correlated in Table 1.

The on/off cum brightness control circuit is based on IC3. Since this circuit has only one input, pin 6, the four functions must be derived from the duration of the input signal. If the pulse width is in the range of 50-400 ms, the circuit arranges on/off switching. When the pulse width is greater (0.5 s to 7.6 s) the IC continuously varies the phase gating angle until the control signal becomes zero.

The mode of operation of the circuit is determined by the level at pin 2—see Fig. 5.

Level = 0 (variant A). In this mode, the brightness is maximum when the light is switched on. Dimming takes place from minimum brightness, renewed dimming continues towards maximum.

ELEKTOR ELECTRONICS APRIL 1991
DIMMER FOR HALOGEN LIGHTS

Fig. 7. Drilling template for transmitter case.

PARTS LIST

(Receiver)

Resistors:
R1 = 47 Ω
R2 = 180 Ω
R3 = 100 Ω
R4 = 220 kΩ
R5 = 1 MΩ
R6 = 470 kΩ
R7 = 47 kΩ

Capacitors:
C1 = 4.7 µF, 16 V, radial
C2 = 47 µF, 16 V, radial
C3 = 22 nF, surface-mount
C4 = 4.7 nF, surface-mount
C5 = 150 nF
C6 = 10 µF, 25 V, tantalum
C7 = 22 µF, 16 V, tantalum
C8 = 22 nF, surface-mount
C9 = 15 nF, surface-mount
C10 = 100 nF
C11 = 6.8 nF, surface-mount
C12 = 470 µF, 10 V

Semiconductors:
D1 = BPW41N (Motorola)
D2 = zener, 5.6 V, 400 mW
D3 = 1N4148
D4 = 1N4002
IC1 = SL486 (Plessey)
IC2 = MV601 (Plessey)
IC3 = SLB586 (Siemens)
Tri = TIC206D (Texas Instruments)

Miscellaneous:
X1 = crystal, 455 kHz
F1 = fuse, 2 A, slow blow
2 PCB-type screw terminals
J1, J2 = PCB pin strip header, double row, 4-way, with jumper sockets
Heatsink for triac (see text on p. 58)
Plastic enclosure 80x26x45.4 mm
La1 = halogen lamp, 12 V, 50 W

Fig. 8. Completed infra-red transmitter.

Level = 1 (variant C). In this mode, operation is similar to variant A, but renewed dimming reverses towards minimum.
Level = three-state (variant B). In this mode, the phase angle at switching off is stored and the next switch-on occurs at the same angle. Renewed dimming reverses direction with respect to the previous dimming.

On the printed-circuit board, pin 2 is connected to earth, that is, the circuit is set for variant A. If one of the other variants is wanted, break the track to obtain variant B, or break the track and solder pin 2 to pin 1 to obtain variant C.

Resistor R7 and capacitor C12 filter the a.c. supply, which is then used for synchronizing the internal PLL (phase-locked loop) time base. Resistor R5 and capacitor C1 form the integrating network for the time base.
Diode D3 reduces to safe values the positive voltages that ensue at the gate of many triacs when they are fired. The TIC206D enables lamps rated at up to 20 W to be controlled; for higher rated lamps, a TIC226D should be used (see also under 'Receiver' on page 58).
Direct voltage is provided by rectifier D5, regulated by R2 and D2, and smoothed by CH. Note that IC3 requires a negative supply.

Construction

TRANSMITTER

Populating the printed-circuit board for the transmitter—see Fig. 6 and Fig. 8—is straightforward.

A drilling template for the top of the enclosure (where the six holes that will give access to the push-button switches will be located) is given in Fig. 7. The switches are not seated on the PCB, but about 11.5 mm above it. Three spacers under the board ensure that the push-buttons protrude through the top of the case.
Furthermore, two small holes must be drilled in the front of the enclosure through which the infra-red diodes will transmit.

After the board has been completed, test
its operation with the aid of an oscilloscope connected between the collector of T1 and earth.

The MV500 is very sensitive to electrostatic charges. It may well operate almost normally after having been subjected to such a charge, but chances are that its power-down facility does not function properly any more. This causes a current of more than 1 mA to flow even during quiescent operation and this does of course shorten the life of the battery quite considerably.

A chromium reflector placed behind each of the infra-red diodes increases its operating range by 40-50 per cent. If that is still not sufficient, resistor R2 may be short-circuited. This increases the current through the diodes, however, and thus shortens the life of the battery.

**RECEIVER**

The completion of the receiver printed-circuit board—see Fig. 9 and Fig. 10—is not so straightforward. Because of lack of space, five surface-mount capacitors are fitted at the track side of the board. Great care must be exercised during the soldering of these components to make sure that no tracks are short-circuited.

Resistor R3 should be shrouded in insulating tape or inserted into a length of insulating sleeve to prevent its connecting wire touching the adjacent a.c. supply terminal.

The triac is soldered at the underside of the board in such a way that its inscription points towards the board. This makes it possible to fit the heatsink as shown in Fig. 11. A template for the heatsink is shown in Fig. 12. The heatsink is made from 2 mm thick aluminium sheet. Note that this suffices for lamps rated at up to 20 W only. If lamps of up to 40 W are to be used, a more substantial heatsink is required, for instance, a 50 mm long Type SK59 (5 K/W). Lamps of 50 W require a 75 mm long Type SK59 (6 K/W). Furthermore, it is advisable to use a Type TIC226D triac (which can handle currents of up to 8 A) instead of the TIC206D (which can handle up to 4 A only).

Lastly, the printed-circuit board can cope with the temperature of lamps rated up to 20 W; higher rated lamps must be fitted externally, for instance, as shown in the photograph on page 55.

Do not yet fit any of the ICs or halogen lamps. When an alternating voltage of 12 V is connected across the supply terminals marked ~, there should be a direct voltage of about 5.5 V across C14. If this is so, disconnect the 12 V supply, discharge C14, and insert IC1 into its socket.

An oscilloscope connected between pin 9 of IC1 and earth should show the PPM signals whenever one of the push-buttons on the transmitter is pressed.

Next, insert IC2 into its socket. A high logic level should appear at pins 13 and 15 when the corresponding button on the transmitter is pressed. When this test is successful, insert IC3 into its socket and fit the lamps on to the board. When then the corresponding button on the transmitter is pressed, the lamps should light.
TO KEEP the AM/FM tuner as small as possible, Philips have housed the TEA5591A not in a standard DIL package, but in a so-called shrink-DIE of which the pins are not on a 0.1 in. but on a 0.07 in. grid. Consequently, the device is no longer than a standard 16 pin DIP circuit, but it is 0.1 in. wider.

Inside the TEA5591A

From the block diagram in Fig. 1 it is seen that the TEA5591A contains two separate receivers, both superhets. The FM section receives the incoming signal via a wideband antenna circuit and pin 2. From there, the signal is amplified and then applied to a mixer via a parallel-tuned circuit.

In the mixer, the signal is mixed with an oscillator signal, which is also controlled by a parallel-tuned circuit. The oscillator is combined with an automatic frequency control circuit—AFC—which only needs an external buffer capacitor.

The output of the mixer is applied to an external filter and from there to the first (internal) IF amplifier. From there, it is again filtered externally and then applied to the second IF amplifier.

Finally, the signal is demodulated in an FM discriminator. The resulting audio frequency signal is output via pin 11.

To prevent the AM receiver simultaneously delivering a signal to pin 11, the power supply to the AF stages is taken to earth via pin 14 during the reception of FM signals. Similarly, during AM operation, the supply to the FM IF stages is earthed via pin 5.

Broadly speaking, the AM section is similar to the FM section. There is, however, a difference in the input circuits: instead of a wideband antenna circuit, the AM section has a tuned antenna circuit, the inductor of which is formed by a ferrite antenna.

The amplified RF signal is applied to a mixer together with the output of an appropriate oscillator.

The mixer is followed by IF filters and an IF amplifier. The output of the IF amplifier controls the automatic gain control—AGC—circuit. The AGC holds the outputs of the IF amplifier and mixer substantially constant in spite of variations in the RF signal.

The output of the IF amplifier is demodulated by a suitable detector and the consequent audio signal is applied to pin 11.

Circuit description

The diagram in Fig. 2 shows the receiver complete with stereo decoder, IC2, and a stereo output amplifier, IC3, which can deliver about 2x1 W into 8 Ω.

Inductor L1 and capacitor C1 form the wideband input circuit for the FM receiver. The tuned circuit for the RF amplifier is formed by L7 and one section of a 20 pF tuning ca-
pacitor.
The oscillator for the FM section is tuned by $L_4$ and a second section of the tuning capacitor.
The first FM IF filter is formed by $L_5$ and $C_{12}$, while the second FM IF filter, $K_1$, is a ceram.
A second ceramic filter, $K_2$, ensures correct operation of the FM discriminator.
The 50 μs time constant for the correct de-emphasis is provided by the internal resistance at the AF output pin 11 (2.4 kΩ) and capacitor $C_5$.
The antenna tuning for the AM section is carried out by $L_8$ and the 140 pF section of the tuning capacitor, while the oscillator is tuned by $L_4$ and the 82 pF section of the tuning capacitor. Since the AM sections and the FM sections of the tuning capacitor are electrically interlinked, $L_4$ and $L_8$ form a transformer. In that way, the AM section remains electronically separated from the FM section.
The AM section contains two IF filters formed by $L_2$-$C_{11}$ and $L_3$-$C_6$ respectively.
Switch $S_1$ selects either AM or FM. When it is in the AM position, the power supply to the AM section is earthed, whereas when AM operation is selected, most of the FM section is without power.
The AF signal at pin 11 of $IC_1$ is applied to stereo decoder $IC_2$, a Type TDA7040T (Ref. 1). This chip occupies only 0.25 cm² of space. It may be switched to mono operation by connecting pin 7 to the positive supply line via a 4.7 kΩ resistor. The same pin may be used to drive a stereo indicator via a transistor stage (mono is logic high; stereo is logic low).
The output of the decoder is taken to the output amplifier, $IC_3$, a Type TDA7053, via a stereo potentiometer, which is combined with on/off switch $S_2$.
Each of the two short-circuit-proof bridge amplifiers in $IC_3$ delivers about 1 W into an 8 Ω loudspeaker. The advantage of bridge amplifiers is that they deliver more power for a relatively low supply voltage (minimum 3 V) than most other types of amplifier.
If modern, lightweight headphones are to be used, these can only be driven by one half of each of the bridge amplifiers (since they have only three instead of four connections).

### SOME TECHNICAL DATA

<table>
<thead>
<tr>
<th>Parameter</th>
<th>AM: 520–1600 kHz</th>
<th>FM: 88.5–107 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity</td>
<td>AM: &lt;5 μV</td>
<td>FM: &lt;2 μV</td>
</tr>
<tr>
<td>I.F.</td>
<td>AM: 468 kHz</td>
<td>FM: 10.7 MHz</td>
</tr>
<tr>
<td>Power output</td>
<td>2x1 W into 8 Ω</td>
<td></td>
</tr>
<tr>
<td>Harmonic distortion</td>
<td>&lt;2.5%</td>
<td></td>
</tr>
<tr>
<td>Supply voltage</td>
<td>3–6 V</td>
<td></td>
</tr>
<tr>
<td>Quiescent current</td>
<td>≈30 mA</td>
<td></td>
</tr>
</tbody>
</table>

Loudspeaker outputs are protected unconditionally against short circuits.

Output amplifier stages switch without any audible clicks.

They are connected to the amplifiers via 100 μF electrolytic capacitors. Their common connection is taken to earth. The capacitors are necessary because the outputs of the amplifiers have a d.c. component of some 2 V.

In spite of the excellent properties of the tuner, it is not advisable to connect it other than via a 19 kHz band-stop filter to a hi-fi installation, because the output signal (during FM reception) contains a strong 19 kHz pilot tone. When the loudspeakers are connected to the TDA7053, this tone does no harm, but if it were amplified in a hi-fi installation, the tweeters might not be able to cope with the level.

If it is intended to use the TDA7053 regularly at full volume, bear in mind that the peak current is 1 A. This requires a medium-duty power supply instead of a simple set of batteries. In portable use batteries are, of course, the only possible supply. If only headphones are used, the batteries will give a long life, since the quiescent current is only 30 mA.

### Construction

The receiver is best constructed on an experimental printed-circuit board as shown in Fig. 3. Note that this board is not available ready made. When preparing the board, a number of points need to be borne in mind: for instance, $L_4$ must be placed very close to the tuning capacitor. Furthermore, near pin 3 of $IC_1$, a common earthing point must be provided for all h.f. returns. Similar multi-connection points must be provided near the neg-
Alignment

1. Set all trimmers to their mid position.
2. Couple an RF signal generator, set to AM and tuned to 468 kHz, to the ferrite antenna via a few turns of wire around it.
3. Adjust L2 and L3 for maximum AF output.
4. Detune the signal generator to check the symmetry of the IF filters; adjust the filter(s) if necessary.
5. Tune the signal generator to 520 kHz and set the tuning capacitor to maximum capacitance.
6. Adjust L4 for maximum AF output.
7. Tune the signal generator to 1600 kHz and set the tuning capacitor to minimum capacitance.
8. Adjust the trimmer of the oscillator circuit for maximum AF output.
9. Repeat steps 5, 6, 7, and 8, in that order, a number of times until no more adjustments of L4 and trimmer are necessary.
10. Tune the signal generator to 600 kHz and set the tuning capacitor to maximum capacitance.
11. Adjust L8 (by shifting the coil on the ferrite rod) for maximum AF output.
12. Tune the signal generator to 1500 kHz and set the tuning capacitor to minimum capacitance.
13. Adjust the trimmer of the AM RF circuit for maximum AF output.
14. Repeat steps 10, 11, 12, and 13, in that order, until no more adjustments of L8 and the trimmer are necessary.

Note that tuning the antenna circuit below the two extreme frequencies ensures optimum synchronization of that circuit and the oscillator circuit.

15. Loosely couple the signal generator to the FM antenna circuit.
16. Set the signal generator to FM and tune it to 10.7 MHz.
17. Adjust L5 for minimum distortion of the AF output signal (either on a scope or by listening to it).
18. Tune the signal generator to 87.5 MHz and set the tuning capacitor to maximum capacitance.
19. Adjust L6 for minimum distortion of the AF output signal.
20. Tune the signal generator to 108 MHz and set the tuning capacitor to minimum capacitance.
21. Adjust the trimmer of the oscillator circuit for minimum distortion of the AF output.
22. Repeat steps 19, 20, 21, and 22, in that order, until no further adjustments of coil and trimmer are necessary.
23. Set the signal generator to 88.5 MHz and set the tuning capacitor to minimum capacitance.
24. Adjust L7 for minimum distortion of the AF output.
25. Tune the signal generator to 107 MHz and set the tuning capacitor to minimum capacitance.
26. Adjust the trimmer in the FM RF circuit for minimum distortion of the AF output signal.
27. Repeat steps 23, 24, 25, and 26, in that order, until no further adjustments of L7 and the trimmer are necessary.
28. Connect pin 8 of ICI to earth.
29. Connect a 3.6 kΩ resistor between pin 7 of ICI and the positive supply line.
30. Connect a frequency counter between pin 7 of ICI and earth.
31. Adjust R7 for a reading of 19 kHz on the counter.


**INDUCTOR DATA**

* L1 = air-cored, 12 µH, inside diameter 4.5 mm; 4.5 turns of 0.8 mm dia. e.c.w.
* L2 = 665 µH; former 7MCS; n1,2 = 14 turns, n2,1 = 133 turns, n4,6 = 7 turns 0.07 mm dia. e.c.w.
* L3 = 665 µH; former 7MCS; n1,2 = 33 turns, n2,1 = 133 turns, 0.07 mm dia. e.c.w.
* L4 = 270 µH; former 7BRS; n1,3 = 86 turns, n4,6 = 4 turns, 0.07 mm dia. e.c.w.
* L5 = 119ACS/301.20N
* L6 = 301SN0100
* L7 = 301SN0200
* L8 = ferrite rod 10x60 mm; 625 µH; n1,2 = 105 turns, n3,4 = 10 turns, 0.1 mm e.c.w.; wind coils on 10 mm outside diameter paper tube.

The tuning capacitor has AM sections of 140 and 82 pF, and FM sections of 2x20 pF; each section is shunted by a 5-10 pF trimmer (e.g., Toko FE22124).
THE PHYSICS OF MUSICAL INSTRUMENTS
by Neville H. Fletcher and Thomas D. Rossing
ISBN 3 540 96947 0
620 pages - 408 illustrations
Price £12.95 (soft cover)

Man has used musical instruments almost from the dawn of civilization. The manner in which we judge the quality of the music produced by a given instrument is subjective and depends to a large extent on the culture in which we and the instrument have evolved. It would be desirable for science to come to our aid in deciding whether a particular instrument is a fine, a mediocre, or a poor one.
The Physics of Musical Instruments describes the acoustical investigations of most of the traditional musical instruments in use in western music today; investigations that give physical criteria that may enable science to make that distinction. That does not mean that the authors have tried to define the ideal instrument on the contrary; they are at pains to point out that "there is no such thing as an 'ideal' instrument, even in concept."

The prime role of acoustics is to try to give us an understanding of how precisely sound is produced by musical instruments. It is only within the past 20 or 30 years that researchers have acquired a reasonable grasp of the fundamental mechanisms that determine the tone quality of most instruments.

To read this book, one needs a reasonable understanding of physics and have no fear of some mathematics. The authors have tried, however, to give detailed physical explanations, rather than mathematical ones. Their efforts have resulted in a fascinating work that will give countless readers many hours of absorbing reading. As far as your reviewer is aware, this is the first and only book that enables all those who are interested in music, musical instruments, and the physics of these, to come to grips with these subjects. As such, it deserves to find a place on bookshelves the world over.

Neville H. Fletcher is associated with the Research School of Physical Sciences, Australian National University, Canberra, while Thomas D. Rossing is with the Department of Physics, Northern Illinois University, De Kalb, Illinois.

Springer-Verlag (London) Ltd, Springer House, 8 Alexandra Road, London SW19 7JZ.
Springer-Verlag (New York) Inc., 775 Fifth Avenue, New York 10010.

THE AUDIO GLOSSARY
by J. Gordon Holt
ISBN 0 96241 914 1
528 pages
Price $9.95

When hi-fi sound reproduction was in its infancy, manufacturers of high-quality audio equipment and technical writers alike depended on quality tests that were soon accepted as performance yardsticks.

When equipment got better and competition fiercer, technical reviewing became more and more important to sales managers. Unfortunately, reviewers continued to rely on the standard tests and measurement data began to look more and more alike. J. Gordon Holt, then on the staff of High Fidelity magazine, became increasingly frustrated with this state of affairs, since he was convinced that although tests and measurements were important, they no longer accounted for the differences he heard during his reviews. He finally left to found Stereophile. Holt abhorred most magazines' tendency to depend almost entirely on measurements, which he considered a safe way to review without upsetting the manufacturer. At that time, no US audio publications were publishing critical equipment reviews.

Holt quickly found that, when reviewing how an equipment really sounds, he faced a serious problem. Of our five senses, that of hearing has the smallest vocabulary. He thus faced the difficulty of describing sound differences with all too few words with which to do it. He therefore not only invented the techniques and disciplines of "subjective reviewing", but also the language with which to do it.

Today, the magazine he founded is a major force in audio quality judgments around the world. And almost all the vocabulary definitions are his work.

Some time ago, Holt sat down to put his definitions in one work: The Audio Glossary. This book includes not only a vocabulary for sound description, but also a comprehensive overview of over 1900 audio terms and their definitions.

Old Colony Sound Laboratory, P.O. Box 243, Peterborough, New Hampshire 03458-0243, USA.

DATA BOOK 4: PERIPHERAL CHIPS
Compiled by J. Hogenboom
ISBN 0 905705 32 7
480 pages
Price $8.95 (soft cover)

The final part in Elektor Electronics' Microprocessor Data Book series deals with general peripheral chips that, at least as far as their type-coding is concerned, do not belong to a specific family of microprocessors. There are so many of these, however, that only a portion of them can be dealt with in one book. Those contained in the present collection have been chosen carefully on the basis of their practical application and frequency of use.

Complete data are given for:
- co-processors from the 80 series (AMD, Cyrix, ITT, Intel, Weitek);
- real-time clocks from MEM, OKI, Static, National Semiconductor, Dallas Semiconductor;
- transmitters and receivers of serial interfaces RS232, 422, 423, 485 from Motorola, Newport Components, Maxim, Texas Instruments, National Semiconductor, Linear Technology, Dallas Semiconductor;
- UARTS, DUARTS and QUARTS, that is, programmable ICs intended for data transfer;
- the CS8221 set of ICs from Chips & Technology that are used in a great number of PC mother boards, including the data sheet of the associated software LIM 4.0 for the management of the Extended Memory System.

Apart from the actual data, the book contains much other useful information, such as:
- comparisons between, and second sources of, all important IC families;
- addresses of manufacturers and their representatives;
- overview tables of all peripheral chips (including many that could not be included in this book) that are available from the various manufacturers.

Elektor Electronics (Publishing), Down House, Broomhill Road, London SW18 4JQ.

ELECTRONIC ENGINEERING SEMICONDUCTORS AND DEVICES
Second edition
by John Allison
ISBN 0 07084 194 2
376 pages - illustrated
Price £12.95 (soft cover)

This revised edition of Dr. Allison's well-known work remains a core text for Electronic Engineering courses on semiconductors and devices. It describes the operation and characteristics of modern, active electronic components in a precise, yet easily understood manner. Dr. Allison has expanded the scope of the book to include all the information on the operation of electronic devices required by undergraduates.

The updated text provides a thorough grounding in the basics of physical electronics that allows students to acquire a full understanding of the electronics of semiconductors and other electronic devices.

Dr John Allison is a reader in the Department of Electronics and Electrical Engineering at the University of Sheffield.

McGraw-Hill Book Company (UK) Ltd, Shoppenhangers Road, Maidenhead SL6 2QI.
set your sights on a better sound!

Experience a new sensation. An experience that opens up a whole new spectrum of sound.

Put yourself on stage at the Albert Hall, surrounded by a great orchestra. Imagine the sound you will hear, every nuance, every note, or travel up the Nile with an intrepid explorer, a journey not only full of breathtaking beauty and colour, but rich in the sounds of another continent; or capture the hidden gasps of 100,000 hardened fans at Wembley for the F.A. Cup Final, when the ball skims the crossbar with the last kick of the match: follow with your ears as well as your eyes, dodging the bullets, as your favourite hero battles out of yet another tight corner. It's just like being in a cinema!

Nicam hi-fi stereo will turn your living-room into a living room of sound! You don't settle for second best with television picture quality, why settle for second best in television sound quality? Nicam sound is the new high quality digital stereo sound system, pioneered by BBC, ITV and TV/video manufacturers. In fact so good is Nicam it is comparable to the superb sound reproduction of the compact disc. When played through your existing hi-fi arrangement. If your television hasn't got a built-in Nicam decoder, you will need the Maplin Nicam Tuner System. Ultimately almost all of your favourite programmes will be broadcast in superb hi-fi quality stereo-sound. Without a Maplin Nicam Tuner you won't be able to capture every sound to its full Nicam hi-fi stereo. Catch your breath, open your eyes, and pin back your ears! It's what your hi-fi system was made for... it's what your ears are made for!

Digital stereo sound companion for your TV set.

Digital stereo TV sound from your hi-fi

The complete kit contains all the components required to build the unit. However you will also need a power supply: 12V at 2.5A at 25% regulated e.g. T250A at £29.95. A co-axial power supply e.g. T275A at £29.95. A co-axial lead to connect to your TV: T324 or T325 at £2.95. A 10m long at £4.95. A SCART lead or a 15m long at £4.95. A 12m long at £4.95. An infra-red remote control kit is also available.

Complete kit £19.95

Subject to availability. Prices subject to change.