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FEATURES

- Software personality programming/emulation of all EPROMs up to 8k x 8 bytes including 2704, 2708, 2716(3), 2508, 2758A, 2758B, 2516, 2716, 2532, 2732, 2732A, 68732-0, 68732-1, 68766, 68764, 2564, 2764. Programs 25128, 27128 with adaptors.
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Freedom — or licence?

To speak of culture is to brand oneself a poseur, a pretending aesthete, an unwordly, impractical bore. "When I hear anyone speak of Culture", Goering is said to have remarked, "I reach for my revolver". His other activities make it seem unlikely that he was impelled to deliver this thought by considerations of market potential, but nevertheless it seems to be in tune with the outlook of producers of software for the millions of stored-programme video display devices that nightly hypnotise a large part of the population.

In an ideal world, the 'freeing' of television programmes from the autocracy of established broadcasting organizations would be a step in the right direction. Why, it may be asked, should the viewing public be constrained by the views of three or four broadcasting authorities, when it can use a video recorder/player to display any one of thousands of programmes, and even make its own?

The world is, however, far from ideal. Freedom is always to be sought assiduously, but when it turns to licence, controls may be required as a regulator.

Engineering applied to domestic 'information systems' has an enormous capability — to inform, to entertain, to instruct and educate — the application of just one form, the v.c.r., being limited only by man's small imagination. People's breadth of view and understanding of others' problems and aspirations could be vastly enhanced by a proper choice of software. Freedom from the shackles of broadcast television as it currently exists could open wide the accumulated knowledge and wisdom of the world.

And what do we find? A wealth of material, certainly. But into which category of mental stimulation should one place an instructional film on ventilating the frontal lobe of the brain by means of a Black and Decker, or some such? Or, indeed, anyone of the cozy little stories designed to encourage the more flamboyant tendencies in the human psyche? The proliferation of such atavistic products of diseased minds is one, regrettable, result of 'freedom'.

The promise of dozens of extra channels of broadcast television by satellite and cable does not do much to encourage hope for the future, either, if the American scene is taken as an example.

Demoralising as it may be, it seems true to say that alternative viewing — that not originated by BBC or IBA — comes nowhere near exploiting the promise of the word 'freedom'. The IBA has to keep market forces well in mind, more so than the BBC, but there are overriding constraints on both organizations of public decency and overall quality. BBC and IBA have unparalleled reputations in both engineering and programme making. With the awful example of video tapes before us, it hardly seems sensible to allow optical, satellite or cable television to flout the laws governing broadcast television simply because they employ different media to carry the signal or because satellite is not, strictly speaking, broadcast. The dissemination of any kind of information to the public should not be solely a money-making venture.
Hearing and seeing

Engineers would find it easier to optimize high-fidelity sound systems and high-definition television if only they knew more about human hearing and seeing. It has, for instance, been said of the human auditory system that "The ear presents some of the most disputed problems of human physiology. Regarded purely technically the ear is of comparatively simple construction, so that one might hold the view that an accurate examination would immediately expose the purpose and function of each individual constituent part. Exactly the opposite is the case, and all theories are still full of contradictions."

In particular, the ability of many people to distinguish very small differences in pitch and the ability to locate the direction of sound from extremely small time differences cannot be explained by the conventional theories. Similarly, the human visual system can detect vernier misalignments with an extraordinary accuracy that cannot be accounted for by simple optical or anatomical considerations - the so-called hyperacuity.

A controversial new theory of hearing has been advanced by Hugo Zacchetti (New Scientist, November 10, 1983) who claims to have developed an electronic recording system that produces spatial effects in a monaural channel. He argues that the ear does not simply and passively receive sound. It also generates a sound wave that interacts with external sound to produce an acoustic hologram or interference pattern. As evidence in support of his theory he notes that several people have succeeded in recording continuous sound at about 1-kHz emitted in the ears of individuals. Just as each piece of an optical hologram produced by coherent light contains the information for a solid image, so, he argues, the acoustic hologram developed in each ear provides full directional information. No details of his recording system have so far been released.

The question of whether conventional "stereo" is really necessary was raised also by Yoshimatsu Hirata in the October 1983 issue of Waves World (pages 60-63) where he showed how ambience can be added to the mono sound transmitted by a.m. radio and television stations. Ever since the pioneer work by Alan Blumlein, engineers have been struggling to reproduce spatial effects without really being sure how the ear-brain system really works!

Current work on digital sound and vision seeks to overcome fidelity problems by transmission at very high data rates, even though human sensors are relatively slow acting devices. Sony, however, have managed to pack four digital stereo audio channels into a 6MHz channel for use with multiplex cable TV systems, basically using the Compact Disc format. Four high-bit stereo channels, with 8 bits of synchronization and 4 service bits form a 168-bit word with a sampling rate of 44.1kHz and a data rate of about 7.4 Mbit/s.

Millimetric rain scatter

The effects of rain-scatter at frequencies between about 10 to 20GHz are well documented. Scatter signals can, for example, result in multipath propagation in terrestrial microwave system from the high-power up-link satellite communications terminals. Heavy rain can also be used by amateurs to produce extended range contacts from locations shielded by hills. But millimetric signals, although scattered by rain drops, are themselves severely attenuated by rain, with the result that rain-scatter effects tend to be far less evident.

A Japanese rain-scatter experiment in the millimetric range (34.8GHz) has been described by Jun Awaka, Kenji Makamura and Hideyuri Inomata in IEEE Trans. Ant. & Prop., vol. AP31 no. 5, September 1983. Using 10-watt c.w. transmitter power with 10-metre dish aerials roughly 45km apart, it was shown that for a small percentage of time relatively strong signals could be received as a result of rain scattering. However for this to happen there has to be an isolated region of heavy rainfall at the scatter point but with no rain over most of the path. During the field test such conditions were infrequent.

Drive by data

Many schemes for providing traffic and vehicle-navigation information have been proposed but have floundered because of cost or lack of radio frequencies or both. However a new "Autoscout" system, developed by Siemens and Volkswagen, is currently undergoing road tests in Wolfsburg, Federal Germany. An on-board microprocessor control unit, plus magnetic field sensor, provides a form of inertial navigation, displaying both direction and bearing of the keyed-in destination on an i.c. display. However, information on local routes can be provided from beacon units mounted on traffic lights. Costs is kept low and spectrum problems overcome by the use of low-cost infra-red beacon transmitters. These continuously emit data on the main roads in the area.

The vehicle control unit selects only data applicable to the destination the driver has keyed into his unit. It is claimed that Autoscout could even direct drivers to a specific building, garage or parking space.

If the idea catches on, quantity production could bring vehicle unit costs down to that of a good car radio, with correspondingly low cost for equipping traffic lights with infra-red beacons, it is claimed. The Merriman Report appears to have removed any incentive for mobile two-way radio to switch to pilot-carrier s.s.b. in 5kHz channels. Yet J.P. McGehee and A. J. Bateeman of Bath University remain convinced that their system of feed-forward signal regeneration could overcome the severe multipath propagation effects shown up in the field trials a few years ago. They consider that the potential advantages of mobile s.s.b. on frequencies up to 1GHz should continue to be investigated. Their f.f.s.r. circuitry could be integrated on a single chip, using current large-scale integration techniques, as simple add-on circuitry to pilot s.s.b. systems.

Exit Radio Officers?

For some time, Inmarsat, the organization set up to provide satellite communication with the world's shipping, has believed that emergency position-indicating radio beacons carried on ships, lifeboats and fitted on buoys designed to float free from sinking ships, will form an integral part of a future global maritime distress and safety system. In the 1990s Morse radiotelegraphy will be replaced, Inmarsat believe, by a combination of satellite and terrestrial telephone and data communications. All countries are expected to make mandatory the carrying of low-power distress beacons. Ships equipped with satellite communication systems are already permitted in some countries to use their facilities in harbours and territorial waters, forbidden on h.f. and v.h.f.

Shuttle success

The in-flight 144MHz transmissions by Dr Owen Garriott, W5LFL, during a number of orbits of the Columbia space shuttle during the STS-9 mission certainly attracted world-wide publicity for the hobby. Even if the technical value of the experiment, using a low-power handheld transceiver, was questionable, it did mean that many more amateurs became interested in the calculation of orbital data, tracking and mixed polarization, etc. It also underlined how much terrestrial v.h.f. ranges are restricted by the curvature of the earth and local obstructions, with signals receivable during 8-minute windows from the 250km high spacecraft. Unlike for the Oscar satellites, standard 144MHz transceivers were all that was needed.

Dr Garriott also came up on a number of unscheduled occasions despite experiencing difficulties with his lightweight headset in high ambient noise. He recorded most incoming signals on tape, but succeeded in two-way contacts with a number of amateur stations including that of King Hussein, JY1.

Impressive also was the role of the
national societies, including RSGB, in providing their members with up-to-date information on the flight. Far less impressive, and of serious concern, was the amount of unnecessary interference, some deliberate, some caused by sheer bad operating.

Grenada and Spratly

Similar publicity, but in more contentious circumstances, surrounded the activities of KA20RK/376, an amateur station operated by Americans on Grenada during the invasion of the island by American and East Caribbean forces.

The US State Department waived limitations on third-party traffic and many of the transmissions from this only radio link with Grenada were used on tv and radio stations. The American government stated that it was “well pleased” with the role played by radio amateurs in keeping open this news channel, and providing information as to the safety of the American medical students and their families.

But from this side of the Atlantic the situation could be seen quite differently, opening up the risk of putting the whole question of reciprocal licensing and the licensing of foreign nationals into jeopardy. It is one thing to provide emergency communications during a natural disaster such as an earthquake or hurricane, but the events on Grenada can hardly be regarded in this light. It differs also from the use made of amateur radio in 1982 in the Falkland Islands on behalf of the government responsible for the issue of the licences!

The sensitivity of the Third World countries to anything remotely resembling “covert” amateur activities is well established but often overlooked by Americans and Europeans. The disaster, resulting in the loss of two lives, that overtook the 1983 German DX-pedition to the Spratly Islands (WW, July 1983, page 23) when the Siddartha was sunk by Vietnamese gunfire has overclouded that were not widely reported at the time.

According to a lengthy report headed “Hide and seek spy” in The Strait Times of Singapore, one of the German survivors, Baldur Drobnica, was an official of the West German “Office for the Protection of the Constitution”, a secret counter-intelligence organization. Although there is no reason to doubt that he was on holiday at the time, it led inevitably to suggestions that the expedition might not have been so innocent as it appeared and that, in any case, any expedition to these disputed islands unwisely courted disaster.

Those resident in the Far East point out that, to an extent not appreciated in the West, national security is there a highly sensitive issue. Any suggestion of amateur transmitters being involved in political or covert activities makes the position of licensed amateurs, particularly if not nationals of the country concerned, much more difficult. They urge that when planning such expeditions the greatest care should be taken not to bring upon the hobby such unfortunate publicity and unnecessary loss of life.

10.1MHz and s.s.b.

Last September I reported the mounting problems of international “planning” of the use of the amateur bands and questioned the extent to which the International Amateur Radio Union is justified in assuming a “regulatory role” without becoming more accountable to the wishes of a clear majority of radio amateurs. An example of IARU pressure on national societies had arisen in respect of the then use of s.s.b. by South Africans in the 10.1MHz band.

Dave Perry, ZS1SG, bandplanter for S.A.R.L., has written to point out that although the society approved s.s.b. operation on the band in 1982 this was changed at the 1983 a.g.m. and members are now advised to adhere to the IARU recommendations.

Nevertheless, he points out, many South African amateurs remain concerned about the validity of IARU’s reasoning and initial assessment. SARL are to raise this subject at the 1984 IARU Region 1 conference.

South Africa is the only country in Region 1 south of the Mediterranean area with appreciable activity. The distances involved means that 10.1MHz is not being used for telegraphy during daytime, since the relatively small number of c.w. enthusiasts are usually not interested in working stations in their own country. Yet the band would be excellent for internal working on s.s.b., especially for mobile operation over distances up to 2000km.

SARL now finds it difficult to justify to its members the IARU’s ban. In Europe circumstances are very different yet even those of us who are c.w. enthusiasts suspect that complete banning of s.s.b. on 10.1MHz, at all times of the day and night, is difficult to justify on a world-wide basis.

Cable and MDS

American amateurs continue to complain about the interference problems caused by signal leakage into and out of multichannel cable tv systems that often distribute some programmes in the 144MHz band or within or close to other amateur frequencies. The cable people, on the other hand, claim that there is no problem with correctly-installed well-maintained systems and tend to put at least some of the blame on the significant number of viewers (including amateur radio enthusiasts) who run 300-ohm twin cable close to the coaxial cables in order to receive subscription channels without payment. Even where the tv programmes are encrypted or scrambled this is often of an unsophisticated type that enables those with technical knowledge to descramble the signals.

The “pirate” coupling wires, it is claimed, are one of the main causes of leakage problems, with signals radiated from the twin wires.

Rather similar disputes have arisen from those increasingly used multichannel microwave distribution systems (MDS) in which the high-powered omnidirectional microwave transmitters at about 2.15GHz are used to send programmes, often initially carried over distribution satellites, to homes. In some locations MDS has considerable economic advantages over cable.

The MDS operators are convinced that many of their subscription channels are being pirated and in a recent lawsuit named 40 radio amateurs as being among some 3000 “pirate” viewers, on the evidence that they had 2GHz aerials on their roofs. The cases have now been dropped after most of the amateurs named had signed as affidavits that they had not used the aerials to receive Home Box Office subscription channels, and pointing out that the MDS frequencies are close to the 2.3 to 2.45GHz amateur band. But it is clear that the bad feeling between American radio amateurs and the cable and MDS operators has not yet ended.

I understand that interest is being shown in the UK in microwave distribution systems although these do not have any of the interactive facilities advocated in the Cable and Broadcasting Bill.

In brief

The 23-cm beacon, GB3WX, that incorporates weather telemetry, is now back in service . . . A number of earth-moon-earth tests are being organized on the 2.3GHz band where it is possible that some moon-bounced signals could be heard on dishes of only 4ft diameter . . . The Bury Radio Society has a Ham Feast at Mosses Community Centre, Cecil Street, Bury, Lancs on February 5 . . . RSGB National VHF convention is at Sandown Park Racecourse, Esher, Surrey on March 24 . . . RSGB National Amateur Radio Exhibition is at the National Exhibition Centre, Birmingham on April 28-29.

PAT HAWKER, G3VA
IEEE488 interface for the BBC Microcomputer

The BBC Microcomputer lacked a GPIB (IEEE488) interface — until Intelligent Interfaces designed this one for Acorn.

by Andrew G. Ray

Many features of the BBC Microcomputer make it eminently suitable for use in the research and development laboratories of educational and industrial establishments. These include its fast structured Basic interpreter, high resolution colour graphics and a number of input/output interfaces for connecting peripheral equipment. However, it did lack an IEEE488 interface, an omission now rectified by Acorn Computers. This article includes a short introduction to the IEEE488 standard* and describes the hardware and software design of the interface.

The IEEE488 (GPIB) interface has been adopted by major instrument manufacturers throughout the world as a means of connecting instruments such as digital voltmeters and spectrum analysers to one another and to a controlling computer to form automatic test equipment systems. A number of computer and peripheral equipment manufacturers have used the interface to connect computers to disc units, graphics plotters and so on.

The IEEE488 standard specifies a system for exchanging digital data in bit-parallel, byte-serial form at up to 1 Mbytes per second between a number of devices in a local area. The interface makes use of two types of messages: interface messages used to manage the interface (commands) and device-dependent messages (data).

Up to 15 devices, including the controlling computer, can be connected using IEEE488 standard cable assemblies. These have a plug and socket at each end permitting star or linear interconnection of devices. The connectors are provided with two securing screws which allow them to be stacked on the socket of each device. The standard permits individual cable lengths of up to 4 m and a total cable length in a system of 2 m per device or 20 m, whichever is the shorter. The cable consists of eight data lines, three handshake lines and five control and management lines. The three handshake lines are used to transfer data between devices; the slowest device determines the rate at which this occurs.

Each device in an IEEE488 system must have a unique address. Some devices have only one address (a primary address) whilst others have extended addressing (both primary and secondary addresses). Secondary addresses are often used to select different functions within the same device: for example an analogue-to-digital converter with a number of inputs may have the input selected by the secondary address.

A device can have the ability to send data (act as a talker), receive data (act as a listener) or do both (act as a talker-listener), or manage the system (act as a controller). Only one device in a system can act as system controller. This is the device which has the control function when the system is initialized.

In my experience, the use of even a fairly simple IEEE488 system transforms research and development work. Apart from the obvious advantage of speed, performing a test automatically has other advantages:

- repeatability, as the test is defined by the program running on the controlling computer
- fast analysis, as the computer can rapidly compare the results of different tests
- faster development, as the results of a test are almost instantly available.

The third advantage means that decisions in the course of development are based on facts rather than speculation and enable further tests to be planned in an informed fashion.

Complex IEEE488 systems, working at high data transfer rates, usually employ a minicomputer as controller. However, most systems consist of one or two instruments connected to a microcomputer and this offers an extremely cost-effective automatic test system.

The overall objectives in the design of the Acorn interface were to allow it to act as system controller and operate as controller, controller-talker and controller-listener with the ability to pass control to another device on the bus and request it back. Additionally, the interface was required to be easily used from any language running on the computer or a second processor.

Hardware

Two approaches to the hardware design were considered: the use of peripheral interface adaptors (p.i.a.) with t.t.l. open collector drivers and terminating resistors, or else the use of an l.s.i. general-purpose interface bus adaptor (g.p.i.a.) with IEEE488 bus transceivers.

The first requires all interface functions, such as source and acceptor handshakes, to be implemented in software. This imposes an unacceptable burden upon the processor and significantly reduces total system performance. In the second approach the g.p.i.a. implements most interface functions, interrupting the processor only when action is required.

The 6502 microprocessor of the BBC Microcomputer has many tasks and makes extensive use of interrupts, and so the second approach was chosen. As the controller function was to be implemented, this restricted the choice of l.s.i. GPIB adaptors. It soon became apparent that the Texas Instruments TMS9914A was the most suitable in that it was the most easily interfaced to the 6502 microprocessor and, together with the Texas SN75160A and SN75162A octal GPIB transceivers, resulted in a compact circuit board layout.

Connection to the 1 MHz bus of the computer is via a 34-way ribbon cable. A 34-way header provides a feed-through connection to further 1 MHz bus peripherals. Resistor packs provide optional 2.2 kΩ pull-up and 2.2 kΩ pull-down terminations for the 1 MHz bus. All 1 MHz bus lines are buffered. A clean NPGFC select signal is produced by an RS flip-flop formed by three gates on IC4. Address decoding is performed by gates of IC7 and IC6. The read and write registers of IC4 are located in page &FC between &FC20 and &FC27. Two gates of IC4 are used to produce a chip-enable signal, qualified by

* The 488 general-purpose interface bus standard, which is identical with IEC625-1 apart from connectors, was described by P. R. Ellefson in 'IEEE bus standard' Wireless World June/July 1980 pages 75-8.
the buffered 1MHz signal. This ensures the correct timing relationship between the processor and the TMS9914A. Note that both register select and data lines of IC₂ are designated using the Texas Instruments convention. This is opposite to that used for 6502-based systems, such as the BBC Microcomputer.

The crystal and IC₁ generate a 5MHz clock for IC₁. Trigger output from IC₁ is available at PL₂; however, this is not fitted in the standard interface. Link 1 determines whether the interface is system controller and link 2 determines whether the outputs of IC₂ are open-collector or three-state.

Software

To enable ease of use with any high level language and permit parameters to be passed as variables, the IEEE488 software was designed to appear to the BBC Microcomputer operating system as an additional filing system. The IEEEFS is selected by *IEEE, in the same way as other filing systems.

Communication between a language and the interface is via two channels. The first is the command channel used for transmitting IEEEFS commands and receiving information on the state of the interface. The second is the data channel used for reading and writing data to other 488 devices. IKEE commands are sent to the IEEEFS by PRINT# via the command channel. Data is sent to and received from other devices by PRINT# and INPUT# via the data channel. These channels must be OPENed before use.

The table lists the commands available. Full simple English syntax produces readable programs. However, the use of upper and lower case together with minimum abbreviations e.g. L. for LISTEN, makes rapid entry of programs possible. The experienced user of IEEE488 systems will appreciate the functions of most commands but the following facilities are worthy of note.

The state of the interface is available through the STATUS command which returns a 32-bit status word. For example, this can indicate whether the computer is controller in charge, or if another device is requesting service, whether a source handshake or timeout error has occurred, etc.

Although it is not part of the standard, an optional timeout after 2.5 seconds is provided to avoid waiting interminably for a device which never responds.

Data can be sent and received as strings of up to 255 characters or, through the use of the READ and WRITE BINARY commands, as longer sequences of binary coded data.

The standard does not specify a particular delimiting character for strings. The END OF STRING command enables the default delimiter of linefeed to be redefined as either one or two characters.

The TRANSFER command permits the computer to carry out some other task while a talker sends data to a listener or listeners on the bus. The end of this sequence is indicated in the status word.

Commands are available that allow both serial and parallel polls to be conducted. All addressed and universal commands specified in the IEEE488 standard can be sent, e.g. GO TO LOCAL, LOCAL LOCKOUT etc.

The TAKE CONTROL and REQUEST CONTROL commands enable control to be passed to another device and requested back.

Example

The following example program in BBC Basic might be used for obtaining the frequency response of an amplifier. An input signal is provided by a programmable signal generator and the output signal is measured with a digital voltmeter.

```basic
10 *DISC
20 result%=OPENOUT("RESULTS")
30 *IEEE
40 cmd%=OPENIN("COMMAND")
50 data%=OPENIN("DATA")
60 PRINT#cmd%,"IEEE DEVICE NUMBER",1
70 PRINT#cmd%,"CLEAR"
80 PRINT#cmd%,"REMOTE ENABLE"
90 siggen%=OPENIN("7")
100 dvm%=OPENIN("3")
110 FOR frequency%=1000 TO 10000 STEP 100
120 PRINT#cmd%,"LISTEN",siggen%,"EXECUTE"
130 PRINT#data%,"0.1","+STR$(frequency%)+Hz"
140 PRINT#cmd%,"UNLISTEN"
150 PRINT#cmd%,"TALK",dvm%
160 INPUT#data%,reading$
170 PRINT#cmd%,"UNTALK"
180 response=20*LOG(val(reading$)/(0.1*0.7071))
190 *DISC
200 PRINT#result%,frequency%,response
210 *IEEE
220 NEXT frequency%
230 CLOSE dvm%
240 CLOSE siggen
250 *DISC
260 CLOSE result%
```

In the example, lines 10 and 20 select the disc filing system and open a file for storing the results of the test. Lines 30, 40 and 50 select the IEEEFS and open the command and data channels.

Line 60 is used to specify the primary address of the computer. This can be any primary address not used by an instrument in the system.

Line 70 returns the IEEE488 system to a known state; line 80 enables the remote operation of the devices in the system; and lines 90 and 100 pass the primary addresses of the signal generator and digital voltmeter to the IEEEFS.

Line 120 commands the signal generator to listen and line 130 sets its signal amplitude and frequency. Line 140 commands...
Microprocessor programming simplified

A new technique for transferring a program directly to machine-code language avoids the necessity of writing the program out in high-level or assembly language.

To write a new program it is often necessary or desirable to set up the sequences in the form of a flowchart. This may then be translated into a computer language, be it high-level, assembly or machine-code depending on the facilities available to the user. In all cases the process of translation can be tedious and time consuming. In order to speed up the process, a simple method is presented here to enable flowchart steps to be entered directly into the system by defining a number of key functions with symbols. It is no longer necessary to key in assembly mnemonics or even remember their exact abbreviations. The symbol sequences can be added to the flow chart and then keyed in.

The proposed symbolic forms of the instruction set are presented in Table 1. Although this particular set is for the Intel 8085 processor, it may be adapted quite easily for use on other processors. The blocks at the left of each instruction represent the keys used, in their correct order.

---

**by Gemal A. M. Labib**

It can be seen that the number of keystrokes for each instruction is less than that required with the usual assemblers. There are few symbols and they are easy to remember. For example, the arrow keys, →, ←, are used for data transfer between registers, register pairs and memory as well as for jumps and return instructions. Similarly, the + and − signs are used for increment, decrement, add and subtract, as well as positive and negative condition flags. Although not shown in the table, every statement must end with a comma terminator.

The symbolic assignments of the keys are shown in Table 2. In order to minimize the number of keys required, two or three functions are assigned to most keys. Eight hexadecimal numeric keys are used as control keys for editing and program execution. The other keys are used to enter some instruction mnemonics and logic operators. 16 further keys are used for the other symbols shown in Table 1. The function of the eight control keys are as follows:

- **Start:** positions the cursor at the start of the current statement.
- **Clear:** deletes the statement at the cursor position.

---

Flowchart of the software that implements Tables 3 and 4.
Forward and backward position the cursor at the next or previous statement. Delete and insert operate on individual keystrokes at the current cursor position. Single step allows statements to be translated into machine-code and to be executed one at a time. Following the execution of a statement, control is returned to the operating system so that registers and memory contents may be checked. Run causes program statements to be transferred to a secondary buffer. They are translated into machine code as a whole, and the program executed.

A few notes may help to avoid syntax errors and simplify key entry. 1. Instructions dealing with register pairs should begin with the (rp) operand. 2. No statement should begin with a numerical operand or the Immediate marker. 3. The source and destination register, register pairs or memory operands may be reversed.

Table 2: Key assignments

<table>
<thead>
<tr>
<th>Original Key label</th>
<th>Assigned Label</th>
<th>Original Key label</th>
<th>Assigned label</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>CALL/NOP</td>
<td>K1</td>
<td>A/RST0/PUSH</td>
</tr>
<tr>
<td>1</td>
<td>HLT/ROT</td>
<td>K2</td>
<td>B/RST1/POP</td>
</tr>
<tr>
<td>2</td>
<td>DAA/COMP</td>
<td>K3</td>
<td>C/RST2/Left</td>
</tr>
<tr>
<td>3</td>
<td>CMA/OR</td>
<td>K4</td>
<td>D/RST3/...</td>
</tr>
<tr>
<td>4</td>
<td>STC/EXOR</td>
<td>K5</td>
<td>E/RST4/...</td>
</tr>
<tr>
<td>5</td>
<td>CMC/AND</td>
<td>K6</td>
<td>H/RST5/Right</td>
</tr>
<tr>
<td>6</td>
<td>IN/RST</td>
<td>K7</td>
<td>L/RST6/C</td>
</tr>
<tr>
<td>7</td>
<td>OUT/INT</td>
<td>K8</td>
<td>M/RST7/nc</td>
</tr>
<tr>
<td>8</td>
<td>Stmt Start</td>
<td>K9</td>
<td>HL/+</td>
</tr>
<tr>
<td>9</td>
<td>Clear</td>
<td>K10</td>
<td>BC/-</td>
</tr>
<tr>
<td>A</td>
<td>Delete</td>
<td>K11</td>
<td>DE/Z</td>
</tr>
<tr>
<td>B</td>
<td>Insert</td>
<td>K12</td>
<td>PC/nz</td>
</tr>
<tr>
<td>C</td>
<td>Forward</td>
<td>K13</td>
<td>PSW/even</td>
</tr>
<tr>
<td>D</td>
<td>Backward</td>
<td>K14</td>
<td>SP/add</td>
</tr>
<tr>
<td>E</td>
<td>Single Step</td>
<td>K15</td>
<td>Stack Top/b/Immmed</td>
</tr>
<tr>
<td>F</td>
<td>RUN</td>
<td>K16</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Symbol sequences needed to produce the full instruction set. Variables r and rp represent registers or register pairs; d8 and d16 are single or double-byte constants.

Table 3: First position

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Binary coded hexadecimal</th>
<th>Next entry link</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>38</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>00</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>08</td>
<td>1</td>
</tr>
<tr>
<td>D</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>E</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>H</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>L</td>
<td>28</td>
<td>1</td>
</tr>
<tr>
<td>M</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>07</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>00</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>01</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>02</td>
<td>3</td>
</tr>
<tr>
<td>E</td>
<td>03</td>
<td>3</td>
</tr>
<tr>
<td>H</td>
<td>04</td>
<td>3</td>
</tr>
<tr>
<td>L</td>
<td>05</td>
<td>3</td>
</tr>
<tr>
<td>M</td>
<td>06</td>
<td>4</td>
</tr>
<tr>
<td>BC</td>
<td>00</td>
<td>5</td>
</tr>
<tr>
<td>DE</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>HL</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>PSW</td>
<td>30</td>
<td>6</td>
</tr>
<tr>
<td>L</td>
<td>28</td>
<td>14</td>
</tr>
<tr>
<td>M</td>
<td>30</td>
<td>14</td>
</tr>
<tr>
<td>A</td>
<td>38</td>
<td>14</td>
</tr>
<tr>
<td>B</td>
<td>00</td>
<td>14</td>
</tr>
<tr>
<td>C</td>
<td>08</td>
<td>14</td>
</tr>
<tr>
<td>D</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>E</td>
<td>18</td>
<td>14</td>
</tr>
<tr>
<td>H</td>
<td>20</td>
<td>14</td>
</tr>
</tbody>
</table>

if the appropriate arrow symbol is included. 4. All instruction statements must be terminated by a comma.

The driving software that handles the machine-code translation operation of the entered statement is detailed in two tables. The data contained in the tables is specific to the 8085 processor but by following certain rules the software can be applied to a variety of processors.

Table 3: the first position table, contains three fields for each entry: the mnemonic field contains the ASCII codes for the symbols that may appear at the start of each statement; the binary code field contains the corresponding binary combination that will be transferred to the first byte of the assembled machine-code instruction; the next-entry link specifies the group of entries in Table 4 which are related to each symbol in Table 3. Table 4,
In Table 1, symbol sequences needed to produce the full instruction set. Variables r and rp represent registers or register pairs; d8 and d16 are single or double-byte constants.

<table>
<thead>
<tr>
<th>Symbolic statement</th>
<th>8085 instruction mnemonic</th>
<th>Symbolic statement</th>
<th>8085 instruction mnemonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>C</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>E</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>G</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>I</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>J</td>
<td>J</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>K</td>
<td>K</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>L</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>M</td>
<td>M</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>P</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>Q</td>
<td>Q</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>R</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>S</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>T</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>U</td>
<td>U</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>V</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>W</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>Z</td>
<td>Z</td>
<td></td>
</tr>
</tbody>
</table>

The flow chart shows how the lists are used by the driving software, and how the translation is accomplished. It can be seen that there are a number of error traps so that it is impossible to terminate a statement with anything other than a comma; to key in more than eight symbols (including the comma) in any one statement; or to use any non-valid symbol combinations. The software described in the flowchart occupies about 280 bytes of memory. Features may be added such as the ability to display the next instruction address; and display the next statement number during program entry; to have a user-defined starting address; and to save programs on tape or disc in their symbolic format for further editing or modification.

When setting up the tables, the following rules should be adhered to:
1. The first position table: a. If symbol used at the start of a statement represents different instruction groups, it will have multiple entries in the table with the appropriate binary codes. These can be distinguished by having different next-entry links; b. Symbols that use the same key should always use the same ASCII code; c. Each entry will require three bytes of memory.
2. The next-entry table: a. All symbol sequences must be linked with and terminate with the comma entry; b. As for 1b above; c. Symbols with several different binary codes must have the same current entry link; d. Each current entry link must have a corresponding next entry link; e. The minimum memory space required for each instruction is four bytes, expandable in segments of two bytes; f. Mnemonics having the same current entry and next entry links may be grouped together so that both fields are stored once only for the whole group. This will reduce the size of the table.

The tables printed here demonstrate the MOV, MVl, Lxi, Push and Pop groups. By following the sequence of the flow chart any instruction within these groups may be assembled. For example, the instruction MOV AB; by reference to the 8085 instruction set it is found to have the hexadecimal code of 78. The key depressions A, forward arrow, B, comma, used in conjunction with the links give the numbers 38, 40 and 00 which when combined give 78.

---

**Table 4: Next position**

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Binary coded hex.</th>
<th>Current entry</th>
<th>Next entry</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMC</td>
<td>←</td>
<td>40</td>
<td>1,2 7,8</td>
</tr>
<tr>
<td>CALL addr</td>
<td></td>
<td>00</td>
<td>7,8 32,32</td>
</tr>
<tr>
<td>CC addr</td>
<td></td>
<td>01</td>
<td>D</td>
</tr>
<tr>
<td>CINC addr</td>
<td></td>
<td>02</td>
<td>E</td>
</tr>
<tr>
<td>CZ addr</td>
<td></td>
<td>03</td>
<td>H</td>
</tr>
<tr>
<td>CNZ addr</td>
<td></td>
<td>04</td>
<td>L</td>
</tr>
<tr>
<td>CP addr</td>
<td></td>
<td>05</td>
<td>A</td>
</tr>
<tr>
<td>CM addr</td>
<td></td>
<td>06</td>
<td>M</td>
</tr>
<tr>
<td>CPE addr</td>
<td></td>
<td>07</td>
<td>N</td>
</tr>
<tr>
<td>CP0 addr</td>
<td></td>
<td>08</td>
<td>O</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>09</td>
<td>P</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>10</td>
<td>Q</td>
</tr>
<tr>
<td>←</td>
<td></td>
<td>11</td>
<td>R</td>
</tr>
<tr>
<td>←</td>
<td></td>
<td>12</td>
<td>S</td>
</tr>
<tr>
<td>←</td>
<td></td>
<td>13</td>
<td>T</td>
</tr>
<tr>
<td>←</td>
<td></td>
<td>14</td>
<td>U</td>
</tr>
<tr>
<td>←</td>
<td></td>
<td>15</td>
<td>V</td>
</tr>
</tbody>
</table>

---

WIRELESS WORLD FEBRUARY 1964
Edison’s electrical indicator

Last November, on the Centenary of Edison’s patent of the thermionic diode, James Franklin argued that Edison had no idea of the significance of his invention and that therefore this could not be taken as the birth of electronics. Here Desmond Thackeray of Surrey University replies

The interest Wireless World has in the realms of electronics brings with it the responsibility for acknowledging inventions (and their inventors) of significance. A use for one electronic invention of great importance, the thermionic diode, was patented by Thomas Edison1 some 20 years before J. A. Fleming thought to use it as a wireless detector. In these two decades, and even before 1883 when my story starts, there was a great deal of investigation into the physics of rather gassy vacuum tubes and the emission from heated and cold surfaces. This work came to fruition in a number of useful inventions, such as the Braun cathode-ray oscillograph tube2 of 1897, the Wehnelt oxide-coated cathode3 of 1904 and the Cooper-Hewitt mercury pool rectifier4 of 1903.

Fleming himself reported5,6 in 1890 and 1896 that unidirectional current flowed through an Edison thermionic diode when its filament was heated by an alternating current (though these are not his own words). What Fleming had observed was the process of rectification; but apparently it had little significance to him at the time. One must remember that alternating power supplies were very much a novelty, and rejected by Edison himself.

Fig. 1. Edison’s patent clearly depicts thermionic diodes with recognisable filament and anode and shows how they could be wired to indicate on a galvanometer any fluctuations in the power supply.

So, naturally, Edison’s American patent no. 307,031 filed November 15, 1883, for an “Electrical Indicator” did not cover the application of his thermionic diode to the conversion of the despised alternating current into his well-regarded direct current. And he did not claim novelty for the diode itself, seemingly regarding it as simply an electric lamp, the use of which as an electrical indicator, and for controlling generators, he wished to cover. Edison must have observed that the emission from his hot carbon lamp filaments only appeared when the filaments were visibly hot, and then increased super-proportionately as the filament current was raised. By connecting the filament to his power lines “changes in the candle-power of the lamp (filament), and consequently in the electromotive force of the source of supply, are made apparent”. His diagram...
(Fig. 1) shows a galvanometer in the plate (anode) circuit to display the changes in filament emission current. The arrangement no doubt exhibited a very high sensitivity to small changes in power-line voltage. It seems therefore a completely practicable application of the thermionic diode in any situation where a plant engineer actually required a more sensitive indicator than say a conventional voltmeter with offset zero. But we cannot be sure that there was such a need.

Edison continues the quoted sentence "... instead... are made to affect circuit controlling apparatus, automatic regulators or other electrical apparatus..."

Here he is envisaging the galvanometer as a relay; and later in the patent he specifies how this may be interfaced to the generator control via "a mechanism such as shown in my patent no. 287,524". Whether or not this latter mechanism worked successfully hardly matters, because Edison could have used here any "sure-fire" interface, such as a reversible motor driving a field rheostat. Clearly, what Edison had invented in 1883 was not only a sensitive incremental electronic voltmeter, but also a complete electronic servo-control of the discontinuous (or bang-bang) kind. Again we might wonder whether a control system of such high sensitivity (loop gain?) was actually needed, and would be used. There could also have been stability problems to solve. Writing in the magazine Scientific American in March 1969, George Shiers draws attention to the historic importance of what he calls "this first patent in electronics"; but he does add the rider that it "was of no commercial value". I think this is rather a brief dismissal of the topic, arising because Shiers' article is really concerned with the string of thermionic developments that were eventually to contribute to early wireless.

Even in wireless, generator regulation must have had some value; but the modest d.c. stability required so long ago could probably have been met adequately with simpler techniques, compound winding of the generator, or the buzzing relay as ubiquitous in automobile battery charging; and so Edison's invention lay idle. It seems to have been the exigencies of World War I, requiring sensitive valved receivers intolerant of such interference sources as buzzing relays, that prompted H. M. Stoller to use a thermionic diode (called a Kenotron by the General Electric Company of America) to stabilise the output of an aircraft generator supplying thermionic tubes.

Gerald Tyne, in his magnum opus "Saga of the Vacuum Tube", devoted more than a page to the TB1 Kenotron (Fig. 2) and said that "approximately 4,500 of these were delivered to the Signal Corps."

Then if one turns to the contemporary account by Van der Bijl in the "Thermionic Vacuum Tube", there is a circuit diagram of a regulator (as devised by Stoller) and some regulation curves. "Edison triumphs at last" we might say? Sadly, not so; there is one little flaw here. The circuit shows that the plate current of the diode (20 to 130mA) actually flows through the differential field winding of the generator itself, so providing continuous regulation without steps. This was a simplification seemingly not envisaged by Edison in his original patent, though the wording "in any suitable manner" was obviously intended to pave the way for alternatives and afterthoughts.

The British version of the Edison patent ran to a second edition in 1922; and Stoller was into hardware again in 1929 with a more sophisticated regulator which added three triodes and a saturable reactor to the diode. This time he was regulating an alternating voltage, for the Edison invention (unlike other methods) would work just as well for regulating an alternating supply as it would when controlling a d.c. generator. Considering how bitterly Edison himself had once opposed alternating supplies, it seems ironic that this work of Stoller should have applied Edison's invention in just that field. Benson quotes a number of later usages, during the next 20 years or so; but it is doubtful whether the users gave much credit to the patent Edison filed on November 15, 1883.

So, should we have been toasting Thomas Edison on November 15, 1883, for the first electronics patent ever? I think that we should. The Germans set us an example by honouring 100 years of the Edison effect itself, in organising a conference on electron tubes May 18-20, 1983, in the Garmisch-Partenkirchen congress centre. In its way, this helped to compensate for much neglect of Edison's invention, which preceded such currently important thermionic devices as the cathode-ray tube of Braun, the X-ray tube of Coolidge, and the fluorescent lamp.

References
1. T. A. Edison, Electrical Indicator US Patent 307031 of October 21, 1884, filed November 15, 1883
2. F. Braun, Ann. der Physik, 1897, vol. 60, pp. 552-9
3. A. Wehnelt, German Patent 157845 of January 15, 1904
5. J. A. Fleming, 1890, Proc. Roy. Soc. 47, p. 120
12. T. J. Handford, British Patent 2982 of February 8, 1884
Circuit Ideas

Thermally-controlled power supply

Supply shown controls power in a low-resistance load such as a single turn of Nichrome wire using feedback from a diode temperature sensor located near the load. Voltage across the diode is compared with the current/temperature setting potentiometer by an op-amp. A second op-amp compares the summed outputs of the first comparator and output sensing resistor with the voltage across a reference diode. Output-current limiting with a 100mOhm resistor is about 7A. The circuit was used to control the temperature of a small zone-melting furnace with good results.

C. L. Barczac
Itajuba
Brazil

Don’t waste good ideas

We prefer ideas with neat drawings and widely-spaced typescripts, but we would rather have scribbles on the “back of an envelope” than let good ideas be wasted.

Submissions are judged on originality or usefulness – not excluding imaginative modifications to existing circuits – so these points should be brought to the fore, preferably in the first sentence.

Minimum payment of £30 is made for published circuits, normally early in the month following publication.

Prom elimination

Using a circuit such as this one designed for 8080-based microcomputers, loading an operating system from cassette directly into ram means that no proms are required— not even for storing cassette-driving software. This increases system speed and reduces cost by allowing all of the microprocessor address space to be filled with rams.

While data is being loaded from cassette, this simple modification slows the microprocessor down to match the data rate of the cassette by forcing it into processor-wait states. Synchronization between the cassette data rate and the processor is automatic. With the switch set for loading, the processor ready input is controlled by this circuit, as are data-ready reset (DDR) and receiver-register disable (RRD) signals. With the reset button pressed the processor wait line goes low, forcing the ready signal at pin 9 of IC1b low and, the processor enters the wait state.

When the cassette player is started, the uart data-ready (DR) output goes high for each byte received. On each low-to-high transition of this signal the high wait-state condition is transferred to the ready line from IC1b and the processor is released from its wait state to process the byte received. Immediately after the IC1b ready

WIRELESS WORLD FEBRUARY 1984
Keyboard encoder

Besides being cheap, this keyboard encoder has roll-over protection, letters-only shift lock and can produce 128 ASCII characters and 128 control codes. It is not necessary to unlock the shift key to type single lower-case characters – an led status indicator prevents ambiguity. When function key S5 is locked, shift lock is released so that bit seven may be active with shifted or unshifted characters or control codes, providing an eight-bit set of codes.

Circuit IC2 is a 16-line decoder for keyboard scanning and IC3 is a priority encoder for sensing. Input sequence of IC3 is the reverse of the priority sequence to provide positive logic at the three data outputs. Each of the 16 decoder outputs is connected to three character switches to provide four least-significant ASCII bits. Switches one to three provide shift-lock, shift and control functions respectively and further optional switches four and five provide control lock and determine the state of bit 7 for special functions. Shift operates differently on letters and numbers by gating which controls bit 6.

Minimal screen flicker and program interruption will occur when the decoder is driven by vertical sync. from the v.d.u. I used a 7493 instead of developing software.

E. Goodchild
Rotorua
New Zealand

The processor stores the operating system programs contained in bytes 1 to n starting at memory location 0000. After the program is loaded, the switch is set to the normal position and the reset button pressed to execute the loaded program.

G. A. M. Labib
Heliopolis
Cairo

Note: Switch 4 enables hexadecimal set of 16 numbers and 6 punctuation keys to supply 32 control codes instead of letters. Letters a–e represent segments of led segment font and connect to +5V.
High-resolution point display

This circuit was developed to display up to 512 points logged to 9-bit resolution on a TV point-digitizing system. Only 2K bytes of memory are used since it is not necessary to reserve a memory location for each possible coordinate on the screen.

Video memory consists of just two MK4801AN, 70ns byte-wide devices. During data loading, video memory is connected to data and address buses of the digitizing system (in this case Z80-based) at the points indicated on the diagram through software-controlled three-state buffers; outputs of these buffers are high-impedance while the display is in use. The memories are divided into four pages of 512 bytes designated X0, X1, Y0 and Y1.

Data outputs of X memory are connected to one side of an eight-bit comparator, the other side of which is fed by the lower eight bits of a nine-bit counter. This counter is clocked by an 8MHz crystal oscillator gated by a modified line-sync. pulse which also resets the counter. Similarly Y-memory data output is compared with an eight-bit counter clocked by line-sync. pulses and cleared by a field-sync. pulse.

The state of the line-sync. pulse from the TDA2571A sync. separator is latched on field-sync. pulses by the field-identifying bistable i.e. to determine which of the two

*Line sync. pulses from the TDA2571A have a 4% duty cycle and are satisfactory for field identification but must be modified for oscillator gating and counter reset.

Fields of the 2:1 interlaced picture are currently being displayed. Output from the bistable i.e. (l.s.b. Y) is connected to A0 of the Y memory and is used to select either page Y0 or Y1. The X counter's most-significant bit (m.s.b. X) is connected to A0 of the X memory and selects either page X0 or X1.

Active-low comparator outputs feed a NOR gate, the output of which is injected into the video signal to produce a positive bright-up pulse when X and Y coordinates are true. This pulse is also used to clock a 9-bit video memory counter, connected to address lines A0 to A8 of the video memory, which selects the next set of coordinates for comparison. After field 1, i.e. after one complete picture has been displayed, this counter is reset. Four bytes of memory are required for each point displayed and the two bytes not holding coordinates are filled with null characters, i.e. 0116 for X0, Y0, Y1 and FF16 for X1. During line and field blanking the comparators are disabled so coordinates represented by these bytes have no effect. Blanking pulses are regenerated from sync. pulses but is not shown on the diagram.

Coordinates must be stored in the video memory in time sequential order with field zero before field one and low-value Y coordinates in a field before values and the same for X coordinates within a line. Bytes stored in video memory are not true coordinates but related to them.

X coordinate <255 — store X coordinate directly in X0 and put FF16 in corresponding X1 location.

X coordinate >255, <511 — store X coordinate—256 in X1 and put 0116 in corresponding X0 location.

Even Y coordinate — store Y coordinate/2 in Y0 and put 0116 in corresponding Y1 location.

Odd Y coordinate — store (Y coordinate—1)/2 in Y1 and put 0116 in corresponding Y0 location.

Values of X and Y lower than say 10 will occur during the blanking period and will not be compared or displayed. Possible hexadecimal addresses for the four pages of video memory connected to the processor buses would be:

X0 1000-11FF
X1 1200-13FF
Y0 1400-15FF
Y1 1600-17FF

Examples of five points loaded into video memory are shown in this table

<table>
<thead>
<tr>
<th>Coordinates (Y, X)</th>
<th>Y0</th>
<th>Y1</th>
<th>X0</th>
<th>X1</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>40</td>
<td>06</td>
<td>01</td>
<td>FF</td>
</tr>
<tr>
<td>160</td>
<td>258</td>
<td>80</td>
<td>01</td>
<td>02</td>
</tr>
<tr>
<td>160</td>
<td>262</td>
<td>80</td>
<td>01</td>
<td>06</td>
</tr>
<tr>
<td>41</td>
<td>60</td>
<td>01</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>301</td>
<td>286</td>
<td>01</td>
<td>150</td>
<td>30</td>
</tr>
</tbody>
</table>

J. M. Graham
Dunstaffnage Marine Research Laboratory
Oban
Argyll
Non-linear rotation sensor

Useful when both coarse and fine adjustments have to be made using the same rotary control, this circuit provides between one and 16 pulses for each slot passing the sensors, depending on the disc's rotary speed. These pulses increment or decrement counters depending on the direction of rotation of the disc. Any number of counters may be used, whether binary or b.c.d. Resistor $R_4$ is chosen to suit the disc and $R_3$ is to set the 555 timer to the highest frequency possible.

D. F. Cook
Cleveland
Yorkshire

Simple divide-by-fraction circuit

A stable p.i.l. with a frequency range of 0.01Hz to 100kHz may be obtained using the XR-2207 v.c.o. and an XR-2208 operational multiplier. These i.cs are used in two ways - to design a divide-by-fraction circuit shown schematically in Fig. 1(a) and a low-noise amplifier as shown in Fig. 1(b). In both cases the mathematical treatment is the same and can be derived using Fig. 1(a). Since

$f_{in} = V_1/V_c R_1 C_1$

and

$f_{out} = V_2/V_c R_2 C_2$

it follows that

$f_{out} = f_{in} R_1 C_1 / R_2 C_2$

for $C_1 = C_2$. Also, the system functions as a simple divide-by-fraction circuit in which the fraction frequency is set by the ratio of $R_1 / R_2$.

The same holds for Fig. 1(b). Under the assumption $f_{out} = f_{in}$,

$V_1 = R_1 V_2 / R_2$

i.e. the circuit may be used as a low-noise amplifier. A practical circuit is shown in Fig. 2. Values of $R_1$ and $C_1$ can be calculated according to the lock and capture range as usual.

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Fig. 2
The Forth application to provide simple polyphonic extemporizations from a given theme was described in outline in last July's issue. Full details of this are now given, including the entire vocabulary (List 3) and a glossary.

The first steps were to find Forth and to put it in a convenient place in ram. This was done by assembling 8080 FIG-Forth release 1.1 (a public domain listing) under the Nascom Zeap editor assembler. Having removed most of the comments, a month of spare-time typing yielded a 40K edit buffer which took about 15 minutes to assemble. The origin was placed at 15000, leaving space below Forth for the essential parts of the organ interface plus a substantial scratchpad area for additional console fields. A Forth-compiled editor from the Forth Installation Manual was added, together with simulation of virtual memory, to suit a Nascom 2 with 64K of ram but without discs.

Forth uses postfix or reversed Polish notation, e.g. HEX 2 A + . when entered returns the answer C. Code groups are separated by spaces. Each group is interpreted as a word (a command, variable or constant) or, if it is not in the vocabulary, a number if possible. Thus FFFF is meaningless in standard Forth unless operation is in a suitable number base such as hexadecimal, which as above is achieved by the word HEX. In this simple example the two code groups after HEX are interpreted as numbers and are transferred to the stack. The + pops them into the HL and DE register pairs respectively, adds them and pushes the answers back onto the stack. The + (pronounced 'dot' although 'print' might be more appropriate) displays the answers and leaves the stack empty.

At first sight, a screen of Forth code such as List 2 might be incomprehensible whilst having a startled appearance because of the sprinkling of exclamation marks, but the mysteries soon fall away. ! is pronounced 'store' and it is a word which does just that, e.g. 9400 TUN !

stores the value 9400 (in whatever number base has been set, being 16 throughout this article) in the variable TUN, which was created with initial value 7400 by loading 0 of List 2. The complementary word is @, pronounced 'fetch'. C! and C@ are the equivalents for single-byte numbers, although these are kept on the stack as two-byte numbers, one byte being zero. Double-precision (four-byte) numbers are also provided for but are not used in this article. The letter U as in U. or U< indicates unsigned, so that positive 16-bit numbers can go up to FFFF. (Any number base can be used. If HEX B250 is entered and operation than changes to base 36 (by DECIMAL 36 BASE !) the number is returned by . as Z80).

Forth has two stacks. The principal one is referred to as the parameter or computation stack, or just as the stack. The other one is called the return stack, used mainly as a temporary parking area for numbers which would otherwise get in the way on the parameter stack.

DUP, SWAP, OVER, DROP and ROT (pronounced rote, short for rotate) and their four-byte equivalents rearrange the stack. ROT, for example, brings the third (two-byte) item to the top: DUP duplicates the top item; OVER duplicates the second item and pushes it on top; SWAP swaps the two top items; and DROP drops one item.

Conditional tests such as = take two parameters from the stack, replacing them with the true (1) or false (0) result, which is in turn destroyed when the test result is used.

An example of a definite loop occurs in List 2, line 1, as far as 'loop'. This also illustrates one use of the return stack. The 'limit' for the first loop (10H) and its 'index' (initially 0) are put to the return stack when the loop is executed. The Forth word I copies the top item on the return stack to the parameter stack, thus allowing the index to be used as a parameter in the loop itself, as in the same example from List 2.

Examples of indefinite (conditional) loops occur in List 2 lines 14 and 15 and in List 3 Screen 6 lines 2 and 3. Forth does not have a 'goto' instruction so that its users are forced to structure their programs and not to be quite so lazy as they might otherwise be.

Perhaps Forth is best known for its so-called self-compiling ability, meaning not that it compiles itself but that it is compiled by Forth. In many applications, such as the one described in this article, this need mean no more to the user than that Forth words may be strung together to form new words, as is done throughout List 2 and List 3. For example, line 7 of List 2 comprises the 'colon definition' of I.PDPS. When this is loaded, I.PDPS is compiled as a new word in the Forth dictionary. I.PDPS can then be used, which causes the words in its definition to be executed, i.e. the value of variable TUN is fetched, incremented, the result stored at 1430H, and similarly for IMP. I.PDPS will disappear after a cold start unless the appropriate Forth start-up parameters are changed. In this way a program can be developed on screens, which may be held in virtual memory or in ram, until a satisfactory version is obtained. This can then be loaded from cold and kept in the protected dictionary. It is not necessary to use the editing screens: the vocabularies of Lists 2 and 3 could be compiled directly.

For the application of Forth described in this article it is not necessary to delve into it more deeply, but ORCF from List 1 is taken as an example of a Forth word. Lines 8140 to 8155 comprise the 'head' and lines 8160 to 8240 form the 'body'. The code pointer distinguishes between the different kinds of word (machine code, colon definition, constant or variable). If ORCF were written in Forth rather than

Complete details of a vocabulary that will provide polyphonic improvisations when used with the Nascom 2 organ interface described in the June and July 1983 issues

by R. D. Easson
machine code it would have a different code pointer (the address of a machine code routine called "do colon") followed by a series of two-byte numbers called the parameter field, being the code pointer addresses of the words which would form the body of the definition. When such a word was fetched, each code pointer ultimately leads to a machine code routine, which might be called levels below.

'Starting Forth' by Leo Brodie (Prentice Hall, 1981) provides a more detailed introduction to Forth.

Forth as ‘composer’

Following the installation of Forth, the next thing was an interesting test to see whether Forth and the organ interface software would co-exist. Fortunately they did. Four Forth words were then written to enable Forth to work in the interface data fields (in data format) and console fields. These were written in machine code (List 1) rather than Forth partly to achieve faster operation (a challenge to someone to prove that Forth is faster) but mainly because the elements of three of them already existed, the extra one being ORCF.

The next objective was to achieve the simplest kind of improvisation, a parallel doubling of the theme at any chosen interval (and, as it happened, at any desired pitch for each part). Thus far, therefore, a sledgehammer to crack a walnut, but of course with further development in mind.

It took two weeks of spare time from the existence test to reach this objective, the additional twelve words vocabulary for which is shown in List 2, which also illustrates two console fields. T.OUT later became the two words TOR2 and OWT, but the other eight words all survive (albeit with some changes) in the current vocabulary (List 3) which was completed five weeks later. Certain weaknesses were identified in the vocabulary of List 2:

-list of hexadecimal addresses rather than variables and constants (this becomes tedious if more than a few such numbers are required)
-lack of clear functional allocation of machine code fields
-badly structured multiple function of T.OUT
-eccentric way of leaving the WHILE loop, with the bogus conditional in ?A
-inefficient use of /MOD and 2 for the nine-bit divide and multiplication required for semitone transposition.

(The substitution of 2/MOD and 2^M also on List 1 speeded things up by a factor of three.)
The operation of TU and TD (and, later on, TR-2 Etc) may be understood from the particular transposition sequence (chosen by chance before even translate mode was planned) for the 128 connections to the key registers. The three divisions of the organ for which the interface was designed are designated ‘M1’ (Manual 1 or Hauptwerk), ‘M2’ (Manual 2 or Ruggpositiv) and Pedal, with 49 notes on each manual and pedal on the pedal, allocated as in Fig. 1. The odd feature of this arrangement is that there is a carry from the top (most-significant bit) of one register appears at the bottom of the register below it in the numerical sequence.

List 2 serves as an introduction to the larger vocabulary of List 3, in which the earlier weaknesses are corrected although Firth expects no doubt find many more. In the shorter vocabulary, only the word which the user need know about is ORGANUM, which unlike the List 3 version does not take any parameters from the stack, so that it is necessary to edit and reload the Firth source code if different transpositions are required. In the List 3 vocabulary five words are available to the user: ORGANUM, 2 CANON, MELISMA, 3 CANON and MOTET, executed as described in the glossary. (Apologies for the fanciful use, or misuse, of some of these terms.)

It is assumed for the harmonization rule that the improvisation is a strict duo or trio, that is, with a single line of notes on each of two or three divisions of the instrument.

An incidental point is that some of the words can be used degenerately (e.g. 0 0 0 MELISMA) to strip out the redundant transposition which would be caused by L in translate mode. The difference is not usually significant: a saving of perhaps 20% of memory.

I am indebted to Ernest Hart for

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Fig 1. Allocation of the 16 key registers. Each accident (after design, the register numbers count in the opposite sense to the bit numbers. Registers also overlap between divisions of the organ. Register and bit-number registers 0-7 are used for stops and thumb-pistons.
drawing my attention to the theme of Tallis' canon, arranged with remarkable forethought about 400 years ago to give the improvisation vocabulary something to get its teeth into. The theme comprises four phases of eight notes, each having the same value. The phrases are:

- G G F# G G A B
- G C C B B A A G
- D C A B B A A G
- D E F# G B A A G

To get consistent results the theme needs to be in strict time, which can of course be achieved by the use of translate mode. If the notes are crotchets the first of each pair of repeated notes can be treated as a dotted quaver followed by a semiquaver rest. The possibilities appear endless—one for example, by changing TUN and IMP one can produce an intricate three-part canon form from a melisma of a melisma of the original theme.

An improvement needed before the vocabulary is developed any further is to provide buffers in the console fields, between the three divisions of the organ, to avoid the ambiguities which can occur at the extremes due to the shared registers (Fig. 1). The structure of the two-part words could also be improved to provide any of the three permutations, and more could be done to provide variation of speed between parts, rather than just having T2* in UDRD2P. Beyond that, some rules for the movement in pitch of one part in relation to another might be useful.

---

**Glossary**

<table>
<thead>
<tr>
<th>Variables</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TUN</td>
<td>start of input (theme) data field.</td>
<td></td>
</tr>
<tr>
<td>IMP, IMP2, IMP3</td>
<td>start of output (extemporization) data fields.</td>
<td></td>
</tr>
<tr>
<td>PI</td>
<td>temporary pointer in input data field.</td>
<td></td>
</tr>
<tr>
<td>P1, P2, P3</td>
<td>pointers in input data field for the first, second and third parts.</td>
<td></td>
</tr>
<tr>
<td>T1, T2, T3</td>
<td>durations for the three parts, taken from the input data field and corrected for the movement of each part.</td>
<td></td>
</tr>
<tr>
<td>BOF2, BOF3</td>
<td>best offsets for the second and third parts in semiquavers (units of 16 frames).</td>
<td></td>
</tr>
<tr>
<td>TA</td>
<td>duration actual (relating to the output data field, to which the individual parts are referenced).</td>
<td></td>
</tr>
<tr>
<td>POFU, POFD</td>
<td>pitch offsets (up and down) for Manual 2 part, in semitones.</td>
<td></td>
</tr>
<tr>
<td>POFH, POFHA</td>
<td>pitch offsets for harmonization rule, in semitones.</td>
<td></td>
</tr>
</tbody>
</table>

**Constants define start addresses but their names are used for the fields themselves**

- FI, FD, FU, FO input transpose down, transpose up and output console fields (FU is also used as the most recent field for CPU/O). For this use, FO and FU are equivalent to console fields 1 and 2 in read mode.
- F1, F2, F3, OF1, OF2, OF3 for each part.

**Vocabulary: Words written in machine code**

**UCUCF1** Update input console field FI (take pointer from scratchpad).
**ORCF** OR two console fields as specified by two stack parameters, leaving result on one of them (as specified by the second parameter).
**CC4/3** Compare FU with FO and read keying information to output data field (takes pointer from scratchpad).
**CF+** Transfer console fields as specified by two stack parameters.
**2/MOD** Nine-bit divide by two (using Shift Right Logical).
**2*M** Nine-bit multiply by two (using Shift Left Arithmetic).

**Words written in and compiled by Forth**

In some cases the explanation of a word is preceded by the pronunciation of its name.

- UCFI transfer FI to and from scratchpad for UCUCF1.
- LCFI initiate console fields.
- TU transpose FU up one semitone (note—bit numbers increase but register numbers decrease with increase in pitch).
- TD transpose FD down one semitone (see subheading Harmonization between M2 and M1 for screen 2 including AMS).
Current followers

Adaptable universal op-amp can be used in any of four basic configurations

by F. J. Lidgey
Ph.D., B.Sc., M.I.E.E.

The conventional operational amplifier such as the 741 type is a very high voltage-gain stage, the single-ended output voltage being proportional to the difference voltage between the two input terminals. This basic amplifier is easily configured into two gain stages, a trans-resistance stage and a voltage-gain stage, as shown in Fig. 1.

It is not so simple to configure the conventional operational amplifier to produce a current gain stage with well-defined current transfer ratio, low input impedance and high output impedance; nor a transconductance amplifier with well-defined transfer ratio, high input impedance and high output impedance.

There have been a number of proposals to develop a universal operational amplifier which has a differential input and a differential output. Such a circuit has the distinct advantage that it may be configured into any of the four basic amplifier stages without the complex multiple-pair resistor-matching requirements that typify many current and transconductance amplifier circuits using conventional operational amplifiers.

Current-follower characteristics

A current follower is a circuit with an extremely low (ideally zero) input impedance and an extremely high (ideally infinite) output impedance. The net performance when used with a signal source is to produce a current drive to a load equal in value to the short circuit current obtainable from the input signal source, as shown schematically in Fig. 2 (a). In contrast, Fig. 2 (b) shows the better known voltage follower. Comparing the two shows that the current follower is the antithesis of the voltage follower.

Practically, it is simple to configure the standard operational amplifier as a voltage follower, it being merely a special case of the voltage amplifier shown in Fig. 1. However, realisation of a current follower is not so straightforward. Nordholt* has shown that a current follower may be constructed using a balanced current source and sink with two series-connected Zener diodes strapped across the supply pins — Figure 3 (a) shows a schematic of the circuit. The result is that the amplifier is effectively biased with floating d.c. supplies and the circuit behaves as a conventional operational amplifier, with the exception that it has a differential output as well as input. This basic building block can be configured into almost any type of amplifier, as shown by Nordholt. In this article, attention is restricted to using this differential-input, differential-output operational amplifier as a current follower, as shown in Fig. 3 (b).

Analysis of the current follower

An incremental equivalent circuit of the current follower is shown in Fig. 5, the operational amplifier being modelled by the input impedance of R1 (typically 1MΩ), output impedance of R2 (typically 100Ω) and dependant generator A.Vi in the output circuit, where A is

\[
A_0 = \frac{A}{1 + j\omega f_p}
\]

As is typically 10^5 or so and f_p is the internal compensation pole, typically at 10Hz, giving the amplifier unconditional stability when used with any value of resistive feedback. The amplifier's bias network is assumed to be ideal, giving a full differential input/output performance.

From the diagram the input current I_{IN} is

\[
i_{IN} = i_{OUT} + I_{IN} + V_{IN}/R_1
\]

Solving Kirchhoff's voltage law gives the input voltage

\[
V_{IN} = -A.V_{IN} + i_{OUT} (R_0 + R_L).
\]

Combining equations (1) and (2) to eliminate V_{IN}, the current transfer ratio is obtained,

\[
i_{OUT}/I_{IN} = \frac{1}{1+(R_0+R_L)/R(A+1)}
\]

Generally R_L(A+1) >> (R_0 + R_L) and so

\[
i_{OUT}/I_{IN} \approx 1
\]

Dr. Lidgey is Principal Lecturer in electronics, Department of Engineering, Oxford Polytechnic


Fig. 1. Conventional op-amp is simply used as transresistance stage as at (a) and voltage-gain stage shown in (b).

Fig. 2. Approximate characteristics

\[
\begin{align*}
\frac{V_{OUT}}{I_{IN}} & \approx R_1, \\
\frac{V_{OUT}}{V_{IN}} & \approx R_1/A_v, \\
I_{OUT} & \approx R_2/A_v
\end{align*}
\]

(a) Transresistance gain stage

(b) Voltage gain stage

Note

R_1 - open-loop input impedance
R_0 - open-loop output impedance
A_v - open-loop voltage gain

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Using the binomial expansion, equation (3) gives

\[ \frac{i_{\text{out}}}{i_{\text{in}}} \approx (1 - E) \]  

where \( E = \frac{R_o + R_L}{A(A + 1)R_1} \) is the error in the current follower from the ideal. To assess the accuracy of the current follower \( E \) can be evaluated for particular values of the circuit components. For example, taking the typical values stated earlier for the operational amplifier gives the d.c. value of \( E \) as

\[ E = 10^{-8} (1 + 0.01 R_L) \]

\[ E = 1.01 \times 10^{-7} \text{ for } R_L = 10k\Omega \]

The accuracy of the circuit is clearly excellent at low frequencies; however, the performance degrades at the higher frequencies where the product of \((A + 1)R_1 \) reduces due to the high-frequency roll-off in the operational amplifier gain \( A \).

Whilst equation (3) above is correct for the ratio of output current to input current the input current \( i_{\text{IN}} \) will not be equal to the Norton equivalent signal source current, except, unless the input conductance is infinite.

Referring to the circuit of Fig. 2 (a), the

![Diagram of current follower stage](image1)

**Fig. 2.** Current follower at (a) produces current into \( R_1 \) equal to current available into short circuit from \( i_{\text{IN}} \). Voltage follower at (b) ideally provides voltage across \( R_1 \) equal to open-circuit voltage from source.

![Diagram of voltage follower stage](image2)

**Fig. 3.** Op-amp using floating power lines and giving effective differential output. Current follower arrangement shown at (b).

![Diagram of practical current follower using op-amps of Fig. 3.](image3)

**Fig. 4.** Practical current follower using op-amps of Fig. 3.

Note: OAs 2, 3 - 741. OA3 offset pot is trimmed to zero the output when the input is short-circuited and \( R_5 \) is used to zero the output when the input is open-circuited.
significant parameter for assessment of the current follower is the ratio \( i_{\text{OUT}}/i_{\text{IN}} \). Now
\[
\frac{i_{\text{OUT}}}{i_{\text{IN}}} = (i_{\text{OUT}}/i_{\text{IN}})(i_{\text{IN}}/i_{\text{S}}) \tag{5}
\]
and clearly one also needs to evaluate the second term \( i_{\text{IN}}/i_{\text{S}} \). From Fig. 2 (a)
\[
i_{\text{IN}}/i_{\text{S}} = R_0(R_0 + Z_{\text{IN}})
\]
where \( Z_{\text{IN}} = v_{\text{IN}}/i_{\text{IN}} \).
From equations (1) and (3), the input impedance \( Z_{\text{IN}} \) is given by
\[
\frac{1}{Z_{\text{IN}}} = 1/\rho_1 + (A + 1)/\rho_0 + R_L \tag{6}
\]
\[
Z_{\text{IN}} = (R_0 + R_L)/(A + 1) \tag{7}
\]
the second term of the r.h.s. of equation (6) is dominant. Taking (4), (5) and (7) gives
\[
\frac{i_{\text{OUT}}}{i_{\text{IN}}} = R_0/(R_0 + (R_0 + RL)/(A + 1)) \tag{8}
\]
Equation (8) shows that if the operational amplifier gain \( A \) is high then the follower will behave almost ideally, i.e. \( i_{\text{OUT}}/i_{\text{IN}} = 1 \). But, if the operational amplifier is a utility device with dominant-pole compensation, then by combining equations (3) and (8) the complete current transfer function is obtained
\[
\frac{i_{\text{OUT}}}{i_{\text{IN}}} = \frac{(1+jf_2)^2}{(1+Kv/(A_0+1))(1+Kv/(A_0+1))(1+jf_2))(1+jf_2)} \tag{9}
\]
where \( f_2 = f_2(A_0+1) \) is voltage gain-bandwidth product of the operational amplifier (GB), \( K_1 = (R_0 + R_L)/R_0 \), \( K_2 = (R_0 + R_L)/R_L \),
\[
f_2p_1 = (A_0 + 1)/K_1 \cdot f_2p_1 \\
and f_2p_2 = (A_0 + 1)/K_2 \cdot f_2p_2.
\]
It is likely that \( R_0 \), the input impedance of the operational amplifier, will be significantly higher than \( (R_0 + R_L) \) and so \( K_2 \) tends to zero and equation (9) reduces to
\[
\frac{i_{\text{OUT}}}{i_{\text{IN}}} = \frac{1+jf_2}{(1+K_v/(A_0+1))(1+jf_2)} \tag{10}
\]
and for \( K_1 \ll A_0 \) this expression reduces still further to
\[
\frac{i_{\text{OUT}}}{i_{\text{IN}}} = 1/(1+jf_2/GB/K_1) \tag{11}
\]
giving a \(-3\text{dB} \) frequency of \( f = GB/K_1 \).

Proposed general-purpose 'follower' amplifier
Using current followers and voltage followers as basic building blocks it is feasible to develop an extremely useful quad operational amplifier, the proposed circuit containing two voltage followers and two current followers. With this general-purpose integrated circuit it can be configured very easily into any of the four basic amplifier types.

Figure 7 shows the circuit diagrams for a current gain stage, a voltage gain stage, a transconductance and a transresistance stage based on the proposed follower i.e. As an example, examine the first shown, which is a current amplifier. The input into the first current follower provides a low input impedance and drives the input current through resistor \( R_1 \), converting the input into a voltage drive. The second drive of the amplifier is a voltage follower which transfers the voltage \( v_{\text{IN}}R_1 \) to a low-impedance voltage source driving into \( R_2 \).

As the third stage is a current follower with

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**Fig. 5. Incremental model of current follower at Fig. 4.**

**Fig. 6. Frequency response of current follower shown in Fig. 4.**

**Fig. 7. An i.c. with two current and two voltage followers would enable any of these circuits to be easily obtained.**

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low input impedance, the input current drive to this third and final stage is
\[ i_{IN} = \frac{R_1}{R_2} \]
which is equal to the output current feeding the load \( R_L \) with
\[ ROUTH = \frac{R_1}{R_2} \]
and clearly the current gain is
\[ A_I = \frac{R_2}{R_1} \]

Using this same approach it is relatively easy to verify the remaining three basic amplifier circuits shown in Fig. 7. This proposal for a general-purpose 'follower' operational amplifier is extremely simple to configure into any type of analogue amplifier. Feedback is localized to each follower, there being no output to input feedback.

As a result, any phase lag from input through to output is insignificant in terms of controlling the stability of each of the amplifiers. The frequency response will depend somewhat on the values of voltage and current-defining resistors, but no instability is likely to be encountered if each of the followers is internally compensated, and a broad bandwidth is possible with careful choice of resistor values. It is interesting to note that none of the resistors are used as feedback components but as voltage-to-current and current-to-voltage converters.

It is feasible for a single i.c. to be constructed with two voltage followers and two current followers on the chip, thus providing a general-purpose quad operational amplifier. With such an i.e. any of the circuits of Fig. 7 can then be constructed, the only additional components required being a maximum of two fixed resistors.

Thanks to R. D. Coombes and C. Tournay for the experimental evaluation of the follower.

### Microcomputer organ interface

<table>
<thead>
<tr>
<th>Glossary continued</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two-part accompaniment</td>
</tr>
<tr>
<td>UDDP2 similar to UDDP2 but the second part is transposed to Pedal.</td>
</tr>
<tr>
<td>UDDP1 similar to UDDP1 but with one part in Pedal.</td>
</tr>
<tr>
<td>UDDR2 similar to UDDR2 but one part (Pedal) moves at half the speed of the other.</td>
</tr>
<tr>
<td>2PCLOP two-part accompaniment loop. UDDP2 until end of input data field is reached.</td>
</tr>
<tr>
<td>Motet</td>
</tr>
<tr>
<td>DU21 store initial values of duration variables T1 and T2 for motet, after accompaniment has been written.</td>
</tr>
<tr>
<td>MOTET write output data field as &quot;motet&quot; in three parts, from IMP3. Firstly write the two-part accompaniment, from IMP2, then write Melisma from IMP1, then combine the two with offset BOFMD, from IMP3. IMP3 &lt; IMP2 so that the accompaniment might be overwritten.</td>
</tr>
<tr>
<td>Execute as BOF2 BOF3 POFU POBU BOFMO MOTET (BOF2 is for the accompaniment, BOF3 for the melisma).</td>
</tr>
<tr>
<td>Harmonization between M2 and M1 (see Fig. 1 and associated text on register allocation.) CSCB and CS are not symmetrical because of the one-bit offset between corresponding notes in M1 and M2. e.g. if M1 is 1401 and R12 is 1010, in these names above (and below) essentially mean &quot;the M2 part is above (or below) the M1 one&quot;. Hence the curious name for THDA, which transposes the M2 part down (temporarily) to see whether it was above the M1 part.</td>
</tr>
<tr>
<td>TDB transpose down below. Transpose the M2 part of FD down one semitone.</td>
</tr>
<tr>
<td>TRDHB transpose down harmonization below. TDB by POFBHM semitones.</td>
</tr>
<tr>
<td>CS check semitones. Find which byte if any in the M1 part of OF1 is non-zero.</td>
</tr>
<tr>
<td>GSCB correct semitone clash below. Compare the active byte (if any) in the M1 part of OF1 with the corresponding one in the M2 part of OF2. TRUHA if the M2 part was a semitone above the M1 one (THDA makes such bytes equal, THUA restores the offset).</td>
</tr>
<tr>
<td>AMS augment minor seconds. CSCBB than CSCA, (if POFBH = POFBHM, 2, minor seconds between the M1 and M2 parts are augmented, i.e. turned into minor thirds).</td>
</tr>
</tbody>
</table>

### IEEE488 interface

the signal generator to cease listening. Lines 150 commands the digital voltmeter to talk and line 160 obtains a voltage reading from the digital voltmeter as a string of ASCII characters. Line 170 commands the digital voltmeter to stop talking.

Line 180 converts the amplifier output voltage reading as an ASCII string to the amplifier's response in dB. Line 190 selects the disc filing system and line 200 prints the results to disc.

Line 210 selects the IEEEFS for further measurements; lines 230 and 240 cancels the reference to the digital voltmeter and signal generator; and lines 250 and 260 close the results file to the FDBase database.

For assembler programmers, all the IEEE commands are available through a single operating system OSWOS file which makes use of a command code in the parameter block.

For users who wish to simulate a simple talker-listener device, i.e. one not possessing the control function, the option select link must be changed to the not-system-controller position and the TMS9914A programmed directly. The excellent Texas Instruments TMS9914A General-Purpose Interface Bus (GPIB) Controller Data Manual contains all the information required to do this.

Every effort was made in the design of the interface and the writing of the User Guide to facilitate the use of IEEE488 instruments by the occasional user of the BBC Microcomputer and it is hoped that this article gives some idea of the potential of this powerful combination.

### Literature received

An eight-page catalogue from Lascar Electronics describes the company's range of digital panel meters, which include: d.c. and i.e.d. voltmeters with 3½ and 4½ digits and a choice of six- or eight-digit counter-timers. Lascar Electronics Ltd, Module House, Whiteparish, Salisbury.

WW 401

Lascar Electronics' 1984 catalogue runs to over 500 pages. For the first time it includes construction kits and educational courses by Heathkit, whose products Maplin now distribute. The catalogue is available from branches of Maplin or W. H. Smith for £1.33, or by post for £1.65 from Maplin Electronic Supplies Ltd, PO Box 3, Rayleigh, Essex SS6 8LR.

WW 402

The 1984 edition of 'Hobby Herald', BICC-Vero's catalogue of products for the hobbyist, lists several new items among which are some insulation-displacement connectors for use with ribbon cable and a range of British Telecom-style pluggable telephone connectors. 'Hobby Herald' costs 50p from BICC-Vero Electronics Ltd, Industrial Estate, Chandlers Ford, Hampshire S05 3ZR. Tel. 02415-62829.

WW 403

More than 2½ million components are held in stock by Conway who have recently issued the 11th edition of their catalogue. It not only lists the available components but also has some useful specification and dimensional details. Along with semiconductor devices and microprocessor development systems is a range of connectors, switches and other hardware, Conway Ltd, Market Street, Bracknell, Berks RG12 10P.

WW 404
BUS STANDARDS
I was pleased to see the article on the IEEE 696 (S100) Standard in the December issue. I congratulate the author on an interesting and informative article. In passing, the author mentioned several other IEEE standards activities: 796, 896 and the Euro-STD bus; unfortunately, some of the information presented was out of date. I would like WW readers to be informed of the current status of these activities.

The Euro-STD bus evolved into the STE bus because the working group could not reconcile the signal specification of the STD bus with their goals of processor independence and longevity of the standard. The IEEE standards board approved the PAR (protocol authorization request) number P1000 to the working group in February, 1983. The P1000 specification now provides 20 address bits, 8 data bits, and a simple, but processor independent, asynchronous handshake. P1000 recommends single Eurocards and uses the IEC603-2 (DIN41612) connector. It is intended primarily for use in cost-sensitive applications which still require the flexibility of an addressable bus. The number draft is due to be voted out of the working group for public comment in January 1984. Information on the current status of the P1000 standard may be obtained from the European secretary: T. G. Fischer, GMT Computer Systems, Newport House, 22 Hartfield Road, London SW19 3TD. I should point out that although the original Euro-STD bus is not now an IEEE effort, it is still the basis of several commercial products including the GII "Micro" Computer Systems manufacture and market boards to the original Euro-STD bus specification.

The P796 (Intel's Multibus) specification (incorrectly called A796 in the article) was approved by the IEEE standards board along with the P696 specification in December 1982. Copies of both the 696 and 796 standards may be obtained from: IEEE Service Center, Attention C74, 445 Hoes Lane, Piscataway, New Jersey 08854, USA.

The VME bus has been the subject of IEEE standardization efforts since January 1983. The IEEE standards board approved the PAR P1014 for the 'versatile backplane bus' (VME) in September 1983. The P1014 working group is currently rewriting the VME specification in the IEEE standards format, and expects to complete their work in early 1984. Information and current status of the P1014 activity may be obtained from the Chairman: Wayne Fischer, 82 Sheren Place, Campbell, California 95008, USA.

The IEEE P896 work has progressed much further than is suggested in the article. Indeed, the work has now been completed and a proposed specification is available. The P896 working group voted to release their completed draft for public comment in September 1983. P896 is a high performance backplane bus providing a 32-bit highway governed by a fully asynchronous and technology independent protocol. Although P896 has a decentralized arbitration scheme, multiple bus locking features, and an independent serial highway, making it ideal for fault-tolerant systems, it is primarily intended for high-performance general-purpose multiprocessor systems. P896 provides its complete signal set on a single IEC603-2 (DIN41612) connector, and is intended for use on double and triple Eurocards up to 280mm deep. The UK IEE hosted a colloquium on the P896 specification in London on November 29 to provide UK industry with advance information on this potentially far-reaching standard. A final draft specification may be obtained from Andrew Wilson, Computing and Control Division, IEE, Savoy Place, London WC2R OBL.

UK involvement with the IEEE bus activities is co-ordinated by the IEE Working Party on Backplane Buses at the IEEE address given above. Other work on microprocessor standards is carried out in the BSI Committee ECL/OSIF-1. I should like to point out to Wireless World readers that the position in (particularly the IEEE and IEE) standardization activities, is open to anyone who has the time and energy, as well as the technical knowledge, to contribute to these standards.

Paul L. Broughton
IEEE Microprocessor Standards Committee

* Reported in News January issue, page 45. Please read IEE for IEEE in line 10 of that item.
- dep. ed.

BEHIND THE MICRO
From my experience when buying a micro a year ago, it seems that you make no mention of the biggest single difficulty confronting someone trying to choose a suitable machine. I do not expect you to overcome this difficulty, but it would have been wise if you had printed the very prominent warning: "Many manufacturer's specifications are barely true and are carefully designed to mislead!"

I wanted a machine for mathematical work, and was looking for something which you would describe as being in the basic price range of £2,000 to £3,000, i.e. a complete price of perhaps £10,000. I will give you two examples of misleading specifications. One manufacturer claimed to be the Forthian, but it did not emerge until late in the discussions that this was a very cut down subset of Forthran, lacking some essentials such as double precision variables. Another manufacturer said that Forthran was available on his micro, but it emerged that it was necessary to compile the source code on a bigger machine of his, and then transfer the object code to the micro. One manufacturer never mentioned this snag in any of his literature; the other one only mentioned it in very small print, part of the sheet where you would not expect to find such information. A specialist dealer who stocked one of the machines was completely unable to understand (and still less to answer) technical questions in the area of languages.

In short, to get reliable information on which to base a rational choice is exceedingly difficult.
J. G. D. Pratt
West Horsley
Leatherhead

AURAL COGNITION
I owe many thanks to D. Wattson (Letters, September 1983) for the extraordinary precision with which he has stated the problem of aural interfacing between a cognitive biological unit (the brain and/or whatever else) and a multinoise environment. It gave me the idea that if the buffering stated therein cannot be implemented with hardware, nature most probably resorts to software. The idea may appear original, but it is not mine. It appeared initially in the Ian Brown editorial of January 1982, viz. that nature interfaces with humans through programming. In the case of aural cognition, I think, nature makes use of various microprogramming techniques, that obviously, like instruments, we are destined to utilize but are not yet able to understand.

Some experimental hints along these lines. A person (or animal) may be microprogrammed to fall asleep in a sound-polluted environment. Subsequent silence will set the flags of software interrupt, overflow will occur, forcing awakening. A second example: People exist that hear voices. Maybe flow of the microprogramming instructions energizes the intake (the ear) by an output, which bounces and returns to the unit, masqueraded as input. In this respect the program generates virtual inputs that do not manifest elsewhere in the world.

I began setting up experiments along similar lines. And I have had another idea: Declare the computer a severe mentally-handicapped configuration. Then program (microprogram will be the final objective) it toward cognitive research; e.g. the computer having memorized via transducers the sounds "a" and "b" to search in real time a stream of words and let all phonemes other than "ab" pass through unmemorized, but operate software interrupt when there is "ah" or seems to be. It will not be easy.

G. Xenouls
Toronto
Ontario

THE PERSUADERS
Your editorial in the October issue whilst putting forward a valid point of view was nevertheless somewhat confused.

Truth is absolute and can be neither accentuated nor minimized. Morality is a function of truth and therefore has no degree nor shades of grey, less than moral immorality is what we should be concerned about.

The society in which we live is immoral, as are all societies because they deny all human beings that most fundamental of human rights, the truth.

Education must be defined as teaching the truth and the methods by which truth can be communicated.

Therefore it is evident that we do not educate our young, rather we indoctrinate them with the dogmas of our current society, paying little regard as to the relevance of our teachings to the truth.

The minds of children are naturally dedicated to the process of determining the truth but the continual brainwashing together with the instilling of irrational fear stimulates a child's emotions and inhibits logical thinking.

This is no more apparent than when following puberty the teenager exhibits a somewhat confused pattern of behaviour.

To achieve a moral society we must assert our dedication to the truth, to logic and discipline our emotions to the role of slave, not master.

By believing in illogical dogmas whether religious or political, we abdicate our responsibilities to the human race.

Norman Webster
Leyland
Lancashire

FOWBERRY ENERGY SAVER
It is good to see engineers turning their skills to
the saving of natural resources, so I was pleased to read of Mr. MacHarg's device which is saving energy in Foxbury Tower*. I too have been developing similar ideas, and have developed and tested a device which gives the desired average temperature, usually about 80°C, and the water temperature cycles by a few degrees about this. The temperature of the gas side of the heat-exchanger may be as high as 550°C, but the associated stored energy is small.

It seems to me that the main achievement of the Foxbury energy saver, as illustrated in Fig. 1, is to reduce the boiler temperature as demand falls. This must be a valuable objective. The 80°C set-point is appropriate for full output, either in extreme weather or when a rapid increase in temperature is required. Under normal steady conditions in the most common mild, damp weather, the heat demand is much less than this. To avoid guarantee claims, heating installers err on the side of over-capacity, and as fuel costs increase house occupiers improve their heat conservation. The result is a lot of powerful boilers running at a fraction of the full output. On a day when the outside temperature was 7°C my gas boiler was running with a duty cycle of 20%. Its own constant loss at 80°C is 7.5%, so over 37.5% of the input was going straight up the flue!

The efficiency, especially at part load, will be improved if the boiler temperature is reduced. A simple-minded calculation on my above example, assuming fuel losses proportional to the temperature difference between the boiler and the combustion air, suggests that the boiler could be run at 32°C if the house is at 20°C, giving 20% of the fixed losses. Even if this is over-optimistic, and if boiler temperature has to be kept up to avoid corrosive condensation, the potential for saving is considerable.

I too considered using thermostat off-time as a measure of heat demand. The problem is that it is an awkward function of heat demand, and an open-loop strategy which does not use a fairly accurate model will give far from optimal results. Hence in Fig. 1 only a 10°C reduction in boiler temperature has been achieved at most. What is needed is a variable which will respond to changes in boiler temperature, so a closed-loop strategy may be employed.

The philosophy I have arrived at is to compare radiator flow and return temperatures. Assuming thermostat valves on all radiators, the return temperature is 10-20°C below flow temperature with valves fully open, falling quite sharply towards room temperature as they commence to control. The economiser cuts off the boiler if this differential exceeds a limit of around 30°C and brings it back on when the differential falls to about 5°C, the pump staying on constantly. The result is a limit-cycling controller which adapts boiler temperature to hold the differential at an average of 17.5°C with the highest-set thermostat wide open. There is an override when hot-water heating is demanded, since this is best served by a short interval at 80°C.

I have tested this scheme briefly using my setup:

- Diode D3 should be reversed in the circuit on page 27 (December). The 78L12 I.c. regulates a 12-volt rail and not 5V as shown. Mr. MacHarg tells us that capacitors C3, C4 and C5 must be low-leakage types.

ZX81 as the controller, and it certainly reduces average boiler temperature on a mild day to around 40-50°C. Heating time from cold and response to sudden as periodical as are reduced, the boiler temperature going straight to 80°C until the disturbance is corrected.

Because the ZX81 obliterates Radio 3 and crashes a little too frequently I am now building an analogue version (two I.c.s) for a long-term trial, to see whether the potential 50% loss reduction is achieved.

The possible improved performance over the Foxbury device is limited at the cost of some convenience, since temperature sensors have to be fitted in the appropriate part of the system. It is only applicable where radiator thermostats are fitted. Systems with a single room thermostat inherited from old shares are not far from optimal re-design. For the same average boiler output, the temperature differential in the other rooms causes overheating, discomfort, or both.

C. Hargis
Bristol

The pulsing boiler controller described in Mr. MacHarg's article (December issue) possesses some disadvantages. If one increases the thermostat setting during the diurnal period, the pressure pulses in the return line due to damping of the pressure waves in the return line cause an intermittent supply of water to the boiler, and the boiler, thanks to the 0-14°C supply temperature to the radiator, cools during the pressure pulses and the thermostat turns off the boiler.

But if the thermostat setting during the diurnal period is reduced, the pressure pulses in the return line due to the 0-14°C supply temperature to the radiator, blow clean through the boiler and the pressure pulses in the return line cause an intermittent supply of water to the boiler, and the boiler, thanks to the 0-14°C supply temperature to the radiator, cools during the pressure pulses and the thermostat turns off the boiler.

In normal operation the boiler thermostat will not switch off when no room heating is required in warm weather. Boiler control is usually carried out by the room thermostat relay.

J. R. Ball
Timperley
Cheshire

The author replies

Everything introduced by man into his domain provides disadvantages (not the least the sheer expense of convenience), and the problem is always to reduce the undesirable priorities which are in effect resonances; integration is made easier by increasing frequency which tends to avert catastrophe by reducing big swings into little roundabouts. Firstly, I ask Mr. Ball, how often he would wish to adjust his thermostat if it is carrying out adequately the function for which it was designed? If it possesses an off-position, turning it off for a few seconds would simulate high demand with immediate response from the energy saver: judging from the experience of my system it is in dire need of some "optimization" because if his room thermostat only controls his boiler directly he must be wasting a lot of energy.

It is unclear what Mr. Ball means by supply device because this adds to the complexity of his system. There is no suggestion that supply device is advisable: the human body dislikes these and quite gladly turns up the temperature to overcome them, neglecting the slight but constant over-temperature which is thus provided wastefully between them if not actually enjoying it. Boiler condensation is a permanent potential hazard from the products of combustion, the degree to which the hazard is realised being largely determined by the time allowed for the boiler to cool down: this is dependent on the saving of energy in all but the smallest installations. Thermal expansion stresses obviously would be increased in frequency but it is difficult to see how they would not be reduced in severity at the same time, both effects being desirable and good engineering.

A much more important point, brought to my notice by a well-known firm of burner manufacturers, is that it might be undesirable to use the energy saver with larger burners for which a pre-firing purge is provided: this blows clean and probably cold air through the boiler for periods of from 10 to 30 seconds before each ignition and obviously cools the boiler fractionally, and, greater frequency of purging increasing the energy wastage up the flue. It is suggested that the energy saver may make the heating of an excellent and inexpensive "optimizer" when used with efficient thermostats, more particularly to control a central heating pump or other distribution means when a boiler serves a dual purpose including the heating of domestic hot water for which purpose it must run at a constant temperature. Those wishing to use one in this mode during the winter may care to devise a switching means so that its attentions may be channelled in the appropriate direction for the season, or, as he with the vested interest is bound to suggest with tongue in cheek, why not improve the operation of all thermostats by applying an energy saver to each and every item which is thermostatically controlled?

Following exhortations from the said burner manufacturers, further development has been carried out with the object of producing improved "optimizer" characteristics which are an extension of the original thinking, the accent being upon greater versatility and thus only indirectly upon general energy saving. The possibility of supplying thick-film microcircuits is being investigated, obviating much assembly and testing time for those who may wish to set up in business assembling and selling the device at their own rate, but all this takes time and testing.
As the designers and manufacturers of a very successful energy saving product for gas boilers we were compelled to write to you after reading the design for the Bowery Energy Saver.

Our energy-saving product is called the Gasaver which has a patent application pending on the design. The unit principally inserts a fixed delay into the boiler off-period of about four minutes and has proved to give reductions of between 20% and 60% in average domestic situations. We spent a lot of time experimenting with variable delays and quite complex self-regulating versions of our product but in the end our simple and cheap design (Fig. 140) has proved to be entirely adequate. The benefits of the more complex schemes were very small when the increased cost of the product was considered. The Gasaver design is complex and therefore more likely to fail in service, a factor which is very important when dealing with low cost consumer goods.

Mr MacHarg quite rightly points out that boiler-cycling, or 'hunting' as it is often called, wastes fuel and noise. He questions the practicality of his point as not accurate and the solution proposed, we feel, is probably only relevant to his own system which has the consideration of secondary heat input, something few of us have, let alone 80 tons of timber!

The initial argument concerns the thermal inertia of boilers. A lot of modern boilers use very low water content heat exchangers which have very little thermal mass and extremely good rates of exchange. These boilers suffer from the fact that there is little lag in heating the water back to the desired temperature setting and in fact tend to cycle more than boilers with cast iron exchangers which have greater thermal mass, and therefore lag.

The 'holiday cottage' effect only occurs, in our experience, when the boiler is undersized for the heating installation. In practice we find that boilers are often oversized which as any heating engineer will tell you is by far the best way. This oversizing allows for additional radiators and also compensates for crude heating requirement calculations. Both our own measurements and users reports show that this design has never caused a noticeable change in room temperature or comfort levels.

One of the losses caused by cycling is the gas wasted during ignition. Since the boiler doesn't light immediately some gas goes straight up the chimney followed by the familiar 'whoosh' sound. The Fowberry design actually causes the boiler to pulse during the On period and this must waste some considerable amounts of gas in itself. The pulsing action will also confuse some boilers such as the Potterton Netaheat, which has its own relay-based timer arrangement for the ignition sequence, a process which takes approximately 45 seconds.

The Fowberry design also has some basic omissions. The first omission is a bypass switch which is necessary for boiler maintenance and also in case of unit failure. The second omission is the facility to work with 24V control systems. Glow-Worm boilers, which have been nearly 50% of our installations, all use 24V systems, and a number of new designs are using 24V with integral transformers within the boiler.

Should Mr MacHarg feel that we have been unjust in our comments then we add that we will gladly challenge his design in a domestic situation under controlled conditions.

David V. Godby
Pixel-Plus Ltd
Nailstone
Warwickshire

I was alarmed to see the suggestion that sheets of polythene should be nailed over ceiling joints and insulation. While this may cause no problems in a large and well ventilated house, there is a very real danger of condensation occurring within the loft insulation of a small, well sealed modern house. The problem arises because the combination of a near airtight structure and a high occupancy (in terms of persons per cubic metre) frequently leads to high temperatures and high levels of water vapour in the house. This water vapour will, to a greater or lesser extent depending on the particular construction, penetrate through the ceiling and into the insulation. While the increase of the insulation will be close to the internal temperature of the house, the top will be close to the much lower loft air temperature, and condensation of the percolating water vapour in the upper, colder sections of the insulation is very probable. Sporadic, short lived outbreaks of condensation can usually be tolerated if there is an airflow over the insulation allowing fairly rapid drying out, but if Mr MacHarg's suggestion was implemented, ventilation would be eliminated and the condensed water would remain for long periods and help to promote an outbreak of dry rot.

The heat saving adduced by Mr MacHarg for his polythene sheets is truly minimal if inadequate insulation is installed: the penalties could be very severe. The advice to readers is quite unequivocal – don't do it.

Nicholas Pillans
Thames Polytechnic School of Architecture
Dartford
Kent

555 MARK/SPACE CONTROL

The "555 mark/space control circuit" of Filanovsky and Piskarev (Circuit Ideas, September, p.68) can be simplified to:

\[
\begin{align*}
1 & \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \\
\text{v} & \quad \text{v} & \quad \text{v} & \quad \text{v} & \quad \text{v} & \quad \text{v}
\end{align*}
\]

C charges through R1 and the diode, and discharges through R2. The diode gives a constant offset during the charge time of \(=0.6V\), effectively reducing V+ by this amount and slightly increasing the charge time (by a predictable amount). Discharge time is unaffected.

Replacing R1 and R2 with variable resistors will produce an independent control of on and off times.

John Bonell
Leicester Forest East

CURRENT DUMPING REVIEW

About the September and October articles: 1. The disturbing dumping Vbe is there modelled by a voltage generator. Then the circuit becomes linear, allowing the effect on output of this generator to be studied by itself. As mentioned, current despatched by it through Z3 of Fig. 11 (all references are to the October article) meets an unpredictable emitter input impedance at T2. This is due to the presence of R12 as seen through the emitter, and it results in some loss of current through the 1801 shunt path. Thus T2 current gain enters the balance condition through the new factor \(\lambda_e\) to yield

\[
Z_4 Z_2 \frac{1}{Z_1} \geq \frac{1-k Z_4}{Z_0}
\]

The meaning of the symbols is explained. The third term is called the gain term because it depends on the parameters of the driver amplifier. Mr Baxandall (Letters, December issue) supports the view that this term is much too small to figure, given the tolerance errors likely to be present in the other terms.

He also insists on ignoring \(\lambda_e\) and proposes to stick to \(Z_4 Z_2 = Z_2 Z_3\). Then, with 5% components, each side of his equation may depart 10% from its designed value due to tolerance errors. The unbalance is measured by defining a quantity \(\epsilon\) such that when the left hand side is multiplied by \(1-\epsilon\) it again becomes equal to the right hand side. His \(\epsilon\) may rise in size to 0.2 or so. The reasoning would hold for \(\lambda\) if \(\lambda_e\) was absent.

But \(\lambda\) is present, and nothing has been found against it. As explained, it may descend to 0.65 if T2 has its minimum gain. Baxandall has set \(Z_4 Z_2 = Z_2 Z_3\), and if the 5% errors possible in these components conspire with this value of \(\lambda\), then the left hand side of (9) above falls to 0.53 of its right hand side. (Now \(\epsilon = 1\) – Nearly 100% increase in the value of \(Z_4\) is required to rectify matters! It is \(R_12\) which causes the gain term \(\lambda\) and its uncontrollable variations. It must go.

Nonsense, replies Baxandall. The design is splendidly uncritical, and takes such things in its stride. But surely we are trying to find the correct value for \(Z_4\)? Is a 100% error of no interest? Actually the article already mentions apparatus to evaluate this suggestion. As just shown, ignoring \(\lambda_e\) instead of disposing of it has pushed up the maximum value of \(\epsilon\) by a factor of five. Equation (13) the variation of distortion promptly multiplies by five. Uncritical? Distortion follows \(\epsilon\) in direct proportion. It has been overlooked that an amplifier is a slave to its feedback loop, and any signal delivered to its input thereby is faithfully reproduced at the output. Accurate balance of (9) is essential, and R12 must be removed to kill the uncontrollable \(\lambda_e\).

2. From the first patents onwards current dumping has been explained as a method for nulling the distortion caused by the variable dumping Vbe. As this varies during the signal cycle it produces no effect at the output terminal. The easiest picture is perhaps the bridge model of Fig. 8, where the essence of the technique is revealed as setting the bridge balance equation off balance by a small but precise amount: the gain term in (9) above. Mr Baxandall supports the view that this term is too small to matter. Worse, of course, is the realisation why it must be ignored. It is real and constant, while the other two terms of (9) are imaginary and proportional to frequency. The gain term must be neglected, and the equation balanced without it. This throws out any current dumping, as the term has always been understood, and establishes the deafening thesis that the Quad 405 current dumping amplifier (as it is named) is not using the current dumping technique.
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WW • 011 FOR FURTHER DETAILS
Some may wish at this stage to change the established meaning of current dumping, so the same thesis is restated without using these words which are now confusing. In the article the bridge network in the Quad 405 has no power to cause nulling of the distorting dumper $V_{be}$.

There is no escape from this: balancing (9) above without the third term cancels the coefficient of $v_{in}$ in the feedback voltage $C$ found in constraint (4) in Fig. 12. Thus no fraction of dumper $V_{be}$ is fed back to the driver, contrary to what is required in Fig. 8.

As an example it was shown that once the gain term was abandoned, the amplifier could easily be converted into a traditional type of ideal performance. Mr. Baxandall observes that this is not a practical proposal, as the alternative is not stable at r.f. The error is admitted. But it only affects the example. The deafening thesis is unaffected, and the ground for it untouched. Indeed, collecting and strengthening some of Mr. Baxandall's remarks, his comments fuse with that thesis to yield the following key paragraph. Admit that the Quad 405 is quite incapable of using the current dumping technique. Its feedback circuits have no power to null the dumper distortion, even if all components have zero tolerance error. Instead, its operation is to be explained in the following quite different manner. Firstly, drop the usual bias arrangements on the output transistors, thus disposing of adjustments and thermal problems. Then use a powerful driver amplifier together with massive negative feedback network to distort the signal so generated. But note that every powerful amplifier has a capacitor within it to ensure Nyquist stability. Observe that C in Fig. 11 is just that capacitor. Indeed, the driver triple is thought of as a single transistor then C is just the classical position. Admit that C will cause a drop in the gain of the driver when it is handling the h.f. components introduced by the quas-recognition $V_{be}$ measure current distortion to reappear. So add L to modify the feedback at h.f. provided by the capacitor C. Remove $R_{12}$ and ignore tolerance errors. Then use bridge technique ($Z_{12}Z_{22}=Z_{12}$) to cancel the distortion. However, this C is now used to distort the output volts E in the usual way. It is left to the usual negative feedback from E to reduce this (constraint 4 now shows feedback is given by h.c.-p.e. nearly.) No V is fed back. And certainly not the appropriate small fraction of it required to arrange cancellation of V in E. This is current dumping.

If sound, this key paragraph would require adjustments all round. Except for the stability errors admission, both the two articles stand. Previous explanation of this amplifier is regarded as erroneous. L does nothing directly to cancel the effect of V on output. What it does is to cancel the clipping effect C would otherwise have on driver gain, C is handling the higher a.f. components of V. This restores the usual negative feedback at those frequencies. The inventive step is the addition of L. And UK patent 22787/74 with US patent 3,976,953 must be examined to discover how much is still required of this to warrant this remarkable amplifier. But focus on the circuit itself, and introduce tolerance errors. With $R_{12}$ removed c can rise in size to 0.2 only, and $R_{12}$ in the correct L to correct as seen through by C is between 4.5 and 6.5 of that required. Distortion is indeed divided by five or more. (Two or more with $R_{12}$ included as at present.) This good effect is clearly not enough to outweigh dropping the usual bias arrangements and, and the correction provided on to h.f. classical of V the figure has generated. But note that the powerful driver arrangements discussed in lines 2 and 3 are unstable and thus must be withdrawn from the discussion.

3. After theory, practice. Baxandall now observes that this discussion has lost meaning, because we have fallen below the distortion levels caused anyway by wiring pickup and the like. This would be useful in support. And certainly if provided they furnish a point against the superior claims of this amplifier. Are the figures in line 1 of Table 1 that good compared to other amplifiers? (As Mr. Baxandall observes, the arrangements discussed in lines 2 and 3 are unstable and thus must be withdrawn from the discussion.)

M. McLoughlin
Haberdashers' Aske's School Ely

Michael McLoughlin's analysis of current dumping contains some interesting observations, but clashes strongly with our earlier analysis (June, July 1978) and a later more complete paper of ours in the Journal of the Audio Engineering Society*. We shall address three relevant points in the debate. Mr. McLoughlin argues (part 1, page 41) that a feedforward explanation does not exclude other explanations, and suggests that Peter Baxandall's letter does not support feedforward. We disagree strongly. In negative feedback two or more signal paths to the output are not necessary. It may appear that there is only one, but that is because current dumping has interwoven the feedforward and feedback paths. It does not really matter how one "derives" current dumping, a feedback explanation alone is insufficient. We struggled many hours over these concepts, and are quite sure that no feedback taken singly from the load can achieve what current dumping does. Thus we are forced to include the concept of feedforward in the description of any circuit that is capable of complete cancellation of distortion in principle, although a simple feedforward scheme may not be evident in a particular realization of the concept.

A second point concerns the practicability of current dumping, using components of standard tolerance. Baxandall argues, however, that it is quite unbalanced. Table 1 of part 2 is quite misleading. It implies that a resistive bridge is better than a reactive one, and that a "traditional amplifier" is better than both. We wish Mr. McLoughlin had tried out each of these options experimentally, for unless the theory is done fairly the comparison is not meaningful. Examination of our AES paper shows some comparisons, using a model experimental circuit, which contradict Table 1. When the bridge is unbalanced, there are error pulses, but they are very brief (microseconds) and do not give rise to a large harmonic distortion. On the other hand an unbalanced resistive bridge (ignoring for the moment the infinite implied gain-bandwidth of the amplifier A) results in roughly a squarewave error with substantial harmonic distortion. In a traditional feedback amplifier the necessary finite gain-bandwidth (for stability and other reasons) generally gives greater error pulses than current dumping.

To make the process clearer, consider a current dumping amplifier that has a reasonably balanced bridge. The distortion error pulses will be small but not negligible. How shall we compare it to normal feedback? Can we short $Z_{1}$, the inductor? This increases the distortion greatly, by about the inverse of the relative bridge balance accuracy. In addition, the circuit stability usually suffers, because the inductor tends to feed back a stabilizing signal representing the difference $V_{b}-V_{d}$, which would be needed in support. And certainly if provided they furnish a point against the superior claims of this amplifier. Are the figures in line 1 of Table 1 that good compared to other amplifiers? (As Mr. Baxandall observes, the arrangements discussed in lines 2 and 3 are unstable and thus must be withdrawn from the discussion.)


The author replies

Nothing said about the Quad 405 in my articles appears to have been overturned. I made three incantations with comparisons with other arrangements, and these had to be withdrawn on grounds of instability. Unfortunately these comparisons have been to held in the conclusions, which have now been rewritten to yield my letter above. Until it is clear whether they will prevail I prefer not to comment on anything other than the Quad 405. I agree that if $e_{10}$ is 0.2 then a fivefold decrease in current dumping should be reduced if a short on L is removed. Inverse of the relative bridge balance accuracy, as our friends suggest. This deals completely with their second point, as the other comparisons mentioned are
not related to the Quad 405. Their third point about the inductor is their own, and this damaging criticism would benefit by confirmation from a second authority.

These leaves their first point, that feedforward alone is the only correct explanation of current dumping. (See also the second sentence of their last paragraph above.) This assertion fully confirms my account of their views. But the italics indicate a great deal. Feedback, it seems, is not feedback unless it is taken singly, and from the load. Whereas feedforward apparently, may negate or deal more elastic. With this special language current dumping violates the feedback definition on both counts, and can only be feedforward.

But starting with Walker in the patents and continuing through Baxandall many authors have given perfectly correct explanations in terms of voltage fed back to the input from one or two points near the load. This use of the term feedback is entirely natural, even though does violate the above curiously narrow definition. There is nothing wrong with this usage, and opposition to it should be dropped. Nothing is at stake: the equivalent of the two explanations (and three others) was demonstrated in the Sept/Oct articles.

THUNDERSTRUCK

I must admit when I read Chirp's account 'Thunderstruck' in BW (Random Echoes, November) or a sound some smug satisfaction that it should happen to such an august company as IBM. Really it should be recognised that this is something which has arrived with microprocessors. The c.p.u. has only to skip one byte (or word) due to electrical interference and it will lose synchronism with the program it is executing. In general it will not regain synchronism of its own accord and the equipment it is supposed to be controlling will remain mute or continuously 'doing something'.

These effects will not be evident in equipment which may do a "9-0-5" job, because the power-up reset each morning will keep everything in order but the other hand those events which operate continuously can, for no explicable reason cease to function. This latter is in the category of 'press reset' and everything will be all right again.

On the subject of reset, this is another button which has been gained with microprocessors. It is either resoundingly prominent on the front panel, or coyly hidden around the back somewhere, or a magic three key operation which performs the same function. Alternatively reset can be generated from a circuit at power-up which brings the equipment into the category of: 'If it goes screwy, switch off, wait a moment, then switch on again' - it'll be OK then!

It is so easy to blame exterior forces - the, 'It wasn't me' syndrome but there are opinions that invasion by alpha particles can disrupt internal saved states of the c.p.u. and send it 'bananas'. On this score it is interesting to note that Hitachi's 8K x 8bit ram has been constructed to allow for this (New Electronics March or April I think).

What can be done? It should be an essential part of every microprocessor design to have some delay circuit completely separate from the microprocessor circuit and definitely not under software control which is kept reset. The input to this circuit should be one bit from the system which is simply toggled by the software at perhaps, say, 100ms or 1 second period, the output should go to the c.p.u. where a suitable interrupt can be generated should the toggling action stop, i.e. c.p.u. lost. This can be thought of as a 'kickstart' or a kick in the pants to the c.p.u. A word of warning, some microprocessors will ignore interrupts when they are lost and need a reset followed by the suitable input.

The type of circuitry which comes to mind is two monostables in cascade, e.g. 74LS123, the first as the 'hold-off' delay, the second to create the 'kickstart'. Another circuit that can be used if delays need to be some seconds is the 'Van Der Veen' timer, sketched above, designed by a former colleague of mine and named after him. Posthuminously I hasten to add.

By now you are probably asking yourself, 'How does this Joker know all this?' well, it happened to me! I would like to find an answer to the problem, perhaps this could be food for thought for those more qualified than myself to examine it.

Alan W. Roscoe

Enfield

Middlesex

SOFTWARE BY RADIO

With reference to your news item on page 39 of the December issue, concerning Radio West's 'Datarama' programme, I noted that no commencement date was given for the programme which transmitted home computer software, etc, but the intimation was that they were the first to do so.

Whilst only inspection of the transmission schedules reveals the real first (I think Radio Victory in Portsmouth also claim the honour), I feel it should be noted that BBC Radio Leeds commenced transmission of a magazine-type programme for computer enthusiasts entitled "Abacus: the computer programme", transmitted fortnightly, started on the 5th October, 1982, and was presented by Dave Banks, Pete Bradley, Martyn Croft and the writer. The content was, and is still, of a magazine nature and included regular experimental transmissions of home microcomputer software, as well as news, reviews, and technical contributions.

The programme is now in the third series, and we hope that software transmission will start again in the new year.

D. R. Coomber

Co-presenter, Abacus

Leeds

XY PLOTTER

In his article ('Computer-controlled xy plotter', January) P. N. C. Hill invites suggestions for an algorithm to draw a straight line between any two points on the plotting area. I have written software for a plotter similar to that described and have developed such an algorithm.

The algorithm involves tracking along the required line drawing line segments which follow the line as closely as possible. At each step along the line there are two or three points to which a line segment might be drawn (by stepping the X motor, the Y motor or, if possible, both motors together). The point is selected which has the smallest perpendicular distance from the required line. A segment is drawn to this point and the process repeated until the line is complete.

In the figure the perpendicular distance of the point (X1,Y1) from the line from (0,0) to (X2,Y2) is

\[ d = \frac{|X_1Y_2 - X_2Y_1|}{\sqrt{X_2^2 + Y_2^2}} \]

where \( l \) is the length of the line from (0,0) to (X1,Y1). This theorem is derived from the formula for the Vector Product of two vectors. For any given line \( l \) is constant, therefore to determine which of the group of points is nearest to the line calculate \( AB(X,Y) = AB(X_2,Y_2) - AB(X_1,Y_1) \) and this can be used to adapt the above equations to allow the line to start from an arbitrary point instead of (0,0). All the variables may be expressed as integers to increase the speed of execution and to prevent accumulating errors.

Richard Griffiths

Whitchurch

Cardiff

TECHNOLOGY AND PEOPLE

"Why then is it such a common observation of human life, that those who do what they like rarely seem to like what they do?" - S. C. Elliston (Letters, December).

If we replace the first "like" with "choose" and the function of following the problem becomes: the discovery of dislike is retrospective.

If we then replace "choose" with "are pressured by events to do", at least a part of the problem becomes clear: none of us has, ever had, or ever will have, complete freedom of choice, more especially in a period of mass-employment.

The more creative an individual is, the more free he or she is to choose, but the more attempts there will be to manipulate simply because the world takes man-made providence and Providence with a capital P, for granted.

There is also such a thing as monotonity, a source of dislike, the permanent plateau of non-fulfilment in which no learning occurs with the consequent failure of information intake for pleasure-giving processing. Such monotonity is commonly provided by an ignorant preoccupation with material pleasures - i.e. non-thinking pleasures such as eating, amusing non-creatively, and mating, and throwing one's self about in an ape-like monkey-hop to some strange cacophony actually calculated to hold the mind in such ignorance while making a lot of lovely lolly. It seems perhaps that one should never cease to be interested in the process of thought in itself, is it ever a rebellion? The true question really is, which is the worse evil - the destruc- tive and vandalistic rebellion of non-thought, or the more constructive rebellion of thought?

Mr Elliston's attitude comes from the same sort of problem mentioned also in December by David A. Chalmers, being the absence of definition for the word "like": it also demonstrates some misunderstanding that the pleasure to
which Professor Campbell refers is a subconscious one rather than the conscious one of the senses: one thinks for pleasure, but in the absence of information for processing one is limited to the simple experience of the frustration of not understanding the cause of one's frustration. One must experience the pleasures of thought before one may realise that one needs to know more if one is to experience further pleasure.

This is why the teaching process is so very, very difficult in the early stages, and even more so in the case of the autist.

J. A. MacHarg
Wooler
Northumbria

In his letter, published in WW November, 1983, W. M. Dalton hit a nasty land-mine that I first noticed some years ago. Let me first quote the moment when he hits it.

"Let us start from known facts. (1) Light is an electromagnetic phenomenon: demonstrated by Faraday and Kerr. (2) Light is not a static problem: it is oscillatory (Hertz). (3) The electric and magnetic fields are at right angles and always 90 degrees out of phase. Some recent textbooks show these in-phase -- an unparadigmatic error."

I am anxious that Mr Dalton expands on why this error is unpardigmatic, and what disasters this error might lead us into.

First let me list some non-recent textbooks which show these in-phase.

G. W. Carter, Professor of Electrical Engineering in the University of Leeds, in his book The Electromagnetic Field in its Engineering Aspects, (Longman 1954) draws the E and B fields in-phase on page 271. Significantly, although he emphasises that E and B are at right angles (page 274) he never seems to say in the text that B and E are in phase.

A. F. Kip, Professor of Physics, University of California, Berkeley, in his book Fundamentals of Electricity and Magnetism, (McGraw-Hill 1962) draws the H and E fields in-phase on page 322. On that same page the text says that the two fields are perpendicular to each other, but does not state that they are in-phase. Again significantly, I cannot find mention in the text that they are in-phase.


"The General Plane Wave... the slab may be of any depth and any strength, and there may be any number of slabs by side behaving in the same way, all moving along independently and unchanged. So E=μvH expresses the general solitaneous wave, where, at a given moment, E may be an arbitrary function of x..."

[Replace μ by V/ωe - I. Catt]

Whereas some books (Carter and Kip) vaguely indicate that E and H are in-phase, other books (Heaviside) emphasise relative phase at all see for example Gullikin 1959, Bewley 1933. The trap was nicely set for Dalton, and he has my sympathy.

Now let us turn to my article in Wireless World, July 1979, entitled The Heaviside Signal.

"We have shown that the passage of a TEM wave and all the mathematics that has mushroomed around it does not rely on a causality relationship (or interchange) between the electric and magnetic field. Rather, E and H are co-existent, co-substantial, co-eternal."

In that article I compare and contrast two mutually contradictory versions of the transverse electromagnetic wave. I believe that the full realisation that E and H are in-phase deals a death-blow to one of these versions, the rolling wave, and leaves the other, the Heaviside signal, the victor.

Because the differential of sin is cos and the differential of cos is minus sin, half-witted mathematicians have invaded the physics of the TEM wave and imposed a spurious story that E causes H to exist. Since sin, and -- sin are 90 degrees out of phase, part of their phoney baggage is to imply that E and H are 90 degrees out of phase. (See my article in WW in March 1980.) Because the sine wave is amenable to mathematical high jinks, another part of their baggage is to imply that a TEM wave is sinusoidal. It's time we cleaned the chaurtrap out of electromagnetic theory.

Ivor Catt
St. Albans
Hertfordshire

FORTH PROCESSORS

In his comparison of processors for FORTH language implementation and his subsequent reply to one of your correspondents (Letters, November) Brian Woodroffe has made some incorrect statements and unfair comparisons in relation to the 18088 processor.

Firstly, it is clear that his published code for the NEXT routine is far from optimal. It uses two instructions to ensure that an exit from the routine, the DX register is one greater than the BX register. This is clearly unnecessary since the 6809 code for NEXT performs no equivalent action, and any use of the value in DX can use BX instead -- probably with less code involved since BX can be used as an index register while DX cannot. I can only assume that the 8088 code was translated from the 8085/Z80 code, which performs a similar (but in this case necessary) action, and that it is intended to work with other FORTH routines translated from the 8085. It is equally clear that the 6809 code is in no way a translation of the 6808 code.

It is therefore possible to code NEXT as follows:

<table>
<thead>
<tr>
<th>LOADS AX</th>
<th>XCHG AX, BX</th>
</tr>
</thead>
<tbody>
<tr>
<td>JMP WORD PTR (BX)</td>
<td></td>
</tr>
</tbody>
</table>

which mimics the 6809 register usage and, being only four bytes long, can be coded inline. This is approximately twice as fast as the code given by Mr Woodroffe and therefore, on his figures, is about 50% faster than the 6809.

Mr O'Connor (Letters, September 1983) has already pointed out that the 8083 code for ADD can likewise be shortened. In his reply (Letters, November) Mr Woodroffe correctly points out that BP will not have a fixed relationship to SP but is wrong in asserting that Mr O'Connor's first example is incorrect. It appears that Mr Woodroffe is unaware that the 8088 can leave the result of an ADD or other operation in memory rather than in a register, and ADD (BP), AX does just that.

Another feature of the 8088 which is particularly useful in FORTH is its ability to push and pop memory locations as well as registers, using all the usual addressing modes. Finally, the 8088 has several more registers than the 6809 making it possible, for example, to keep the top-of-stack item in a register instead of in memory. These features are adequate compensation for the drawback of not having a stack pointer relative addressing mode. To illustrate this, I show 8088 versions of the 6809 routines which Mr Woodroffe illustrates (FORTH Language, November). These routines use the DI register to hold the top of stack operand, but even without this optimisation the code need be no larger than the 6809 versions.

Apart from these comparisons, I have enjoyed Mr Woodroffe's illuminating series on the FORTH language.

D. Crocker
Woking
Surrey

APPENDIX. Some FORTH routines in 8088 code. Di register holds top of stack value; initial DW $+2 and final NEXT macro omitted.

| "++" | POP AX | ADD AX | D/LAX | 3 bytes |
| MINUS | NEG DI | 2 bytes |
| "@" | MOV [DI] | 2 bytes |
| "-" | POP WORD PTR [DI] | POP DI | 3 bytes |
| DUP | PUSH DI | 1 byte |
| OVER | MOV [BX],[SP] | PUSH DI | MOV DI,[BX] | 5 by/jas |
| DROP | POP DI | 1 byte |

CLOSED LOOP

Your correspondent James A. MacHarg (Letters, November) likens Wireless World's Letters section to the House of Commons: a more appropriate name, perhaps, would be Physics Commons. Physicists need these rare, popular outlets not just to air their views but also to realise their own shortcomings. We have all thought that we knew something until we try to explain it. Furthermore, a problem that may baffle one physicist may be obvious to another. If only the young Einstein had had the advantage of a Physics Commons the world would have been spared his silly theory of Special Relativity.

Mr MacHarg's interpretation of my expression "closed loop" is fascinating. I was merely describing to electronic specialists the sort of closed-circuit arguments which are employed to uphold Special Relativity. One begins such closed-circuit arguments by assuming something is true. After that, one can argue along any circuit and prove that something really is true!

I take it that Mr MacHarg's explanation why phoney closed-loop arguments are used to support Special Relativity is because of the mind-boggling conclusions of that theory. Presumably, if one can accept that mass is energy they can accept closed loop arguments! However, when the error in Special Relativity is corrected, mass becomes energy and becomes movement of that mass. One's mind is de-bogged overnight.

A. H. Winterlood
London N10

Letters in reply to Ian McCaulands' article 'Problems in Special Relativity' appear on pages 71 & 72.
Active filter calculations

Using programmable calculators it is a simple matter to write a sequence of operations to allow transmission of bootstrap and Sallen and Key circuits to be calculated.

by J. L. Linsley Hood M.I.E.E.

The bootstrap and Sallen and Key filter circuits make convenient unity-gain circuit modules that can be implemented using standard operational amplifier gain blocks. With the availability of programmable calculators it is a simple matter to write a sequence of operations that allows the transmission of these circuits to be calculated for any desired component values, with greater potential accuracy and much less labour than would be involved in instrumental measurements. For my own interest I have done this exercise for the Texas Instrument TI58/59 calculators and for the Hewlett Packard HP-65.

While I have no doubt that better mathematicians than I would be able to simplify both the calculation and the resultant program, these do work and give accurate answers. In all cases, the program is written so that the circuit parameters $Q$ and $\omega/\omega_0$ are entered into the calculator memory stores, and the transmission in decibels is given when the desired frequency is entered and the program sequence initiated.

I have assumed that the operational amplifier behaves in an ideal manner, having a very high open-loop gain, giving unity gain in the voltage-follower mode and a sufficiently high input impedance for the effect of this to be neglected. This assumption is fully valid for the TL071. It is also assumed that the source impedance seen by the filter is low.

Third-order l.p. bootstrap filter

The first part of the transmission expression for a third-order low-pass bootstrap filter refers to the active circuit, and the second part to the passive RC element. The expression is

$$20\log_{10}\frac{\sqrt{(1-k^2)^2 + A^2 k^2} + A^2 k^6}{(1-k^2)^2 + A^2 k^2} + 20\log_{10}\frac{A^2}{A^2+k^2}$$

where $k=\omega/\omega_0$ and $A=1/Q$ and $\omega=2\pi f$.

Turn-over frequency is

$$\omega_0 = \frac{1}{\sqrt{C_1 C_2 R_1 R_2}}$$

and $Q = \frac{\sqrt{xy}}{1+y} = \frac{\sqrt{R_1 C_2 R_3}}{1+C_2/C_1}$.

In practice, it is probably more convenient in the design of the filter circuit to choose the required $Q$ and operating frequency, and then derive the values of $R$s and $C$s for this.

The method is as follows. Try an arbitrary ratio of $C_2/C_1 = y$ (say 1). Then

$$x = R_1 R_2$$

and

$$y = C_2/C_1$$

with $x=R_1/R_2$ and $y=C_2/C_1$. To use the program shown, enter the chosen values of $Q$ and press B. Enter $\omega/\omega_0$ and press A. Alternatively, enter $f_p$ store 08, enter $f$, press C. Read out transmission in dB.

Fig. 1. Low-pass bootstrap filter of 20dB/octave for $Q=2.2$.

$$C_1 (\mu F) = \frac{1}{2\pi f_c R_2 (1+y)^2}$$

$$R_1 = R_2 \frac{Q^2 (1+y)^2}{y}$$

and $C_3 (\mu F) = \frac{10^6 Q}{2\pi f_c R_3}$.

If this gives awkward or non-standard values, try another value for $C_2/C_1$.

Third-order h.p. bootstrap filter

The transmission expression in the case of a high-pass filter is

$$20\log_{10}\frac{\sqrt{A^2 k^2 - k^2(1-k^2)^2 + A^2 k^2}}{(1-k^2)^2 + A^2 k^2} + 20\log_{10}\frac{A^2}{A^2+k^2}$$

Fig. 2. High-pass bootstrap filter of 20dB/octave for $Q=2.2$.

$$C_1 (\mu F) = \frac{1}{2\pi f_c R_2 (1+y)^2}$$

$$R_1 = R_2 \frac{Q^2 (1+y)^2}{y}$$

and $C_3 (\mu F) = \frac{10^6 Q}{2\pi f_c R_3}$.

If this gives awkward or non-standard values, try another value for $C_2/C_1$. 

T158/59 program

<table>
<thead>
<tr>
<th>LRN</th>
<th>1</th>
<th>2nd LBL</th>
<th>2</th>
<th>B</th>
<th>enter Q</th>
<th>50</th>
<th>x</th>
</tr>
</thead>
<tbody>
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T158/59 program
To use, enter Q, press B. Enter $\omega_{0a}$, press A. Alternatively, enter $f_0$ in store 9, enter f, and press C.

$Q$ and $\omega_{0a}$ are as in the previous case, but here $x = C_2/C_1$ and $y = R_2/R_1$. Again, it will probably be more convenient to choose the required $Q$ and operating frequency, and then derive the necessary values for the Rs and Cs.

Method: Try an arbitrary value of $R_1/R_2 = y$ (say 1). Then

$$C_1(\mu F) = \frac{10^5}{2\pi f_0 R_2 (1+y) Q}$$

$$C_2(\mu F) = \frac{Q}{2\pi f_0 R_1 (1+y)^2}$$

and

$$y = \frac{C_2}{C_1}$$

A Q-value in the range 2 to 2.2 will give a reasonably flat response for the third-order filter. (For convenience I have defined Q in a manner that differs from the true circuit magnification factor and hope to be forgiven for this small transgression.)

The phase shift produced by these filters may be calculated as follows.

**Low pass**

$$\phi = \tan^{-1}\left(\frac{K[A^2 - 2A^2k^2 - Ak - (1-k^2)]}{A[A^2k^2 + (1-k^2)k^4]}\right)$$

**High pass**

$$\phi = \tan^{-1}\left(\frac{K(k^2 + 2A^2 - 1)}{A[A^2k^2 + k^4 - 1]}\right)$$

Programs for the HP65 (or similar RPN calculators) are as follows.

To use, set MC to run, enter program. Enter Q, press A. Enter $\omega_{0a}$, and press B for low-pass phase shift, or press C for high-pass phase characteristic.

As a check, both of the validity of the calculations shown above and of the program written for them, the predicted and measured characteristics of two circuit embodiments, the treble and rumble filter circuits employed in the modular preamplifier design (Wireless World, Oct. 1982 to Feb. 1983) are shown in Figs 5 and 6, and a steeper cut treble filter, having a Q of 2.2, and an $f_0$ of 5.9kHz, is shown in Fig 7.

**Sallen and Key filter**

The widely used Sallen and Key circuit shown in Figs 3 and 4 can be used as a third-order filter with a following or preceding passive filter element, similar to that shown in Figs 1 and 2. It is, however, most commonly employed as a second-order filter element having an ultimate attenuation rate of $-12\text{dB/octave}$, and it is for this form that the equations and program below are derived. As previously, $\omega_{0a} = k$ and $A = 1/Q$, and here

$$Q = \frac{\sqrt{\frac{xy}{1+x}}}{1+x}$$

In the low-pass circuit, $x = R_1/R_2$ and $y = C_2/C_1$ and in the high-pass form, $y = C_1/C_2$ and $x = R_2/R_1$.

Transmission expressions are

**Low pass**

$$\frac{1-(k^2)^{-1}}{1-kA}$$

**High pass**

$$k(2k^2 - 1) - jkA(k^2)$$

$$\frac{(2k^2 - 1)^2 + (k^2)^2}{1}$$

![Fig. 3. Low-pass Sallen and Key filter of 12dB/octave](image-url)

![Fig. 4. High-pass Sallen and Key filter of 12dB/octave](image-url)
Fig. 5. High-pass bootstrap filter

Fig. 6. Low-pass bootstrap filter. Frequency scale in kHz.

Fig. 7. Low-pass bootstrap filter with Q = 2.2

T168/59 transmission and phase for Sallen and Key filters

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HP65 Sallen and Key filter

Transmission characteristics

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<td>J</td>
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Enter Q, v/x, and store 01 (VQ). To use, enter v/0, press A for low-pass. This displays gain. For high-pass, enter v/0, press B. This displays stage gain. In both cases, for phase press v/x. To obtain result in dB, press E.

The HP65 program for the same circuit is shown below.
To use, select MC to run, enter program. Enter chosen Q value, press A. Enter \( \omega_{0m} \). Press B for low-pass transmission in dB. Press C for high-pass transmission.

**Appendix**

The equations for the transmission of these two filter systems are shown below for the generalized form. The actual transmission for the h-p and l-p circuits can be obtained by substituting \( R \) or \( \omega_{0} \) for the impedance blocks denoted by \( Z_{1}, Z_{2}, Z_{3} \), etc.

**H or bootstrap filter**

\[
\frac{E_{out}}{E_{in}} = \frac{Z_{1}Z_{3} + Z_{2}Z_{4} + Z_{2}Z_{4}}{Z_{1}Z_{3} + Z_{2}Z_{3} + Z_{1}Z_{2} + Z_{1}Z_{4}}
\]

In the low-pass case, this becomes

\[
1 + j\omega R_{2}(C_{1} + C_{2})
\]

and in the high-pass case

\[
\frac{\omega^{2} R_{2}(R_{1} + R_{2}) - \omega^{2} R_{2}C_{2}}{\omega^{2} R_{1}(R_{1} + R_{2}) - \omega^{2} R_{1}C_{2}}
\]

**Sallen and Key filter**

\[
\frac{E_{out}}{E_{in}} = \frac{1}{1 + Z_{1}/Z_{4} + Z_{2}/Z_{4} + Z_{3}/Z_{4}}
\]

In the low-pass case, this becomes

\[
\frac{1}{1 + j\omega R_{2}(C_{1} + C_{2}) - \omega^{2} R_{2}C_{2}}
\]

and in the high-pass case

\[
\frac{\omega^{2}R_{2}(R_{1} + R_{2}) - \omega^{2} R_{2}C_{2}}{\omega^{2}R_{1}(R_{1} + R_{2}) - \omega^{2} R_{1}C_{2}}
\]

These can be transformed into more easily manipulatable forms, of the type quoted in the article above, by the use of the relationship

\[
\omega_{0} = \sqrt{\frac{1}{R_{1}R_{2}C_{1}C_{2}}}
\]

or its appropriate equivalent depending on the component numbering, and the simplifying relationships \( R_{1}/R_{2} = x \) and \( C_{1}/C_{2} = y \), again using the appropriate component numbering.

---

**More active filter calculations**

Time-saving programs for the TI59 calculator give poles and filter order for both Tschebyscheff and Butterworth low-pass filters

As a rule, filter requirements are expressed by the maximal attenuation of the pass-band \( A_{\text{max}} \), the minimal attenuation of the stop-band \( A_{\text{min}} \), and by the normalized frequency \( \Omega \). With these values only the filter order \( n \) and the poles \( p_{k} = a_{k} + j\omega_{k} \) of the transfer function of a normalized low-pass filter need to be calculated. If the poles are known, the resonance frequency and the quality factor \( Q \) are easily obtained by

\[
Q_{0} = \sqrt{\omega_{0}^{2} + \omega_{k}^{2}}, \quad \omega_{k} = \frac{1}{2} \left( 1 + \left( \frac{\omega_{k}}{a_{k}} \right)^{2} \right)^{1/2}
\]

Hence the programs of both the Tschebyscheff and Butterworth normalized low-pass filters have to give \( n \) and \( a_{k} \) as well.

1. As the Tschebyscheff approximation is explained in detail in reference 1, only the formulas needed to understand the programs are given. The loss of an order \( n \) Tschebyscheff low-pass filter is

\[
A(\Omega) = 10\log \left( 1 + \left( e^{T_{n}(\Omega)} \right)^{2} \right)
\]

where the T-polynomial of order \( n \) is

\[
T_{n}(\Omega) = \frac{1}{2} \left( (\Omega + \sqrt{\Omega^{2} - 1})^{n} + (\Omega - \sqrt{\Omega^{2} - 1})^{n} \right)
\]

2. The order \( n \) of the Butterworth normalized low-pass filter is calculated using the equation

\[
\log \left( \frac{\left( 10^{0.1A_{\text{min}} - 1} \right)}{\left( 10^{0.1A_{\text{max}} - 1} \right)} \right) = 2\log\Omega
\]

and the roots are for even

\[
s_{k} = \exp \left( \frac{j\pi}{2n} (2k-1) \right) \quad k=1,3,5,...
\]

for n odd

\[
s_{k} = \exp \left( \frac{j\pi k}{n} \right) \quad k=2,4,6,...
\]

In program 1 we find \( n \) in \( X \geq t \) and displayed before the pause, \( a_{k} \): ST000-ST007; \( \gamma_{k} \): ST020-ST027.

**Example.** Given \( A_{\text{max}} = 0.4576 \) dB, \( A_{\text{min}} = 32 \) dB and \( \Omega = 2.0926 \), we obtain \( n = 4 \) and

---

**by Kamil Kraus**

The passband ripple \( A_{\text{max}} \) is related to \( \varepsilon \) by

\[
\varepsilon^{2} = 10^{0.1A_{\text{max}} - 1}.
\]

Equations 2 and 3 are used to calculate the filter order \( n \). After some manipulation, the expressions for the real and imaginary part of roots yield

\[
a_{k} = \frac{\sin \frac{\pi}{n} \left( K^{1/n} \right)}{\frac{\pi}{n}} \quad k=0,1,2,...
\]

\[
\omega_{k} = \cos \frac{\pi}{2n} \left( K^{1/n} \right) \quad k=1,3,5,...
\]

where \( K = -1 + \sqrt{\frac{1}{\varepsilon^{2} - 1}} \).

In program 1 we find \( n \) in \( X \geq t \) and displayed before the pause, \( a_{k} \): ST000-ST007; \( \gamma_{k} \): ST020-ST027.

---

Continued on page 57
Program 1.

```
090 05 5 CLR
091 25
092 01 1
093 63 SUM
094 03 3
095 14 D
096 76 2nd Lbl
097 43 X^2
098 08 1
099 44 SUM
100 10 1
101 35 1/2
102 36 2nd Lbl
103 06 5
104 30 5
105 95 RCL
106 02 2
107 11 12
108 12 12
109 14 5 RCL
110 14 11
111 22 INV
112 43 RCL
113 44 4
114 43 RCL
115 50 5
116 75 1
117 45 X^2
118 11 12
119 24 13
120 10 1
121 32 42 RCL
122 36 2nd Lbl
123 14 11
124 13 14
125 01 1
126 34 25 CLR
127 22 12
128 95 =
129 32 2
130 06 5
131 22 02 2
132 76 95 +
133 01
134 11
135 28 2nd log
136 65 x
137 01 1
138 35 15
139 43 RCL
140 15 15
141 02 2
142 22 09 0
143 22 00 0
144 99 2nd Int
145 11
146 01
147 34 25 CLR
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149 32 2
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154 35 15
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157 02 1
158 22 05 5
159 77 2nd X^at
160 11 A
161 13 15
162 45 95 +
163 42 2nd Lbl
164 11 A
165 95 =
166 43 RCL
167 57 16 17
168 42 2nd Lbl
169 58 16 2nd A'
170 32 Xat
171 43 RCL
172 10 10
173 05 5
174 22 09 0
175 66 2nd Pause
176 12 02 2
177 00 0
178 66 2nd Pause
179 85 +
180 01 1
181 01 1
182 61 STO
183 16 55
184 75 =
185 38 2nd X^at
186 38 2nd Lbl
187 02 2
188 95 =
189 43 RCL
190 03 3
191 62 2nd X^at
192 09 0
193 11 12
194 17 2nd B'
195 00 0
196 72 STO 2nd Ind
197 09 0
198 91 R/S
199 79 2nd B'
200 21 17 2nd B'
201 21 17 2nd B'
202 00 0
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204 43 RCL
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207 25 40 2nd Ind
208 06 5
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221 06 5
222 06 5
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238 06 5
239 06 5
240 06 5
241 06 5
242 06 5
243 06 5
244 06 5
```

Program 2.

```
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002 05 5
003 52 2nd Pause
004 02 2
005 00 0
006 65 x
007 93 3
008 04 1
009 04 1
010 95 -
011 06 22 INV
012 06 22 INV
013 06 22 INV
014 06 22 INV
015 06 22 INV
016 06 22 INV
017 06 22 INV
018 06 22 INV
019 06 22 INV
020 06 22 INV
```

Input:

```
STO 00
-0.7 - STO 01
```

Program 2.

```
000 43 RCL
001 01
002 05 5
003 52 2nd Pause
004 02 2
005 00 0
006 65 x
007 93 3
008 04 1
009 04 1
010 95 -
011 06 22 INV
012 06 22 INV
013 06 22 INV
014 06 22 INV
015 06 22 INV
016 06 22 INV
```

Input:

```
A_{min} - STO 00
A_{max} - STO 01
```

WIRELESS WORLD FEBRUARY 1984
Elliptic filter design using TI-59

Using this program the design of an elliptic low-pass filter takes only a few minutes

by Kamil Kraus

Besides poles and zeros of $R_n(x,L)$, one might want to know where $R_n=\pm 1$ or $R_n=\pm L$ as these points determine the location of the maximum passband or minimum stopband attenuation. The location of maxima $x_m$ is

$$x_m=\frac{(1+2\gamma)K}{n} \text{ for } n \text{ odd}$$

and

$$x_m=\frac{2\gamma K}{n} \text{ for } n \text{ even}.$$  

The location of minimum stopband attenuation is given by equation 4, where $x_{m+}$ is inserted instead of $x_{m-}$.

The program written for the TI-59 follows the sequence of equations from equations A2 to A5. First, the program answers the question: is $k^2<0.5$ or $k>0.5$? And then approximates $q_1$ and $q_2$ using A2. To get $n$ as an integer the calculated value of $n$ is rounded downwards and then 2 is added. In the final part of the program, the elliptic function formula given by equation A2 is computed. Here two cases are to be distinguished: $n$ is even, zeros are stored in STO 11-20 and the maxima are stored in STO 21-29, when $n$ is odd the location of zeros and maxima is interchanged!

To compare the results obtained using this program with the values calculated by another method the answers given in ref. 1 are solved. Here, instead of $x_{m+}$ and $x_{m-}$ frequencies are given so we have to multiply the results by 20.

Program appears on page 59

Appendix

The modular function is

$$k^2=16q-\frac{1+4q^2}{1+8q+24q^2}.$$  

Newton's approximation formula is

$$q_{n+1}=q_n-f(q_n)$$  

where $f(q)=64q^3-24k^2q^2+(16-8k^4)q-k^2$.

The relation between $q$ and the complete elliptic integrals $K(U/x)$ and its complementary form $K'(U/x)$ by ref. 2 is

$$K(U/x)=\frac{1}{n} \ln q_1$$

$$K'(U/x)=\frac{1}{n} \ln q_2$$

so that the filter order $n$ is

$$n=\frac{1}{\pi} \ln q_1 \ln q_2.$$  

Introducing

$$q_1=\exp(\pi^2/\ln q_1)$$

we have

$$u=\sin(1+4q;3+4q)$$

where $u=U/K=2y/n$ and $u=2y/K/n$ for $n$ odd, $u=(2y-1-K)/n$ for $n$ even.

References


continued from page 55

Example. Given $A_{\text{max}}=28$ dB, $A_{\text{min}}=3$ dB, $\Omega=2.2382$, we obtain $n=4$ and

<table>
<thead>
<tr>
<th>$\Omega$</th>
<th>$\gamma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>STO11</td>
<td>-0.382683424</td>
</tr>
<tr>
<td>STO12</td>
<td>-0.923879532</td>
</tr>
<tr>
<td>STO20</td>
<td>0.923879532</td>
</tr>
<tr>
<td>STO21</td>
<td>0.382683424</td>
</tr>
</tbody>
</table>

These values are in full agreement with those in reference 2.

References

Compensated active summer

Adding two op-amps and six resistors to the basic summing amplifier can reduce phase and magnitude errors to negligible levels.

by A. M. Soliman

It is well known that the complex open-loop gain characteristics of operational amplifiers (op-amps) degrade significantly the performance of the weighted summing structures. With the introduction of low-cost dual and quad op-amps having closely matched characteristics which track with changes in temperature and voltage, active compensation techniques have proved very attractive. Recently several active phase-compensated weighted summers using two op-amps have been described. It has been shown that for low frequencies the two op-amp compensated summer has phase and magnitude errors proportional to \(\omega/\omega_0^3\) and \(\omega/\omega_0^4\), where \(\omega_0\) is the unity gain bandwidth of the summer. That is, the phase error of the two op-amp summer is reduced to a negligible level; whereas the magnitude error remains a second order term, as that of the uncompensated summer.

Most recently, active compensated amplifiers using three op-amps have been considered; however, the reported are not suitable by their nature for realizing generalized weighted summers for both positive and negative gains.

With the circuit described here, at low frequencies the phase and the magnitude errors are proportional to \(\omega/\omega_0^3\) and \(\omega/\omega_0^4\) respectively. That is, both the phase and the magnitude errors are reduced to negligible levels. The design equations assume the use of mismatched op-amps, although the special case of matched op-amps will also be considered.

Compensated summer

The circuit is shown right. The voltage \(V_{11}, V_{12}, \ldots , V_{1m}\) represent the \(m\) inverting inputs and the voltage \(V_{21}, V_{22}, \ldots , V_{2n}\) are the \(n\) noninverting inputs. Let the open loop gain of each of the three op-amps be represented by the single pole model given by

\[
A_i(s) = \frac{\omega_0i}{s} \quad \text{for } i=1,2,3
\]

where \(\omega_0\) is the unity gain bandwidth of the op-amp and is ideally infinite. By

\[\begin{align*}
V_o &= \frac{(K+1)}{G} \sum_{i=1}^{n} (V_{2i} G_2i) - \\
&= \frac{K}{G} \sum_{i=1}^{m} (V_{1i} G_1i) \frac{K_{i}+1}{K_{2}+1} \epsilon(s) \quad (2)
\]

where

\[G^+ = \sum_{i=1}^{n} G_{2i}, G_{2i} = \frac{1}{R_{2i}} (i=1,2,\ldots,n) \quad (3)
\]

\[G^+ = \sum_{i=1}^{m} G_{1i}, G_{1i} = \frac{1}{R_{1i}} (i=1,2,\ldots,m) \quad (4)
\]

\(\epsilon(s)\) is the remaining error function of the compensated circuit and is equal to

\[1+\frac{\tau_2}{\tau_3} + \frac{s}{\tau_3} \quad (5)
\]

Choosing \(K_2 = K\), equations (2) and (5) become

\[V_o = \frac{(K+1)}{G} \sum_{i=1}^{n} (V_{2i} G_2i) - \\
&= \frac{K}{G} \sum_{i=1}^{m} (V_{1i} G_1i) \frac{K_{i}+1}{K_{2}+1} \epsilon(s) \quad (7)
\]

\[\epsilon(s) = \frac{1+\frac{\tau_2}{\tau_3} + \frac{s}{\tau_3}}{1+s(\tau_1 + \tau_3) + s^2\tau_1\tau_3} \quad (8)
\]

Examining the above equation for the remaining phase and magnitude errors, it is seen that by taking

\[\tau_1 = \frac{\tau_2}{2} = \tau_3 \quad (9)
\]

will yield relatively negligible phase and magnitude errors over a prescribed frequency range. The compensated error function reduces to

\[\epsilon_i(s) = \frac{1+2\tau_1s + 2\tau_1s^2}{1+2\tau_1s + 2\tau_1s^2 + 2\tau_1s^3} \quad (10)
\]

From the above equation, it is seen that the phase and the magnitude errors of the compensated circuit are given respectively by

\[\phi = \arg \left[ \frac{\epsilon_i(s)}{\epsilon_i(\omega)} \right] = 2\left( \frac{\tau_1}{\omega} \right)^3
\]

\[= 2 \left[ \left( K_{i}+1 \right) \frac{\omega}{\omega_0} \right]^3
\]

\[\gamma = \left( \epsilon_i(\omega) \right)^{-1} = 4\left( \frac{\tau_1}{\omega} \right)^4
\]

Ahmed Soliman received the B.S. degree in electrical engineering from Cairo University, and the M.S. and Ph.D. degrees from the University of Pittsburgh. He is currently in the department of electronics and communications engineering at Cairo University.
w\text{where} \quad \omega_{t_1} < 1 \quad (i=1,2,3)

Thus with the conditions of equation (9) being satisfied and at frequencies such that \( \omega_{t_1} < 1 \quad (i=1,2,3) \), the phase error is reduced to a third order term and the magnitude error is reduced to a fourth order term.

The gain requirements are controlled by the parameter \( K \). The compensation conditions can be satisfied by selecting the resistors \( R_1, R_2 \), \( R_3 \), and \( R_4 \). The design equations for \( K_1, K_2 \), and \( K_3 \) are obtained from equations (6) and (9) and are

\[
K_2 = 2(K_1 + 1) - 1
\]

\[
K_3 = (K_1 + 1) - 1
\]

It is not necessary to use matched op-amps with this generalized summer. If matched op-amps are used however, the design equations simplify to

\[
K = K_2 + K_1 + K_3
\]

It should be noted that the above design is based on the choice \( K = K_2 \). Other choices for the parameter \( K \) are possible. It is worth noting that the three port filter reported most recently is a special case from this generalized summer by setting \( m = n = 1 \) and \( t_1 = 0 \).

References


\[
\text{Elliptic filter program}
\]

\[
\text{Table:}
\]

\[
\text{Program to calculate the order of a normalized elliptic low-pass: STO 08, zeros and maxima of Tschebycheff rational function: STO 11-STO 20, STO 21-STO 29 respectively.}
\]
Advanced IT and Alvey

The first four definition studies for large-scale demonstrator projects under the Alvey programme for advanced information technology have now been started by ICL, GEC Electrical Projects, Racal Research and Marconi Avionics. A further six studies are to be commissioned, leading to the final selection of about five projects to be implemented over the five years of the programme.

GEC, working with the Artificial Intelligence Department of Edinburgh University and the National Engineering Laboratory, East Kilbride, are developing a ‘Design to Product' system for a completely automated factory where design concepts are input at one end and the finished product, which includes maintenance data, will emerge from the other. The system will automatically provide all the detailed design work, process planning, machining of parts and assembly all with a minimum of human intervention. The demonstrator will provide a skeleton system for the whole process.

An efficient service to the public in their contact with the complexities of the legislature system is the aim of ICL in partnership with the DHSS and Logica. This could be achieved by using knowledge-based decision systems and improved user-machine interfaces. Mobile information terminals could bring many new facilities to road users and business people on the move. Part of Racal's study is the development of terminals which will use all the other technologies developed through the Alvey programme to form the basis of multi-purpose data communications, processing and display console for mobile and portable use. Racal will be working with a consortium including SPRL, BL Technology, the Human Science and Advanced Technology Research Group, Loughborough University and the Transport and Road Research Laboratory.

‘Replacement of man underwater’ for the inspection and maintenance of installations in gas and oil fields is the goal of the project proposed by Marconi Avionics in association with Offshore Engineering Ltd.

The Alvey programme follows the Alvey Committee Report recommending a national research programme into advanced information technology costing £350M over five years. It aims to combine the strengths of industry, the academic sector, research organizations and the Government to work in four specific key technologies: very large scale integration, software engineering, user-machine interfaces and intelligent knowledge-based systems. The programme works in collaboration with ESPRIT, the European Strategic Programme for Research and Development in Information Technology.

Secondary radar will oust primary

Marconi Radar have introduced a monopulse secondary surveillance radar system that can provide greater directional accuracy, and which is capable of operating the proposed Mode S, where each aircraft can be individually ‘interrogated’ to establish a data link. New technologies being introduced into s.s.t. systems, Marconi say, mean that they are set to replace primary radar as the main source of air traffic control data. In secondary surveillance radar all aircraft within a specific distance from the airfield, fitted with a transponder, receive digital coded signals transmitted from the ground station and automatically transmit back details of the identity and height of the aircraft.

The first element in the system is a new, patented, large vertical-aperture antenna, specifically designed for monopulse working which can produce three azimuth patterns at both 1030 and 1090MHz. This forms the means of considerably improved sidelobe suppression and direction finding, and also reduces the ‘clutter’ caused by ground reflections and false targets, such as buildings or aircraft on the ground.

The transmitter/receiver, known in this context as an interrogator/responder, is completely solid-state including the final output power stage of 500W to 2kW. The monopulse receivers have parallel outputs from balanced channels to allow very accu-

OU to study IT in education

Appropriately for a university that was founded on mass communication, the Open University has been commissioned by the EEC to study the future use of information technology in education and training. The outcome of the study will be recommendations, all financially valued, for action by the EEC to stimulate the appropriate use of IT-based educational technology in the member states. Eight researchers, under the direction of Dr. Peter Zorkoczy, will take six months to look at media, educational technology, computing, electronics and communications.

The team is anxious to contact individuals and organizations who are considering the use of such technologies in their training programmes. They are the EEC Project Office, Block T12, The Open University, Walton Hall, Milton Keynes MK7 6AA.
Optical memory

Another development in optical disc storage devices capable of holding vast amounts of memory has been announced in Japan by Hitachi. At the same time they have announced the development of an electronic filing system based on the optical discs. A 12in optical disc can store up to 1310Mbytes per side, the equivalent of 20000 A4 size pages. In addition images and illustrations can be included. The average access time is 250ms. Hitachi is making available an optical disc ”library” which uses 16 discs with an average access time of 5s and another with twice the capacity, 32 discs, accessed within 6s. The discs are designed to work with Hitachi computers and work stations but are also available with GP1B interfaces for use with other computers.

The electronic document filing system, Hifile 60, consists of a disc controller, a high-resolution display unit, keyboard, scanner, printer and facsimile adaptor with one or more optical discs. At the maximum configuration this system can hold 8640Mbytes of data, or about 1.3 million A4 documents. Documents are stored as facsimile images of the document produced by a scanner. Each document may be entered into up to eight different files and then can be retrieved from any of these. A document retrieved on a display can be magnified or reduced in size by simple control from the keyboard or a ’mouse’ and for high-speed magnification and reduction, Hitachi offer an image processor as an option. The 15in monochrome display produces a high resolution picture composed of 1728 by 368 dots, enabling a user to read newspaper type characters with ease. Different models of document scanner and output printer depending on the degree of speed and resolution required.

Computer for railway signals . . .

A trial installation of a new computer system capable of automatically setting signalled routes for trains has been commissioned at the new Three Bridges signal box controlling the London-to-Brighton main line. The Automatic Route Setting system is superimposed on the signalling safety interlocking system and covers about 13km. It can cope automatically with substantial deviations from the timetable without the signal operator’s intervention, though it may be manually over-ridden. The system uses two microcomputers. One is linked to the signalling train identifier and to the regional master timetable system; the other takes into account any deviations and routes the trains so as to minimize any aggregate delay. During development of the system at BR’s R & D Division at Derby, considerable use was made of a large simulation package, or in everyday terms, a train set. This enabled engineers to produce a software package capable of general application throughout BR and assisted them in exploring the interactions and interfaces between the signalling system, the signal operators and the computer.

. . . and traffic signals

A remote monitoring and control system for traffic lights has been developed by Stonefield Electronics Ltd and Leicester County Council. The system, known as REMAC, can automatically call up a central control room if a fault develops at a set of signals. It also enables the control room operator to check the correct working of the signal lamps and vehicle detectors and to verify the timings of the signal sequences. It works equally well for light-controlled pedestrian crossings. Using normal telephone lines, through an integral modem, REMAC only calls if there is a fault, there is no need to keep the lines open. Provision is made for the system to contact a maintenance contractor or to dial more than one centre or a standby central co-ordinator. The system can work in conjunction with microprocessor-based traffic controllers.

Stonefield produce a self-contained computer to work the system. With a colour v.d.u. and a disc memory that stores the details of each junction so that if a call comes in the junction may be automatically displayed with symbols for lights, road markings, traffic sensors etc. There is also space to display the reported fault. The computer can also hold traffic flow information so that the gravity of a fault may be assessed. The first production model of REMAC has been installed at Slough, Berks with the central terminal at the Department of Transport South East Regional Office.

Decoding and plot extraction modules for the Marconi Messenger secondary surveillance radar use many processors interconnected by a high speed data bus. (Inset) The Large Vertical Aperture antenna used with the system.

WIRELESS WORLD FEBRUARY 1984
The BBC Microcomputer continues to consolidate its reputation as a machine for the experimentalist, and among the computer games at last December's Micro User Show in London some interesting new add-ons were visible.

A 6809-based second processor board from Cambridge Microprocessor Systems provides the basis of a versatile development system for industrial applications. The card, which can be fitted inside the computer or mounted in a rack externally, carries two 28-pin EPROM sockets and 64K of RAM with optional battery back-up. Software is available to allow standard FLEX discs to run on the BBC, giving access to a wide range of high-level languages including Pascal, Fortran, C, PL/I, Fort and BCPL. Basic price is £249 and the system is now available also as a single-board controller. C.M.S., 11 St Margaret's Road, Girton, Cambridge CB3 0LT, tel. 0223 276791.

Second processors were being shown by other exhibitors, including Acorn themselves (Z80 and 6502 with a 16032 promised, and Watford Electronics (Z80A). The Watford unit has 16K of ROM space and 64K of RAM, with room internally for a further 64K. Expansion options include a hard disk interface, additional serial channels, an IEEE488 interface, a real-time clock and a prototyping board. The operating system is CP/M 2.2 and the price £299. Watford Electronics, Cardiff Road, Watford, Herts, tel. 0923 40588.

Acorn also showed their IEEE488 instrument interface (described elsewhere in this issue, and featured on our cover); the unit, styled in a case to match the computer, costs £282.60.

One drawback of the standard BBC Micro is that high-resolution graphics are incompatible with long user programs, since in some display modes the operating system sequencers up to 20K of RAM to store the screen display. A board from Cambridge Microcomputer Consultants, the Aries B20, provides a substitute for this lost memory. Paging is carried out automatically, allowing programs as long as 25K to run even in the highest resolution modes. The board, which costs £86.91, fits inside the computer case; and, for compatibility with software which makes direct access to the screen, it can be enabled or disabled from the keyboard.

The same company offered at the show yet another IEEE488 interface; its price, £195, includes software on disc or cassette. C.M.C. Ltd, Freeport, Cambridge CB1 1BR, tel. 0223 210677.

From SJ Research comes the Control Rom, a useful piece of firmware which its designers believe will do for control applications what high-level languages have done for computing in general. Plugged into one of the BBC Micro's pagged ROM sockets, it enables data to be written to or read from specific bits on the I/O ports as easily as loading or saving to disc or tape. Its commands are available to any language which can support filing systems. The Rom can handle up to 32 channels at once, giving direct access to the computer's memory space, and it has two special channels suitable for communication with Control Universal's 8-bit and 12-bit analogue cards. As a bonus, the ROM has a 'terminal' mode allowing communications through the RS232 port. The price is £99, and a version will be available for the Acorn Electron. S.J. Research, 108 Mill Road, Cambridge CB1 2BD, tel. 0223 69927.

Commmotion Ltd, who were showing the Control Rom, also had an interesting miniature servo interface — the Beastie. Designed for use in robotics, this module makes it possible to control up to four servo mechanisms, including standard model aircraft servos, through software or directly from the computer keyboard. The Beastie is accessed via a single pin of the computer's user port. It costs £43.45 from Commmotion, 241 Green Street, Enfield, Middlesex EN3 7SJ, tel. 01 394 1378.

Among other new ROMs for the BBC Micro was a very flexible machine code data base program, Beebase-1, which enables the creation of files of up to 20,000 characters with potentially unlimited storage capacity on tape or disc. Up to 25 data fields are possible in each record, with a maximum of 250 characters per field. Beebase-1 is supplied with a Basic printer routine on cassette which could easily be adapted to print data in a variety of unconventional formats — including, for example, tables. GCC (Cambridge), 66 High Street, Sawston, Cambridge CB2 4BG, tel. 0223 835330.

For plotting graphs and charts, a graphics dump routine from D.A. Computers includes fast machine-code routines for several popular dot-matrix printers, including models by Epson, Seiko, and NEC. The ROM can be called from software or from the keyboard and it offers a choice of print densities and magnifications. The screen can be printed complete or in part, in four or eight shades of grey or in plain black-and-white. The ROM costs £15.66 from D.A. Computers, 104 London Road, Leicester, tel. 0533 549407.

Beebug Publications have added to their range of software a Basic programmer's aid in ROM, to complement their Exomn machine code monitor. The Toolkit includes a powerful screen editor, an error trap, a 'bad program' recovery routine and many other utilities for manipulating Basic programs. Toolkit and Exomn cost £23.48 each, or to Beebug subscribers £14.35. Beebugsoft, P.O. Box 109, High Wycombe, Buckinghamshire HP11 2TD.

Prices quoted do not include VAT or delivery.

**New frequencies for land mobiles**

A technical specification for land mobile radio services operating in the frequency range 174 to 225 MHz has been published by the Radio Regulatory Division of the DTI. The specification lays down the parameters and related methods of measurement for equipment including digital signalling techniques. The method of measurement described in the specification have been aligned with CEPT recommendations to enable British manufacturers to compete in European markets.

This frequency band was released from 405-line TV service, due to close down at the end of this year. Among the user groups to be assigned channels in the new band will be the power industries who will be displaced from the 105 to 108 MHz band when this is re-allocated to FM broadcasting services.

For the technocat who has everything: a servo control module which plugs in to the BBC Microcomputer.

This 6809 second processor card from CMS comes with a 2K monitor ROM and linking software in BBC Basic.

For plotting graphs and charts, a graphics dump routine from D.A. Computers includes fast machine-code routines for several popular dot-matrix printers, including models by Epson, Seiko, and NEC. The ROM can be called from software or from the keyboard and it offers a choice of print densities and magnifications. The screen can be printed complete or in part, in four or eight shades of grey or in plain black-and-white. The ROM costs £15.66 from D.A. Computers, 104 London Road, Leicester, tel. 0533 549407.

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Cellular radio – first details

Plans for the implementation of a cellular radio system have been unveiled by Telecom Securicor Cellular Radio, the joint venture between BT and Securicor who were offered one of the two licences to start a cellular service. The switching system to be used is TACS (Total Access Communications System), which is a UK development of AMPS, the system which has had trial operation in Chicago. The heart of the system is a non-blocking, digital mobile switching exchange (EMX) that controls signalling and voice communication within the cell system as well as connecting with the public switched network. Each cell site contains a base site controller and multichannel transmit/receive equipment. Each unit may be expanded to handle up to 64 channels on a single antenna. EMX keeps track of caller switches between base stations as the caller moves between cells, ‘handing-off’ the call to each new cell and switching to a free channel in that area. This process is unnoticed by the user and the channel previously occupied is free for re-use.

There is to be a multi-layered hierarchy of areas; the base station comes within a location area, which is connected to an EMX, joined to others through a service network with an overall systems area. All this is invisible to the user who needs only to dial a user’s number to be connected anywhere in the country.

TACS includes a dedicated control channel, has allocated channels without hunting for a vacant channel; it uses 6kHz supervisory audio tones and offers good recovery and registration of signals. Data may be transmitted on the Skb/s ‘Manchester’ signalling system which offers five repetitions of each block of data.

Capacity of the system may be expanded by reducing the size of each cell in heavily populated areas. The minimum size of a cell is about 1km radius around the transmitter. The system has 25kHz bandwidth and as there is no need for guard bands between adjacent channels broadband transmission is possible to reduce interference. Further noise reduction is achieved by using expansion and compression. In theory there could be as many users as now use conventional telephones, with no reduction in sound quality.

User equipment is not provided by TSCR but many manufacturers are said to be planning car-based and portable sets. These are likely to include many facilities associated with office telephones such as an internal memory for frequently dialled numbers, automatic re-call of engaged numbers, call transfer, conference calls and so on. Initially, a car-based set could cost as much as £2,500, but mass production and the use of very similar sets in the USA, could bring the price down considerably. Data facilities with the use of a modem and a portable computer could mean connection with electronic mailboxes, databases and word processors.

There is no attempt at co-operation between TSCR and their rival licensee, Racal-Milgo, and two independent parallel systems are to be developed. The only way that a caller on one system will be able to contact another on the rival will be through the public switched network.

TSCR expect to have an operational system in London by the beginning of 1985 and to cover 90% of the UK population by 1989, or sooner.

Patented brainware

A solution to the problem of copyright and computer programs is suggested in a Government Green Paper. It proposes that in a sweeping reconstruction of the patent laws such works are ‘intellectual property’ and like other ideas or inventions they should be covered by patents. Because of current delays in the patenting system they also propose streamlining the Patent Office by making it a separate statutory body, independent of the Department of Trade and Industry, and breaking the monopoly of the Patent Agents.

One way of speeding up the system, the paper suggests, is to introduce a ‘petty’ patent which would have a ten-year life and provide the owner of an idea with a simpler form of protection, without the long and costly procedures of a full patent. Other forms of intellectual property, such as designs, would also be transferred from copyright to patent protection.

In the Green Paper, the academic world is castigated for freely exchanging information, nationally and internationally, without any attention to the possible commercial application of their ideas. On the other hand school pupils are encouraged to copy software without any thought to copyright. All fields, including small businesses, should be encouraged to look to the protection and commercial exploitation of their intellectual property. Employees who develop ideas should be given the right to take over their inventions if employers do not intend to exploit them.

Another new departure from existing procedures would be the right to challenge the validity of a patent even after it has been granted.

The paper proposes an Intellectual Property and Innovation Bill to bring together all these ideas.

More News appears on page 71.
Improving colour television decoding

This third installment of David Read’s decoder article continues the January discussion of a PAL modifier with adaptive notch and follows with colour tube problems.

Some of the colour prints in this article are referred to in previous instalments. Colour print 1 relates to the first paragraph, in December, page 76 and prints 2-5 to the January article. Due to last-minute alteration of figure numbering, figure numbers in the last (January) paragraph did not match properly with the illustrations. This paragraph, repeated with correct numbering, precedes the concluding paragraphs of part 2, followed below by part 3 on tube problems.

Traces in Fig. 24 (January) show the inverting and non-inverting inputs; the output summing point is shown in the bottom trace of Fig. 25. The envelope timing is matched, i.e. the two traces of Fig. 24 are delay-adjusted to obtain the 64µs spacing, and the colour subcarrier phase and amplitude values are also balanced to achieve cancellation. In the top two traces of Fig. 25 the carrier frequency has been shifted slightly from the 25Hz term and changing ¼ to ½ in the subcarrier expression, the result being that the subcarrier is now stationary with respect to line timing. You can now see that phase (group delay) in the gaussian chroma bandpass filter and the clean DL60 chroma delay line, below, reduce the ability to obtain cancellation at the vertical colour transition where the sidebands generated are large. Residual error is shown in the bottom trace, Y-out, Fig. 25. Some is also due to the changed rise times of the subtracting chroma transitions due to the reduced bandwidth of the chrominance signal. Comparison of the two traces in Fig. 24 shows this rise-time difference. Colour print 5 shows the effect of the reduced rise time on the chroma-only display.

For the horizontal colour bars signal, however, where the combing action across the adjacent lines could make cancellation worse, the notch has to be switched back into circuit. (A mixed vertical and horizontal colour bars signal could be used, as in colour print 6, but the small areas detail would not show up in the colour printing when showing the whole screen. This test pattern is useful for showing defects in adaption switching, where vertical and horizontal transitions occur.) With the sort of notch indicated in Fig. 17 (a) (January) the picture is visibly softened, but with an electronically switched notch, as in the present application, the notch depth and width can be set according to the analysis. Fig. 26 shows the effect with the notch switched in and Fig. 27 with the notch out. The extra marker on Fig. 27 indicates the subcarrier frequency, the other markers are in 1MHz steps.

Comb decoding techniques reduce the moving dots on coloured edges, i.e. the cross-luminance, but they also increase the luminance bandwidth so that luminance detail can be displayed up to 5.5MHz. The last grating on test card F is at 5.25MHz and if the main criterion is to have a better luminance resolution then it must be considered whether the display tube is capable of displaying the higher frequencies and, if not, whether application of high frequency luminance to the tube could result in a worse picture. Moiré beat patterns might occur due to the structure of the tube and the luminance highband detail. The high frequencies may not be usefully displayed, and the beat pattern could degrade the picture. Slow panning of the camera could also result in high frequency components producing additional moving beats and twitter.

New colour tubes, such as the Philips 30AX self-aligning 110% in-line gun, have fully interchangeable picture tube and deflection yokes that are truly self-aligning and self-converging. When these tubes are replaced it is merely a matter of the deflection unit being pushed against the tube neck onto registering lugs. In such in-line tube arrangements the corrections normally achieved by external magnet sets are carried out in the neck of the tube by two, four and six-pole fields, produced by thin magnetic wire rings within the electron gun and which correct all that was previously carried out externally on the tube neck.

Other advantages are that the phosphor has an improved pigmentation providing

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**Colour tube limitations**

Part 3 – Inability of the modern colour tube to display full bandwidth luminance

by D. C. A. Read

B.Sc. (Eng), M.I.E.E.

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Fig. 26. Line-rate sweep signal fed to the modifier comb circuit. (Tr1 and Tr3 bases). Lower trace shows adaptive notch ‘snapping in’ as explained in the text.

Fig. 27. Trace of the output of the modifier comb circuit with the adaptive notch non-operative, (gate of f.e.t. is at OV and is thus switched off).

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1. Three-line chroma decoding, no luminance. Colour print forms Fig. 12(b), referred to in Fig 12 caption, part one, December 1983 issue, page 78.
2. Line sweep skew with PAL modifier in the luminance signal, as per page 53 January 1984 issue. (Two-line chroma decoding, one narrow line delay.)
3. Result of comb filtering across three lines with wideband 64µs delays, as in Fig 12(a) and 12(c) block diagram. See page 78 December 1983 issue.
4. Non-linearity is evident when the signal overloads in processing stages, producing indecipherable patterning due to harmonic generation.
5. Effect of reduced rise-time due to gaussian bandpass filter and narrow chroma delay line, on chroma-only display with two-line chroma decoding. See Fig. 24 page 56 January 1984 issue. (No luminance.)
6. Displayed signal is a mix of vertical and horizontal colour bar. The decoding effects are not clear as detail would not show up in the colour printing. This test pattern is useful for showing up defects in adaptive switching where vertical and horizontal transitions occur.
7. Line sweep skew with one-line chroma decoding (no luminance).
8. Line sweep skew with two-line chroma decoding (no luminance).
9. Line sweep skew with three-line chroma decoding (no luminance, two wideband delay lines used.) See also Fig. 12, page 78, December 1983 issue.

Fig. 28. Typical slot shadow-mask tube with its phosphor faceplate.
Fig. 33. Triad tube face structure, as used on earlier and some current high resolution CRTs. Centre circle is shadow mask hole.
greater light output and the tube guns have quick-heating cathodes, giving a picture 5-10 seconds after switch-on, also the spot defocusing with high beam current and deflection defocusing in the corners is very much reduced by what the Mullard manufacturer describes as a quadrupole lens. The tube doesn’t require adjustment for convergence, colour purity or raster orientation, and together with its reduced deflection energy, improved raster shape, general sharpening up of the spot, and soft flash on the e.h.t., it seems a very attractive component.

Sampling properties of the tube face

Figure 28 shows a typical shadow-mask tube with its phosphor faceplate. The upper section illustrates how the slots in the metal shadow mask are stood back from the glass screen to ensure that the electron beams from three guns in the tube neck only reach the appropriate phosphor stripes. The spacing of these stripes determines the subjective performance of the tube with high frequency luminance.

Considering the green gun, which produces the images that the eye is most sensitive to as far as revolving detail is concerned, the video signal is effectively sampled by the spacing of the green vertical stripes illuminated by the gun as it scans across the screen. The Nyquist theorem states that the sampling frequency must be at least twice that of the highest signal frequency. Any higher frequencies would reappear in a lower frequency spectrum; this is called an aliasing component. The pitch of the stripes can be 0.83 to 0.799mm, but for calculation an average figure of 0.81mm spacing is used.

As an example of the effect of stripe spacing, consider the dimensions of a 26in 30AX tube in a Ferguson TX10 receiver. The measured screen diagonal is 633mm and as 660mm is the metric equivalent of 26in, this must therefore be presumed to be an interpreted or a projected dimension of an ideal display tube that is considered square. Progressing from this slight deceit, more significant for displaying pictures is the usable width of the tube, which is 530mm (17in). Dividing 530mm by the 0.81mm stripe spacing gives a total of 654 RGB stripe sets in the picture width. From this, Fig. 29 derives an equivalent half sampling frequency of 6.3MHz.

The structure of the stripes is clearly visible in Fig. 30 on the left-hand side of the screen. The tube, as used on a JVC 6in 12-volt portabe receiver, is typical of the coarse slot type. In the displayed line sweep, the frequency of the video signal increases to the right of the screen, and you can see that at one-third of the frequency the spacing is beginning to be width-modulated, and at half the sampling frequency it is not displaying anything useful at all. Therefore accurate representation of horizontal luminance detail is prevented in the 26in 30AX tube because luminance bandwidth is reduced to 4.2MHz, as derived in Fig. 29. Applying text card F directly from a slide scanner and with no PAL coding or decoding, luminance resolution was of display value up to 4.5MHz. At 5.25MHz it was clear that some vertical lines were displayed but their spacing was modulated. With a line sweep test signal the Moiré patterning was pronounced. So in spite of the improved bandwidth from the comb, the final video...
drive to the tubes was allowed to roll-off, typically 1 to 2dB down at 4.5MHz, and 3 to 4dB at 5.5MHz.

Observing Fig. 28, it seems possible that there would be a display problem due to the horizontal bridges supporting the structure of the shadow mask. For a 26in tube the horizontal spacing between the vertical stripes is 0.759mm. The vertical spacing is 0.810mm, so there could be difficulty in sampling on a vertical sweep.

In Fig. 31 the Moiré patterning is not apparent, but there is a significant interference in the 625-line sampling structure beating with the vertically increasing frequency, i.e. the number of cycles per increment of picture height beating with the 625 line raster. This produces a very prominent horizontal 'twitter'. The evidence therefore shows that the problem due to the line structure interfering with vertical video detail is far greater than that of the shadow mask. Looking closely at the picture on Fig. 31, the only effect of the shadow mask structure is that some lines appear to be straight and others appear as a row of white dots. At normal viewing distance this is not apparent and the horizontal twitter is the dominating effect.

The vertical stripes have a different effect on diagonal luminance information as might be expected, shown in Fig. 32, along a diagonal luminance line the vertical stripes generate a castellation of 'knotted rope' effect. Radially (from the centre) the zone-plate test pattern represents increasing spatial frequency. The fundamental television system gives a square display of detail, so that fine luminance information will be in the corners, although the slot shadow-mask structure tends to prevent this being displayed. In the horizontal direction width modulation is clearly visible before the Moiré patterning builds up.

Vertically, there seems to be more resolution available. This is because the bridges supporting the shadow mask are small in area compared to the horizontal spacing between individual slots. This spacing is typically 1/3 of the vertical slot spacing, as shown on Fig. 28. On the new higher resolution tubes, which use 0.6mm spacing between the vertical slots, the horizontal support distance is only 0.1mm. For the more common 22in colour tube, the spacing between the vertical slots measured with a travelling microscope, is about 0.8mm. Usable screen width is 444mm and from these figures the sampling frequency is calculated to be approximately 10.6MHz. Maximum display frequency is now limited to 5.3MHz but as the Moiré patterning clearly starts at a lower frequency, the 26in tube with similar slot spacing is evidently the minimum tube size for which it is worth trying to improve the luminance resolution. On a smaller tube, improved luminance resolution would only make this Moiré patterning more visible without fine detail being effectively displayed.

When viewing closely these types of slot tubes, the structure of the shadow mask is certainly discernable, as seen on all three photographs, Figs. 30, 31 and 32.

**Colour tube using triad hole spacing**

In most high resolution tubes using the triad spacing and the dot structure is not particularly discernable. They also use lower spacing, a typical figure being 0.68mm compared with 0.83mm for some of the slot tubes. The equivalent half sampling frequency for 0.68mm is 7.4MHz (22in tube). Fig. 33 shows a triad phosphor screen where the interaction between the shadow mask structure and the video information is much less noticeable. Also, low frequency Moiré patterning occurs at a later point as a result of the higher half sampling frequency. With the triad structure, the step effect on luminance diagonals is again not apparent. Viewig both a slot tube and a triad tube side-by-side the convergence drift on the triad tube causes an effective reduction of resolution, and on balance the slot tube is more stable. To take advantage of the increasing display resolution from higher luminance bandwidth it is certainly necessary to use either a 26-in slot tube or the triad structure.

With microprocessors in the home and the greater uses of electronic graphics there are now available higher resolution (slot spacing 0.4 to 0.6mm) RGB monitors capable of displaying up to 80 characters per line; but although greater detail can be displayed their screen sizes seem to be limited to 20in at the moment. The electronics driving the new tubes are also much improved. Supply rail regulation on the Ferguson TX10 receiver for example is excellent, with a switched-mode power supply stabilizing all rails; with the e.h.t. supply separate from the line scanning, an extremely stable picture is obtained even in the presents of widely varying picture level. Overall, this enables the receiver to be set up with no overscan, so that the transmitted picture can be visible to the full width of the screen (as paid for in the licence fee).

If the stability is not good, the 'cover-up' method is to deliberately overscan the picture. This can have some advantage, in that a small amount of overscan causes the sampling frequency to be effectively increased e.g. by about 0.3MHz for 5% overscan. Most sets sold in the shops have 7-10% overscan. So, if a 22 or 26in set appears to be extremely stable on picture size with brightness changes, it is certainly worth reducing any excessive overscan.

**Competition news**

Twelve entries have been selected for the finals of our competition, which are to take place on January 30th. There are six prizes to be won and the winners will receive their awards from Princess Anne. The list of finalists is:

- David Battison of Cambridge, whose Microphone provides a speak-back facility for blind disabled typists. With the help of this device, the young user for whom it is designed is now able to type and prepare non-braille correspondence.
- Chris Batchelor of Stockport, designer of the Speakeasy. About the same size as a portable radio, this incorporates a keyboard and an allophone-type speech synthesizer.
- Michael Bolton and Alastair Taylor of Aberdeen: their entry is a computer interface using a pneumatic suck-puff transducer.
- T. G. Clarkson of London SE13, whose eye-controlled communicator allows a severely disabled person to select data presented on a television screen, using eye-movements to direct a cursor.
- Ian Dilworth and David Boley of the University of Essex, who have entered a v.h.f. wireless alarm system for use in hospitals or old people's flats.
- Tony Heyes of Nottingham University, whose entry is a microprocessor-based sonar aid for the blind.
- S. Ishiguro of Guildford, whose Touchvision enables the blind reader to follow ordnary printed text.
- William McCarthy, who lives in Edinburgh. His entry is an audible electronic depth gauge for the visually handicapped.
- Ian Mitchell of Hull, designer of another speech device, the TAB or Talking Box, produced as a communication aid for a group of children with speech difficulties.
- Henry Myatt of Harrow, who has designed a braille printer. This reproduces ASCII text from a microcomputer as braille characters on thin card.
- Phil Pickersgill and N. J. Stewart, who lives in Wokingham: their entry is the Frenchay speech-slowing aid, a device to help stammerers control and so improve their delivery.
- J. W. Smith of Haverhill, Suffolk, whose infra-red remote control device allows a user to switch up to 30 electrical appliances.
The inspiration for writing this article arose recently when I found myself in the radio shack looking for a coil of specific inductance. I had gone to a good deal of trouble to calculate the value of inductance required for this particular function and was now faced with the daunting job of going through my box of inductors, trying various coils until one worked satisfactorily. After ten minutes of trial and error and getting nowhere I came to the conclusion that there must be an easier way.

I began thinking of ideas for measuring the values of pre-wound inductances using basic test equipment which most enthusiasts have available in their radio shack. The method of measurement I eventually decided on is an application of two mathematical rules, the “cosine rule” and the “sine rule”.

Looking at the phasor diagram of Fig. 1, if the frequency applied to the circuit shown is changed, then $X_L$ will change in direct proportion thus the phase angle $\alpha$ will also change.

For the purpose of inductance measurement, this phenomenon can be ignored as it is allowed for within the calculations. This can be verified by measuring the voltages at a number of different frequencies and repeating the calculations. As will be shown, once this phase angle has been calculated the value of inductance can be derived.

The test equipment required for this inductance measurement are
- low frequency oscillator with variable frequency and amplitude
- alternating voltmeter
- resistor whose value is known accurately and measures about one quarter of the d.c. resistance of the coil whose inductance is to be measured (perhaps a decade resistor).

The frequency generator should be set to oscillate at about 100Hz to 500Hz as long as it is known. It will be apparent when the frequency is sufficient as the algebraic sum of $V_R+V_L$ will be greater than the applied voltage, $V_T$. Output amplitude is not critical as it is measured as part of the test.

When the oscillator is running voltages $V_R$, $V_L$, and $V_T$ as shown the circuit must be measured as accurately as possible. Once these values are established, the inductance is simply calculated by substituting them into the formulae below.

**Example.** To test the method I used a low-frequency oscillator set to 100Hz with an output amplitude of 2V r.m.s., laboratory-type inductor with an inductance of 1 henry, decade resistor set to 200 ohms, and a d.m.m. set to measure 10V a.c. full scale, all connected as in Fig. 2 to measure the voltages: $V_T=2.000V$, $V_R=0.373V$ and $V_L=1.714V$. This gave $\cos\alpha=0.804$ and therefore $\sin\alpha=\sqrt{1-\cos^2\alpha}=0.594$, hence $L=1.01H$.

**Check.** $V_{XL}=V_{L}\sin44.2-1.194V$

$V_{LR}=(V_{KL}-V_T)=1.229V$

$V_{LR}=\sqrt{(V_{KL}-V_T)^2}+V_{KL}=1.998V$.

Since 1979 David Fownes has been employed as an electronics technician by a company producing aircraft power controls for both ministry and civil aircraft, and which currently has a world lead in fly-by-wire technology. He gained City and Guilds full technological certificate in power engineering and O.N.C. in electronics at technical college during his apprenticeship. Mr Fownes believes that due to new technological advances in powered flight we are now witnessing the most exciting developments in aviation history since the Wright Brothers’ first flight.
This Morse code system enables the computer to be used as an electronic Morse keyboard and runs on a 16K ZX81 under Basic.

by D. Ibrahim

hardware requires no setting up.

Software
Special care has been taken to ensure a fast execution speed. A message (up to a carriage return) is read from the user's terminal. The length of a message can be as long as you like, limited only by memory size. Once a message is received from the keyboard, it is converted to Morse code, with the proper inter-letter and inter-character spacings. The complete message is then sent to the output port. It is important to realise that a character is not sent as soon as it is received; a complete message is first received and decoded and then sent to the output. With this approach it is possible to achieve a fast execution time.

In the software listing lines 100 to 198 convert the input characters to Morse code. Only the letters A-Z, numerals 0-9 and the space key are included in the program, though it is possible to extend the list to include other characters e.g. period, comma, question-mark, etc. The decoding is:
- each dot is converted to a "·" ( "0")
- each dash is converted to a "-" ("1")
- individual elements of a character are separated by "·" ("2")
- individual words are separated by a "-" ("3")

Fig. 2 shows how the message "MORSE TX" is decoded. Line 205 calculates the transmission speed and stores it as variable "T". The input message is stored in the string variable "L". The command input "END" transfers commands back to the ZX81 operating system.

Lines 500 to 510 call the appropriate output subroutines to drive the serial output port. The program runs in fast mode and the usual Morse code timing rules apply:
- a dot ("·") is one unit-time
- a dash ("-") is three unit-times
- characters are separated ("2") by three unit-times
- words are separated ("3") by seven unit-times.

Sending Morse code with the system described is very much like typing. Transmission speeds of over 30 word/min can easily be achieved. Line 205 has been adjusted to provide a correct speed in the range of about 1-20 word/min. For higher speeds there is a non-linear relationship between the speed and the delay generated by the pause statement of the ZX81. It should therefore be necessary to scale up the required speed appropriately before entering to the computer.

Program appears on page 73

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PROBLEMS IN SPECIAL RELATIVITY

Recent issues of Wireless World have seen writings by many people who feel disenchanted with the Special Theory, but whose case has been put in such a way as to cause further polarisation of the camps.

As a student, I was privileged to be lectured by Dr G. J. Whitrow, then Reader in Mathematics at Imperial College, who was then, and still is, one of the foremost authorities on the subject. I vividly remember the model posed by Whitrow in which the time-travellers would be taken round a circle at infinity, thus avoiding the problems of accelerated frames of reference. As a mere student, my protestations at the physical unreality of this model were, I feel, looked on as based on youthful inexperience.

Many years later during the course of one of my many public lectures in an unselected audience I was charmed by the hallucination of Otto Frisch, the pioneer of nuclear fission, himself a considerable mathematical physicist. In conversation we lightly stepped on the territory of Special Relativity and I found that the same feelings were aroused in me as to the response of what I might call the hierarchy of the world's physicists. I found again the attitude of the master talking to the schoolboy.

Unfortunately, there may be many of us who are intellectually ill-equipped to appreciate the foundations of something as profound as the Special Theory, but I must stick to my feelings that the application of theoretical structures in those areas in which their approximations are so clearly invalid is extremely dangerous. Furthermore, the "instantaneous" light signals which formed a key element of teaching in my days as a student, that subject seem to me to be totally divorced from physical common sense.

Surely, if signals are to be sent, reflected from a moving body and then received by a detector in the frame of the sender, the entire mathematical problem must be worked out clearly and with great attention to a "foot on the ground" approach. Without labouring the point we should have to ask when is a signal regarded as being received by the detector (how much of it do we perceive before we draw useful conclusions)?

Overall, as an average mathematical physicist, I still feel as unconvinced by the use of Special Theory in conditions of accelerated frames of reference as I did as a student some 25 years ago. It is, therefore, a great pleasure to see a level-headed article such as this essentially reiterating those doubts I have as a non-member of the family of scientists who are bow-beaten into believing in the general applicability of a theory in those areas in which its validity is in doubt. At the same time, I have sufficient humility to accept that there are many people of greater intellect than myself but, sad to say, that large body has been incapable of presenting its case to me in a convincing fashion.

N. J. Phillips
University of Technology
Loughborough

Before worrying too much about 'Problems in Special Relativity' [Prof. J. McCausland, October issue] it would be as well to find out just what are the relevant predictions of Special Relativity really are. Suppose that one has a set of observers at rest with respect to another and spaced out along a line, that they synchronise their clocks according to conventional procedures, and that another observer B is in motion relative to them along the same line. Then Special Relativity predicts that each time he encounters a new member of the initial set of observers he will find that observer's clock registering a number in advance of his own.

From this way this statement is framed it evidently doesn't matter whether B is considered to be moving relative to the other observers, or to be at rest while they move relative to him. The reason is that the observer is encountering a sequence of observers. The situation can be reversed by associating B with another string of observers moving along the same line, but this time at a velocity relative to him, and with them their clocks synchronised with his. Then each observer of the first set will have the same kind of experiences as B as he encounters in succession the observers of B's set. This seems thoroughly paradoxical until one realises that simultaneity does not transfer between inertial frames, i.e. that when the first set of observers synchronise their clocks B's set claim that they have made systematic errors in the synchronisation, and conversely when B's set synchronise theirs. This appears to be the situation envisaged by McCrea (M12), where the M denotes a McCausland reference. Dingle never did catch on to the failure of simultaneity, and some of his impressive paradoxes result from ignoring it.

The second prediction involves introducing a kinetic assumption to the effect that at any instant an accelerated clock keeps the same time as the clock in the frame in which it is instantaneously at rest (see Hill). Originally Einstein appears to have made this assumption implicitly rather than explicitly, since it follows naturally from the postulate that the Minkowski space must be continuous. It then becomes possible (pace G. Studlien (M11)) for Special Relativity to deal with accelerated clocks, including a polar clock and a clock located at the equator, provided that one ignores gravitation effects. As a result two or more encounters between two clocks may occur, and one is faced with the phenomenon of differential ageing, as in the so-called twin paradox. These are the conditions Einstein had in mind in making the statement about an equatorial clock losing time with respect to a clock at one of the poles. Professor McCausland didn't try very hard to arrange a meeting of clocks by a jet craft flying round the equator in the opposite direction to the earth's equatorial motion at appropriate speed would have done very nicely.

This is essentially Dingle's response (M10) to Dingle's supplementary question.

Dingle's original question is paradoxical from the beginning, it does not correspond to any specific prediction of Special Relativity, and therefore it cannot be answered without making some guess as to what he might have had in mind. J. M. Ziman's response, with a clear indication in the quotes round "Dingle's questions should be answered by a polar clock" should be rephrased (M5), was the General Relativity answer to the question of which clock registers the greatest time between any two events at which it is present when there are gravitational fields to consider.

Finally Professor McCausland might have mentioned why Einstein excluded pendulum clocks from his observation about the time-keeping of equatorial clocks. The reason is that a pendulum does not in itself constitute a clock; the clock consists of the pendulum together with the earth.

C. F. Coleman


The theories of relativity and quantum mechanics are the two major leaps forward in physics this century, and they appear to have attracted more than their fair share of controversy. One reason for this may be that most of our everyday experience of physical phenomena happens to be in the area where both theories agree with Newtonian mechanics.

As far as we know, neither relativity nor quantum mechanics contain any inconsistencies - and this is despite the effort put in to trying to discover them, by people of Einstein's calibre. Special Relativity is so well established among physicists that attempts to discredit it tend not to be taken seriously. However, a theory as rich as Special Relativity cannot be demonstrated to be consistent - just as we know that arithmetic cannot be shown to be consistent.

There are problems with both theories, and these arise from the fact that while the assumptions on which they are based are simple, the application of the theories contains subtleties. These subtleties lead exponents and opponents of the theories to make slips of thought which lead them to the conclusion they require.

For example, people often claim that they have found an inconsistency in Special Relativity by applying it to a physical example. They claim that when they attempt to do this, they obtain a result which is clearly false.

Problem Special Relativity - falsity

In fact, they have inadvertently added some Newtonian idea (which is inconsistent with Special Relativity). It is this combination of theories which produces the false result.

Problem Special Relativity - falsity

It is this slip which Dingle makes. Although (as I pointed out earlier) we cannot prove that Special Relativity is consistent, we can at least conclude that as there are mistakes in Dingle's argument, his case is not proven.

To turn to the specific example of the two clocks, Special Relativity does not say that one is faster than the other - in fact it denies the existence of absolute speed both of objects and of clocks. Special Relativity is a theory of measurement denying the existence of absolute space and time against which to measure the speed of material particles and clocks.

In McCausland's reference 10 Einstein is writing many years before formulating his general theory of relativity, and is using a very simplified model of two clocks. One is at a pole (i.e. stationary with respect to the fixed stars), the other is moving with the equator. He concludes that an observer who is stationary with respect to the fixed stars measures the clock on the equator as moving more slowly than that situated at a pole. His argument here avoids the complication of gravitation, except in so far as it is the mechanism by which the moving clock traces its path. He excludes pendulum clocks from the argument, not through oversight, but because he realised that to include them he would have to include the effects of gravity. This would have complicated the argument unnecessarily.

A. D. Vella

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The author replies

Mr Coleman raises several interesting points. Referring to my statement that Ziman's answer

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does not apply to the polar and equatorial clocks because they do not meet, he says that he didn’t try very hard to arrange a meeting of clocks. I had thought that it was Ziman’s responsibility to show how his answer applied to that case, not mine. But in Coleman’s book, as he points out, he suggested a clock carried by a jet aircraft flying round the equator in the opposite direction to the earth’s equatorial motion at appropriate speed. I assume that by “appropriate speed” he means a speed equal to the earth’s peripheral velocity at the equator; such a clock would be stationary relative to the polar clock, and would presumably work at the same rate. In that case, Einstein’s prediction corresponds to a prediction that the airborne clock would work faster than the earthbound equatorial one. Now, if Ziman’s answer is applicable to the comparison of those two clocks, as Coleman implies it is, then in order to deduce Einstein’s result using Ziman’s answer one would first have to show that the airborne clock was in free fall between the two meetings of the clocks, or for one full circuit of the earth. It is fairly obvious that the clock is not in free fall between the two meetings by free fall, but could perhaps be made to do so if one made the small extra step of removing the earth; however, Coleman does not seem to have that possibility in mind, since he stipulates that it should be carried by a jet aircraft. It is also unclear how he uses this example to justify Whitrow’s answer, since what he says does not alter the fact that the earthbound equatorial clock is not in an inertial frame.

Coleman also tells us that Ziman’s response shows a “clear indication” that Ziman thought Dingle’s question should be rephrased. But Ziman does not rephrase any of his it was “a perfectly reasonable question to which science should indeed given an answer”. Professor Ziman is a prolific writer who may be assumed to have sufficient command of the language to be able to say what he means without requiring readers to indulge in mind-reading. If he believes that Dingle’s question ought to have been rephrased, he should tell us so himself.

Coleman goes on to say that Ziman’s response was the General Relativity answer to the question. But the whole point of Dingle’s question was to find out what justification was given by the Albert Einstein: Philosopher-Scientist, who wrote that in The Listener dated 30 December 1971. He also pointed out, in Science at the Crossroads, that when a pair of relativistically stationary clocks are synchronized they are synchronized for all observers. Although this is a crucial part of Dingle’s question, Coleman seems to have overlooked the book that discusses synchronization, and it agrees with Dingle that synchronization is independent of the observer; that review is Staden’s, which was cited in my article. Coleman’s original paper on Special Relativity, that observers moving relative to the pair of synchronized clocks would find that they were not synchronized, let us now consider Einstein’s original definition and argument.

Einstein gave a definition of synchronization in the following way. Two clocks A and B are at rest relative to one another, and a flash of light is emitted from A and reflected back from B to A. If the reading on B at the moment of reflection is halfway between the readings of A at emission and return of the flash, the clocks are synchronized. Any observer, in any state of motion, would then have identical readings, and would reach the correct conclusion about the synchronization of the clocks. If desired, the experiment could be done in darkness, and the only three clock readings seen by anyone would be the readings illuminated by the flashes; the observer need not consult his own clock, nor indeed need he posses one.

Now consider the argument by which Einstein concluded that observers moving relative to a pair of clocks would find that they were not synchronized. The argument involves a rigid rod aligned with the x axis of a stationary reference frame, and moving longitudinally along the x axis, at its ends A and B are two clocks, and along the x axis are several stationary, equatorial clocks which are synchronized with one another. A flash of light is emitted from A and reflected back from B to A to test for synchronization.

The crucial fact about this experiment is that each of the clocks at A and B is constrained to give the same reading as the stationary clock that happens to be adjacent to it at any instant. I say “constrained” deliberately, since it turns out from results derived later in the theory that the clocks at A and B, if they were running freely, would not continue to give the same readings, the stationary clock adjacent to them as they move along, but would fall further and further behind the stationary clocks. To make them continue to show the same readings as their stationary neighbours they would have to be continually readjusted, in which case they would not be regularly-running clocks. To put it more bluntly, they would not be clocks at all, for their clock works could be removed and their readings adjusted by demons to correspond to the readings of the adjacent stationary clocks. Even more simply, the "clocks" could be removed altogether and replaced by mirrors which would simply reflect the appropriate readings.

In the experiment, the flash of light reflected from B arrives back at A, the end of the rod from which the flash was emitted. Since A has by then moved on, relative to the stationary row of clocks, the clock then opposite A is not the same one as the one that was opposite A when the flash was emitted; the reading at B is therefore not halfway between the two clock readings at end A of the rod. Therefore, according to Einstein “observers moving with the moving rod would thus find that the two clocks were not synchronous”.

But Einstein is not using his definition of synchronization in reaching that conclusion. The “clocks” at the ends A and B of the rods are not regularly-running clocks, but merely objects which reflect the readings of the stationary clock. In the original definition, requires the reflected flash of light to return to the regularly-running clock from which the original flash was emitted, and since it does not do so until after it has passed the new position of end A of the moving clock, Einstein makes any inference about synchronization of clocks from the reading of the clock at the new position of A. Einstein’s conclusion is therefore unjustified.

Reply to A. D. Vella
Dr Vella states that Dingle made an error, but does not identify a specific error. He goes on to say, referring to the two clocks, that “Special Relativity does not say that one is faster than the other” – in fact it denies the existence of absolute speed both of objects and of clocks.” I do not think that a statement that one clock works faster than another is a claim about absolute rates of clocks, but that a statement about Einstein hypothesis that each observer explicitly that the equatorial clock must work slower than the polar one.

Vella goes on to say that the polar clock is stationary with respect to the fixed stars, which is not true. He then says, referring to Dingle: “He concludes that an observer who is stationary with respect to the fixed stars measures the clock on the equator as going more slowly than that situated on a pole.” Vella implies that it is the state of motion of the observer that determines which clock is measured as the slower one, but this is not what Einstein said; he stated that the equatorial clock must work more slowly than the polar one.

Now, let us consider the two sentences that I have quoted from Dr Vella’s letter, I would ask him to answer, with a simple yes or no, the following question: Would an observer on the equator measure the clock at the pole as going more slowly than that situated on the equator?

Reply to J. C. Laine
After a fairly obsuse derivation, Mr Laine concludes that “it is the travelling clock which runs slower than the stationary clock”. Exactly. But the theory says that either clock can be taken to be the stationary one (as Laine seems to agree when he says that “stationary” is a relative expression), so Laine’s reply supports Dingle’s claim that the theory requires each clock to work slower than the other.

Laine then goes on to talk about observation, in an apparent attempt to avoid the obvious result of the statement quoted above. But that does not remove the problem. As I pointed out in Wireless World in October 1980, Professor P. C. W. Davies, in his book Space and Time in the Modern Universe, makes the following statement about two clock-carrying observers in uniform relative motion: “It is not that each observer merely sees the other clock running slow, it actually runs slow, it runs real physical slow.” [Emphasis in the original.] In any case, the observer is not an essential part of the special theory, as has been pointed out by H. Reichenbach, one of the contributors to the book Albert Einstein: Philosopher-Scientist, edited by P. A. Schip, who wrote that “In a logical exposition of the theory of relativity, the observer can be completely eliminated”.

General comments
Without exception, critics of my article have failed to answer my main point, which is that defenders of the theory have published arguments which are inconsistent with one another and/or with Einstein’s own statements. Clear evidence that there are problems in the theory is provided by the fact that these inconsistent statements remain uncorrected. The alternatives are clear: either some of these scientists’ statements are wrong, or the theory from which those scientists claim to have derived their statements is internally inconsistent. Therefore, unless the defenders can correct the inconsistencies by showing that some of their statements are wrong, they have themselves proved that the special theory is untenable.
How reliable is Cruise?

A study of the technical aspects of the ground-launched Cruise missile has cast doubts on the system’s reliability. An engineering critique of the system says that purely technical grounds, there are good reasons for not deploying it. The Ground Launched Cruise Missile, A Technical Assessment, written by electronics design engineer, Tim Williams, and published by Electronics for Peace, concludes that the system as been insufficiently tested, and has been rushed into production for political reasons; it has not been designed or built to the standards required for deployment in Europe. Particular areas for concern are pinpointing; the over-hasty software testing; inadequate manufacturing quality control; the use of unproven systems concepts could lead to long-term unreliability; the competence and training of maintenance personnel and operators is below the standard necessary.

The report, which took a year to prepare, draws on a number of sources including Congressional hearings, technical articles and the manufacturers’ own material. In the pamphlet, Tim Williams states: “the hazard posed by a system which involves transportable nuclear warheads is greater than for any other current deployed nuclear weapon. Acceptance of deployment is an offer of hostility to an untested, unreliable, bug-ridden system that could turn out to be fatal to its hosts.” History has overtaken Mr Williams, the system is already here.

Electronic scrap recycled

The first refinery in the world designed and built specifically for electronic scrap has been opened by Engelhard Industries. A wide range of precious metal bearing materials have hitherto been too expensive to recover, but the new Cinderford plant built at a cost of £2.2M uses a combination of processes, equipment and computer control to optimize the recovery efficiency. Electronic scrap amounts to thousands of tonnes a year in Europe alone, and locked within it lies a potential fortune in precious metal.

The process involves calculation, burning at very high temperature to burn off the plastic and to reduce the raw metallic scrap to an ash. The ash is pulverized in a vibratory crusher and then separated into different sized particles by a series of sieves where an electro-magnet sorts out the ferrous scrap. These and the non magnetic fractions are taken to a melt shop for separate refining. Computer analysis of the ‘fines’ determines the precise type and quantity of flux to be added to optimize melting. The powdered mixture is rolled into pellets for the furnace.

Nine induction melting furnaces are used in the melting process and the hot impure metal is cast into bars which consist of mixtures of silver, gold and platinum-group metals in a greatly enriched form suitable for processing in a conventional refinery. Particular care has been taken to keep air and noise pollution to an absolute minimum.

Another dish in the docks

Following the announcement of BT’s satellite earth station in London’s dockland, Mercury Communications have received outline planning permission for the use of East Wood Wharf on the Isle of Dogs, London for a satellite station of their own. Two dishes are to be installed: an eight-metre dish providing TV distribution within the UK, to be operational in March. A 15m unit for transatlantic television and digital telecommunications should enter service in May. Both systems are supplied in containerized form by Marconi Communication Systems. In summer an 18m dish will come into operation for further communications with North America. This is to be sited in Tackley, Oxfordshire at a disused quarry within 400m of a railway line and BR’s wayleaves, used by Mercury. Like BT, Mercury have an eye on providing programmes via satellite to cable operators as well as communications to remote and offshore sites.

Optical fibre cables have been laid by BT between Luton and Milton Keynes along the A5 trunk road. Joining successive lengths of the fibres must be carried out so that they are lined up to within 0.05 microns on a fibre 8 microns thick. Alignment and electric fusion are carried out on this automatic machine, developed by BT, shown here operated on site by technician John Gule. A pair of cables use a multiplexed monomode transmission system to carry up to 2,000 phone calls at once.
NEW PRODUCTS

Rotary encoder
A compact, lightweight photointerrupter type of rotary encoder is shown in the photograph of the Sharp GP-IR04. This uses an infra red led and an integrated photodiode to provide three types of two-phase output: a sinewave, a cosine wave and an index output. Different slotted discs are used in the five models to give resolutions of 96, 100, 192, 200 or 360 pulses per revolution. Besides their compact and lightweight design, the encoders feature high accuracy through the laser trimming of the circuitry and a high frequency response because of the use of a laser diode with very good thermal characteristics. The encoder can detect arc angles, count revolutions, measure rotational speed and indicate rotational direction. It has applications in a variety of tools and instruments including micrometers and vernier calipers but the small size suggests that it would be highly suitable for robotics. Available through Hero Electronic Ltd, Dunstable Street, Ampthill, Beds MK45 2JS.

5Mbyte disk with back-up
The availability of the Memorex 410 series of hard disks has been announced. Each disk has 5.2Mbit formatted capacity and are packed together in a standard 5.25in disk housing. The removable cartridge disk has been designed in the style proposed as an ANSI standard. The next drive in the range, the 415, available soon, will offer a main disc storage capacity of 10.48Mb with the same 5.24Mb disc fitting into the slot for back-up. A range of controllers and the drives themselves are from Craft Data Ltd, M and M House, Frogmore Road, Hemel Hempstead, Herts HP3 9RW.

Low-cost eraser
It has always surprised us that something as simple as a light-proof box and an ultraviolet lamp should cost as much as many available on the market. A more realistic price of £19.95 is asked for the Uvpace eraser which can operate on up to three erpoms at once in a unit only 90 by 80mm. Erase time varies from 5 to 20 minutes depending on the device. A built-in 15-minute timer costs £5 more (prices inclusive of v.a.t.) Ground Control, Alfreda Avenue, Hullbridge, Essex SS5 6LT.

Real-time analyser for PC
An add-on 1/3-octave real-time analyser board uses the processing and display facilities of the IBM Personal Computer. RTA 331 consists of 31 two-pole filters from 20 to 20kHz and has a package of assembly-language routines called from Basic. It features instantaneous display, variable decay rates and averaging periods, peak hold and weighting functions, display of two independent bar graphs. It includes a pink noise generator which may be controlled through the program as may the input gain. Eight-bit sampling at 20kHz means that it can store up to 22 seconds of input in 128Kbytes of memory. Similar systems are available for use on Apple, TRS80 and Commodore computers. Marquee Electronics Ltd, 90 Wardour Street, London W1V 3LE.

Hand-held dmm
A three-and-a-half digit, l.c.d. multimeter comes from Keithley in their model 130A. This model claims a 0.25% accuracy on the direct voltage range and has current measurement up to 10A on both a.c. and d.c. The sensitivity is 10001V, 110A and 100mA in the respective ranges and the meter can also be used for diode checks. It is protected against overloads and has indicators for polarity if the battery voltage drops. The meter is warranted for two years and needs to be recalibrated after about the same period. Battery and fuse may be replaced without taking the meter apart. Keithley Instruments Ltd, 1 Boulton Road, Reading, Berks RG2 0NL.

Bespoke firmware
A number of utility programs are available as listings or programmed roms with user guides. They include mc/m monitors for the 8080, 8085 and Z80 processors; Tiny Basic, Control Basic, floating-point mathematics packages, serial communications interface, an eprom programmer which includes verification before 'burning'; and a number of system simulation packages. Isis for example is an interactive computer program which enables the user to solve non-linear differential equations and may be used as a replacement for an analogue computer to solve problems in dynamics and transient behaviour of continuous systems, such as servo systems or automatic control systems. Most of these are designed to run on 8080, 8085 or Z80-based microcomputers, and some may be run through CP/M. The manufacturers say that they may make the programmes available for use on other computers. Simulaton Systems Ltd, The Gables, North End, Yatton, Bristol BS19 4AS.

Mike power
A battery unit to provide power for condenser microphones where no power feed is otherwise available, is provided by the AKG B18. Running off two PP3-type batteries, the unit may be connected to balanced and unbalanced amplifiers, mixer or tape recorder inputs. The compact casing is provided with a swivel clip for attaching to the user's belt and a led indicates the battery status. Weighing only 130g, the unit provides opportunities to use condenser mikes when it would otherwise be impossible. AKG Acoustics Ltd, 191 The Vale, London W3 7QS.

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Image store/processor
By using the latest processors and dynamic read/write memory, Cambridge Research say that they can produce Alphascan, an image frame store and processing system, for a fraction of the cost of any (Far East) rival. The system has a wide range of applications in scanning microscopy, medical scanning instruments, data transmission, image processing, ultrasound imaging, and displays for non-destructive testing, amongst many. Signal collection at slow scan rates and c.r.t. presentation of the final image is standard and a number of software extensions permit digital processing, quantification, image analysis, two and three-dimensional measurement, disc storage and printer options. Cambridge Research Instruments, Chesterton Mill, French's Road, Cambridge CB4 3NP.

Domestic timer
A plug-in time switch for home or business use provides the accuracy of digital quartz timing with a neat compact case and a number of useful features. It is accurate to the minute, unlike most mechanical time switches and it can remember up to three on/off times which are protected in the memory against power failure by an internal battery. Any setting may be overridden by a touch of a button and programs may be suspended whenever the normal routine is not required, for example, at weekends. The unit, called Tempo, displays the time and the display is also used when setting the switch times and for checking them. Because of its accuracy, the time switch may be used to control remotely the recording of radio programmes, for alarm calls or for setting security systems. It may also be used to turn lights on and off around the house to deter burglars. Tempo, at £19.95 inclusive + £1.95 postage and packing is available by post from Tek Marketing, Burrel Road, St Ives, Huntingdon, Cambs PE17 4LE.

PCB CAD
A computer-aided design system for p.c.b.s has been developed by Dyad. The Chroma-cad system includes a high-resolution colour monitor with a second monochrome monitor displaying numerical information simultaneously. There is a dedicated keyboard and a trackerball for rapid cursor movement. Developed for the creation of multi-layered designs, a complete board can be output to a plotter to produce camera-ready masters; or transmitted to a bureau for the production of higher-standard masters. The system uses two processors (Z80 and 8088) with the Z80 acting as a system organiser while the 8088 is solely concerned with controlling the colour display. Drawings for p.c.b.s up to 28m each side, working to a tolerance of 0.001m, is possible while up to 80 i.c.s or their equivalents may be handled on the standard system. With memory expansion boards, the capacity can be increased. Component layout, or whole sub-circuits may be stored to and recalled from a library held in disc memory. Different layers of a board are displayed in different colours. Images may be selected for displaying together and the image may be 'panned' across or 'zoomed' into for a closer look. A variety of plotters, including photoplotters may be used and the system may be optimized to find the best combination of pad size and track width for particular pens, inks or paper. The makers point out that DoI grants are available for those companies purchasing CAD equipment. Dyad Developments, The Priory, Great Milton, Oxon OX9 7PB.

Tiny support package
A useful addition to the Essex Tiny Basic single-board computer is Alex. Intended for developing machine-code routines on the INS 8073-based system, it includes an assembler, enabling source code to be entered at a terminal; a disassembler for examining code already in memory; a text editor to allow lines to be altered without rewriting it all and a monitor routine which allows memory to be examined, copied, modified, compared and tested with a debugging program. Alex is supplied on a 4K eprom with a comprehensive users' manual. Essex Electronics Centre, University of Essex, Colchester, CO4 3SQ.

If you would like more information on any of the items featured here, enter the appropriate WW reference number(s) on the mauve reply-paid card bound in this issue. Overseas cards require a stamp.
Compumotor
Advantages over both stepper motors and d.c. servo motors are claimed for the Compumotor motor-and-control combination. Smooth linear acceleration over intermediate incremental positions compares with the stop/start magnetic detents of the stepper motor. This means that much less high frequency energy is transferred to the driven system so mechanical damping and dissipation can be greatly reduced. It provides high torque over a wide speed range and is claimed to have a much better slow-speed control combined with high resolution. Similar comparisons may be made with the d.c. servo motor system. With an increase in low speed torque while "the elegant simplicity and completeness of the Compumotor packages mean shorter design, specification, procurement and check-out times". Open and closed-loop configurations are available and the accuracy at slow speed frees the system from hunting the final position, as is common with many servo systems. The Compumotor is available with a variety of resolutions, up to 50,000 steps per revolution with a maximum step rate of 50,000 steps/s. Output power is from 0.001 to 2.5 horsepower. Unimatic Engineers Ltd, 122 Granville Road, London NW2.
WW 312

Miniature CCTV
What is claimed to be the smallest available self-contained monochrome TV camera with broadcast-standard picture quality, the Insight 75 includes ×10 automatic gain, edge enhancement, automatic black level, motorised vidicon rack, built-in iris drive servo and an external lock. All this is in a package which fits into the palm of a hand and yet provides a resolution of 600 lines, a 56dB signal/noise ratio and a power consumption of 1.6W. A socket is provided for clip-on modules including a battery pack and a remote control unit. Applications include robotics, scientific research and surveillance. The system has been successfully used in surveying sewers and drains, boreholes, ducts and pipelines, for which purposes the manufacturers have devised and patented lighting and control systems. Insight Vision Systems Ltd, Unit 1, Merebrook Industrial Units, Hanley Road, Danemoor, Malvern, Worce WR13 6NP.
WW 313

Inter-pcb connections
A double-decker p.c.b. connector obviates the need to use multi-layer boards. Using 0.1in pitch dual-in-line socket frames incorporating special stepped stand-offs with pin ends compatible with standard p.c.b. holes, collar supports ensure that the p.c.b.s are held rigidly at 15mm parallel spacing. 17 options cover six to 64-pin d.i.l. packages which may be used with extender boards to add, e.g. more memory to a computer board. Test facilities may be added to a board using this system. Scott Electronics Ltd, 50 London Road, Sevenoaks, Kent TN13 1AS.
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A quick visual check on sinewave purity is provided by a pair of oscilloscope graticules which incorporate accurate sinewave traces printed on them permanently. The regular graticule is removed from the oscilloscope and the Sinecheck may be attached to the face of the c.r.t., alignment marks are provided. According to the designer, it is possible to monitor sinewave purity with a precision limited only by the fineness of the trace. Graticule 1 has a complete sinewave which may be used for initial setting up. It is itself adequate for most purposes, but for the more demanding occasion, graticule 2 may be used for further testing. This latter has two traces; a positive and negative half cycle. The graticules are available to fit up to a 100 by 80mm working area. Other sizes may become available if there is sufficient demand. The pair of graticules are available for £2. Enquiries should include screen working dimensions and a stamped addressed envelope to Sinecheck Graticules, Freepost, Watford, Herts WD1 8FP.
WW 315

In brief...
Three-stage power darlington transistors made by TI can switch voltages up to 1150V and currents up to 20A. They can withstand overload conditions up to 33kV. Available from VSI Electronics (UK) Ltd, Raydonbury Industrial Park, Harlow, Essex CM19 9BY.
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Two variations of Mains input filters are stocked in 1, 3, and 6A versions. The standard version (WF100) meets the 0.5mA leakage current standard for domestic use and may be used with equipment while the WF100B meets the need for less than 5uA for medical applications. Comway Ltd, Market Street, Bracknell, Berks RG12 1QP.
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TYPE 2524/2523A. 2 pole changeover relay rated at 1 amp., with a coil resistance of 40Ω, nominal voltage 12V DC, approx. dimensions, length 22mm, width 12mm, height 13mm. Price £16 for 1, £30 for 2, £47 for 50, £105 for 100. Sample sent for £2 + 35p P & P (£27.60 inc. VAT).

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TYPE FF1B. Cradle including clip manufacturer for 24 relay listed above. P.C. Board. Mounting. Price £5 for 1, £22.50 for 25, £45 for 100, £205 for 1,000. Sample sent for £2 + 35p P & P (£47.60 inc. VAT).

TYPE FF1B. Cradle including clip manufacturer for 25 relay as listed above. P.C. Mounting. Price £5 for 1, £27 for 25, £59 for 100, £270 for 1,000. Sample sent for £2 + 35p P & P (£47.60 inc. VAT).

1967-50s DEPC P.C. Mounting. Socket designed for Crockelex when mounting in rows with flush mounting, head dimensions, height 12mm, width 25mm, length 40mm. Price £17 for 1, £90 for 10, £150 for 100, £1,200 for 1,000. Sample sent for £1 + 35p P & P (£15.30 inc. VAT).

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All Resistors are listed by ±5% tolerance & ±0.1% with a standardisation of ±1% and an exponential accuracy of ±0.05% per decade. We have a full range in stock from 1Ω through 1,000,000. All Band values £1.50 for 1,000. Bulk Specials... £1.25 each.

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Panel mounting rocker switch in white or black nylon body, and snap-fit lugs, rated at 250 V AC 15 amp, connected by 16" awg. receptacles, approx. dimensions, height 22mm, depth 22mm, length 48mm. Price £5 for 5, £25 for 25, £49 for 100, £120 for 250, £175 for 500, £290 for 1,000. Sample sent for £2 + 35p P & P (£15.30 inc. VAT).

CONTEMPORARY STYLE DUAL-POWER INDICATOR with green and red rectangular moulded in a black nylon body with a snap-in lens. Rated 250V operating temp up to 80° C. Approx dimensions, height 32mm, depth 32mm, width 22mm. Auto-pan 12mm x 12mm. Price £5 for 5, £19 for 25, £35 for 100, £165 for 500, £280 for 1,000. Sample sent for £2 + 35p P & P (£15.30 inc. VAT).

Single Pole Single Throw Rocker Switch

Single pole single throw rocker switch in white or black nylon body with orange centre rocker action, rated at 250 V AC 15 amp, dimensions approx. 22mm x 30mm, weight 45 grammes. Price £4 for 1, £18 for 10, £30 for 50, £60 for 100, £125 for 250, £220 for 500, £375 for 1,000. Sample sent for £2 + 35p P & P (£15.30 inc. VAT).

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In hand built panel, 4 pole fuse holder, rated for 250V 30amp, fuse size up to 35mm. 50° C. approx. dimensions, height 14mm, depth 14mm, width 22mm. Price £5 for 5, £20 for 25, £35 for 100, £85 for 250, £150 for 500, £260 for 1,000. Sample sent for £2 + 35p P & P (£15.30 inc. VAT).

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Core Diam 10, E23

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OVERSEAS
Please add sufficient to cover Surface or Air Post as required.

PLEASE ADD VAT TO ALL PRICES

(0691) 652894

VALVES

AMERICAN

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<th>Valve Code</th>
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Minimum Order £1

VALVES VAT IS INCLUDED

*Prices shown are subject to change without notice.*

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HARNESS "A" & "B" CONTROL UNITS "A" & "B" Microphones $8.50 each, £12.00 pair. Call for carrier rates. See your local supplier or fill out and return the coupon below.

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<table>
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<tr>
<th>MODEL REFERENCE</th>
<th>1302.1 Medium Resolution</th>
<th>1302.2 High Resolution</th>
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<td>RESOLUTION</td>
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<td>580 x 470 Pixels</td>
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<td>EXTERNAL CONTROLS</td>
<td>On/off switch and brightness control</td>
<td>On/off switch and brightness control</td>
</tr>
</tbody>
</table>

To Opus Supplies Ltd, 158 Camberwell Road, London SE5 0EE.

Please send me ______ Medium Resolution Colour Monitor(s) at £149.95 each (ex. VAT).

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WIREWOUND RESISTORS

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ZENER DIODES

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BZX111 1.5
BZX112 1.5
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BZX154 1.5
BZX155 1.5
BZX156 1.5
BZX157 1.5
BZX158 1.5
BZX159 1.5
BZX160 1.5

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Position
Company
Address
Tel: Sarel Limited, Cosgrove Way, Luton, Beds

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---

### TEST EQUIPMENT

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<th>Type</th>
<th>Description</th>
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<td>Feedback 1/O 602 Variable Phase Oscillator</td>
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<td>Marconi TF-9032A AM/FM 100kHz-1MHz</td>
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<td>Fluke 6050A 3½ digit DMAM</td>
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<td>Fluke 8840A 3½ digit DMAN (New)</td>
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<td>DEC SL 1000 Analyser</td>
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<td>Heathkit O-652 Oscilloscope 0.2-2MHz 1V/20mV</td>
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<td>Sullivan AC Test Set</td>
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<td>Philips 1962A 4½ digit DMAM</td>
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<td>Sorensen VR-2500AM Single Channel Signal Generator</td>
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<td>Tel repeater (O4000) Dual Trace Delay 7/8 Scope</td>
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<td>Transmitter (O7500) Dual Trace Delay 7/8 Scope</td>
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<td>Leader DB5070 Dual Channel 40MHz Scope (Good Channel)</td>
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<td>Tek 7835N Timebase Plug-in</td>
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<td>Advance DS10100 40MHz Scope with OM5010 DMAM option</td>
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<td>Advance DS10510 80MHz Dual Trace Scope</td>
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<td>Tek. 504 Storage Scope.</td>
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<td>Leader LF-660 Frequency response recorder</td>
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<td>J.J. Lorentz 10MHz XY Plotter with spare Amp</td>
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## INTEGRATED CIRCUITS

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## Terms of Business
- C.W.O. Postage and packing valves and semiconductors 50p per order. CR7s £ 5.00. Prices excluding VAT, add 15%.
- Price ruling at time of despatch.
- In some cases, prices of Mullard and USA valves will be higher than those advertised. Prices correct when going to press.
- Any other facilities available to approved customers with minimum order £ 50.00. Can be quoted on any credit orders.

Over 10,000 types of valves, tubes and semiconductors in stock. Quotations for any type not listed. S.A.E.
Electronic Engineers – What you want, where you want!

TJB Electrotechnical Personnel Services is a specialised appointments service for electrical and electronic engineers. We have clients throughout the UK who urgently need technical staff at all levels from Junior Technician to Senior Management. Vacancies exist in all branches of electronics and allied disciplines - right through from design to marketing - at salary levels from around £5000-£15000.

If you wish to make the most of your qualifications and experience and move another rung or two up the ladder we will be pleased to help you. All applications are treated in strict confidence and there is no danger of your present employer (or other companies you specify) being made aware of your application.

Please send me a TJB Appointments Registration form.
Name .................................................................
Address ............................................................... (861)

LEADING LONDON RECORDING STUDIO

Required: Young Person

with good basic knowledge of physics and electronics to train as assistant to chief maintenance engineer.

The successful applicant will be trained to work with the latest audio equipment including solid state logic, studer, etc.

Apply in writing to Box No. 2402

UNIVERSITY OF SURREY

ELECTRONIC/ELECTRICAL ENGINEERING OPPORTUNITIES

The Industrial Electronics Group in the Department of Electronic and Electrical Engineering at the University of Surrey has vacancies for Technicians/Engineers who are keen to further their education at a higher level in electronic fields and are qualified to at least ONC standard.

The work will involve operating on a project basis covering all phases of production equipment manufacture, development and documentation.

The Group of present consists of a small team of Professional Engineers and Technicians who liaise closely with academic staff in problem solving for industry. Projects usually entail the development of novel instrumentation. owing to communication, re-drawable timing and simulation techniques, this increasing emphasis on microprocessor based systems.

The commencing salary will be within the range of £1751 to £2332 on Grade 3, r or A technician salary scale depending on age, qualifications and experience for a 36-hour week. Excellent working conditions include the possibility of day-release study for higher qualifications.

For further information or to arrange a visit contact the Head Teacher, University of Surrey, Guildford, Surrey, GU2 5XJ.

Appointments Registration forms must be returned by 31st January 1984.
Career Opportunities in the High Technology Broadcast Industry

Located in Hampshire, Sony Broadcast is an internationally renowned world leader in the professional broadcast television industry. Our extensive product range includes cameras, VTR's/VCR's, sophisticated editing control systems and now the exciting new range of Betacam equipment. Applications are now invited from experienced engineers who feel they have the potential to develop with the Company.

Field Service Engineer
The successful candidate will be engaged in the service, repair and commissioning of our extensive range of equipment. This will involve travel throughout our marketing territory of Europe, the Middle East and Africa. Full product training will be given where necessary. Applicants should have several years experience gained in the broadcast television industry, either in operations or allied manufacturing industries, and up-to-date knowledge of VTR's and cameras is essential.

Senior Project Engineer – Systems
To co-ordinate a small team responsible for the manufacture and commissioning of complex static and mobile television systems including dubbing and editing systems, full production studios and EFP packages. This is a challenging and responsible position and candidates should have direct experience of sound and television principles. A background in project management together with the ability to plan and meet deadlines is also required.

Engineer – Customer Acceptance
To join a department responsible for the evaluation of product performance. Key activities will include conducting customer acceptance tests, the provision of engineering support to our inspectorate and an involvement in the establishment and maintenance of ATE. There will be a significant involvement with customers. Candidates aged 25 plus should possess HNC electronics or equivalent together with 5+ years experience in a high technology electronics environment.

Lecturer
To co-ordinate theoretical and practical courses on our range of equipment. The department boasts excellent lecturing facilities together with a technical publications department and library. Applicants, educated to at least honours degree level electronics, should be able to present ideas clearly and have the ability to assimilate state of the art broadcast technology. Previous lecturing experience would be an advantage, although training in teaching skills and on our product range will be given where appropriate.

Product Engineer
We are looking for a professional electronics engineer to join our Product Management team. The person appointed will provide technical support to the Marketing and Engineering divisions of Sony Broadcast. This position combines in-depth technical involvement with interdepartmental and customer liaison, and there will be an opportunity for overseas travel. Applicants should be honours graduate electronics engineers, preferably experienced in the electronics industry. Full product training will be given where necessary.

If you like the thought of enjoying the success of world leadership together with a highly attractive salary and benefits package, write with details of career to date and present salary to David Parry, Personnel Department, Sony Broadcast Ltd, City Wall House, Basing View, Basingstoke, Hants RG21 2LA. Telephone (0256) 55011

Sony Broadcast Ltd.
City Wall House
Basing View, Basingstoke
Hampshire RG21 2LA
United Kingdom
SYSTEM PROJECT ENGINEERS

The Ampex Broadcast Systems Group based in Reading, Berkshire, supplies complete television studio and mobile systems to broadcast installations worldwide.

Owing to expansion of the group's activities, we are now looking for Systems Project Engineers to join our innovative project teams involved in the design installation and commissioning of television studio and outside broadcast vehicle projects.

These appointments involve occasional overseas travel for on-site commissioning.

Key requirements are:

* Thorough knowledge of video and audio principles – HNC/Degree in Electronics preferred.
* Experience in broadcast television industry.
* Previous knowledge of TV systems an advantage.

Attractive salaries and benefits, which include pension, life assurance, permanent health scheme, Bupacare option, product training, overseas allowances and relocation expenses where appropriate.

Please contact Maureen Brake for an application form:

AMPEX GREAT BRITAIN LIMITED
ACRE ROAD
READING RG2 0OR
TEL. READING (0734) 875200

VIDEO ENGINEERS

Rediffusion Consumer Manufacturing Ltd is seeking an intermediate and a senior video engineer with OND, HND or similar qualifications, together with a knowledge of modern consumer electronics circuitry techniques, to join a small team looking after Rediffusion's mammoth investment in domestic video recorders and video disc players.

In addition to analysis of performance and long term reliability factors, assessment reporting is an important part of the team's function and the ability to express oneself verbally and in writing is essential.

Our laboratories are situated at Chessington within easy commuting distance of the Surrey countryside. Attractive salaries and the usual big company benefits, which include assistance with relocation expenses, are offered to suitably qualified and experienced engineers. If you believe you can make a significant contribution to our video projects please write to or phone:

Harry Brearley,
Rediffusion Consumer Manufacturing Ltd.,
Pullers Way South,
Chessington, Surrey. KT9 1HJ.
Telephone: 01-397-5411.

CAPITAL APPPOINTMENTS LTD
THE UK's No. 1 ELECTRONICS AGENCY

If you have HNC/TEC or higher qualifications and are looking for a job in design, test, customer service, technical sales or similar roles.

Telephone now for our free jobs list!
We have vacancies in all areas of the UK
Salaries to £15,000 pa
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(24 hours)

CAPITAL APPOINTMENTS LTD
29-30 WINDMILL STREET, LONDON W1P 1HG

CUSTOMER SERVICE TECHNICIAN

£6,000-£8,500

Due to continuing expansion, a vacancy exists for a first-class technician in our busy Service Department.

The successful applicant will be engaged primarily in the repair and calibration of our range of premium voltmeters and calibrators, and will be prepared to undertake site visits in support of our systems activities.

He or she will have practical experience in the repair to component level of precision analogue and embedded microprocessor circuitry. Some understanding of high level programming and IEEE 488 BUS is desirable.

Relocation assistance will be offered where appropriate. Please apply in writing for an application form to:

David Marsh, Customer Service Manager
DATRON INSTRUMENTS LIMITED
Hurricane Way, Norwich Airport
Norwich NR6 6JB

WIRELESS WORLD FEBRUARY 1984
Telecommunications

Marathon's Aberdeen office is the nerve centre of a private wire system linking the Aberdeen office with the Peterhead Shore Base and the Brae-A platform. We currently have two vacancies within the Telecommunications function for experienced individuals to become part of a small team. This group has overall responsibility for our communications networks, comprising data, telex, facsimile and all voice equipment.

Telecommunications Analyst - Onshore

Working at Marathon's Aberdeen office you will be responsible for the efficient day-to-day running of the network. You will be required to provide technical support to users and to produce clear and concise progress reports on system development and maintenance. There will be some opportunities to be involved in the specification of various systems.

Candidates will be qualified to HNC level with at least three years' experience of speech systems, data lines and international circuits; you should also have some relevant practical experience. Relocation assistance, as appropriate, is available for this position.

Telecommunications Technician - Offshore

Working offshore on a 2-week rotation you will be responsible for all telecommunication and radio equipment on the platform. As an experienced technician, your main functions will be to undertake repair work, preventive maintenance and fault-finding. You will form part of the offshore maintenance group and report directly to the Topsides Maintenance Supervisor.

A City & Guilds or ONC qualification is required for this position and your three years' experience should include some time offshore.

For both positions, we are offering competitive salaries supported by an attractive range of benefits including non-contributory pension scheme, subsidised BUPA and generous offshore allowances where appropriate.

Please write or telephone for an application form to:
Ian M Drysdale, Employee Relations Representative, Marathon Oil U.K., Ltd., Marathon House, Rubislaw Hill, Anderson Drive, Aberdeen AB2 4AZ.
Tel: (0224) 576133.
Radio Systems Planning Engineers

Middlesex

Over the past 35 years IAL has been involved in almost all areas of communication technology and has developed an expertise for which demand continues to expand worldwide. Consequently we now need additional Engineers to join the Telecommunications Engineering Department at our Headquarters near Heathrow.

These appointments represent excellent career moves for Engineers with varying levels of qualifications and experience and offer complete involvement in a planning and consultancy role on modern radio communications systems. These systems will be in the HF to SHF bands and range from point to point links through mobile area coverage schemes to broadband microwave links.

A generous starting salary can be expected depending on position, qualifications and experience, plus an excellent benefits package which includes Pension and Life Insurance Scheme and relocation expenses where appropriate.

For further details phone the Technical Recruitment Officer, on 01-574 3134 or write to him at Recruitment Services Division, IAL, Aeradio House, Hayes Road, Southall, Middlesex, UB2 5NJ. Please quote Ref. K004.

THE HIGH TECHNOLOGY TASK FORCE
COMMUNICATIONS SYSTEMS
COMPUTER SYSTEMS AND SERVICES
MEDICAL SERVICES
AVIATION SYSTEMS AND SERVICES-WORLDWIDE

WANTED
School-leaver for busy West End electronic component factors
Qualifications minimum O level Maths, English, Physics/Electronics
Good salary for enthusiastic applicant
Apply Box No. 2441

CAREER IN MUSIC ELECTRONICS
Music Electronics company specializing in the design of electronics for music industry requires an engineer to join design team.

Duties will include design and test, knowledge of digital, analogue, C.A.D., microprocessors.

Ability to work on own initiative. Knowledge of music and sound would be appreciated but not necessary. Ideal candidate will have H.T.C. or H.T.D., A.M.C., degree or equivalent.

Sound knowledge of business administration will be expected. Excellent promotional prospects.

Salary negotiable. Position would suit ambitious graduate.

Candidates write with full C.V. to:

MUSIC ELECTRONICS CO.
20 Kynaston (Business Consultants) Block D, Metropolitan Wharf
Wapping High Street, London, E.1
Telephone: 01-205 0722 (24-hour phone)
or 01-606 5127 (Evenings)

PHOTOGRAPHS NOT ACCEPTED

TECHNICAL AUTHORS

We have vacancies for experienced and trainee technical authors, to write handbooks on some of the latest technology electronics equipment.

Prospective trainees should have a sound knowledge of electronics and the ability to express themselves concisely in the written word.

We offer varied and interesting work, pleasant working conditions and an attractive salary.

Applications to:

The Manager
Engineering & Technical Publications Ltd
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Wokingham, Berks

Telephone: Wokingham (0734) 790123

Bored?
Then change your job!

1) Computer Field Service Engineer
Required with V.A.R. machine experience £1,030 + car bucks.

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To work on printers, disc drives, terminals. To £1,800. Berks.

4) Service Personnel
(RAF, RN, Army)
We have many clients interested in employing ex-service lads and technicals at sites throughout the UK. Phone for details.

5) £500 per week
We are paying very high rates for contract design and test engineers who have a backlog in RF, MODULATION, DIGITAL ANALOGUE or SOFTWARE, at sites throughout the UK.

Hundreds of other Electronic and Computer Vacancies to £12,500. Phone or write:
CIVILIAN CONSULTANTS
8 St. Leonard's Road, Windsor, Berks. Windsor (0753) 58022 (5 lines)

THE UNIVERSITY OF SHEFFIELD
AUDIO-VISUAL AND TELEVISION CENTRE
SENIOR TELEVISION ENGINEER
Applications are invited for the above permanent university service post. The successful applicant will take charge of all engineering aspects of the Centre's work, including planning and development, studio and mobile operations and supervision of the technical staff. Production is based on 1" master video tape for recording and editing. This busy and successful Centre operates to high professional standards. Applicants should preferably be graduates or have comparable qualifications in electronic engineering and wide experience in broadcasting, industrial or educational television.

Grade II is for other related staff £1,150-£1,435. Grade II a year according to qualifications and experience. Particulars from the Registrar and Secretary (Staffing), the University, Sheffield S10 2TN to whom applications (3 copies), including the names of three referees, should be sent by 3 February 1984.

Preston Polytechnic School of Electrical and Electronic Engineering
Applications are invited for the post of SENIOR LABORATORY/WORKSHOP TECHNICIAN
Salary: Scale 4/5M (DLW) £5,264 to £6,884 plus up to £120 per annum for possession of appropriate qualifications.

Applicants must possess a recognised electrical/electronic technician qualification and have experience in electronic design and construction.

Application forms and further details, obtainable from the Personnel Officer, Preston Polytechnic, Corporation Street, Preston, PR1 2TD. Telephone: Preston 262027.

Reference No.: NT/83/64/49.
Closing Date: February 17th, 1984.

WIRELESS WORLD FEBRUARY 1984
Trainee Broadcast Engineers

We are responsible for broadcasting the programmes of Independent Television, Channel Four and Independent Local Radio. The continued growth of our broadcasting services means we have a number of vacancies for Trainee Broadcast Engineers who, on completion of their training, will work in a challenging and secure environment.

The selected candidates will embark on our 18-month residential training course which commences in June 1984. It will be conducted at our Training College, in Devon, and also at the Newcastle Polytechnic. The course is designed to give you a training in Broadcast Transmission Engineering that is second to none. It demands a high standard of understanding and personal commitment from those selected to undertake it. During the course we will pay you a salary and in addition, all your fees, accommodation and meals.

Applications are invited from men and women who hold an HND/HNC/HTEC in Electrical or Electronic Engineering or the City and Guilds Telecommunication Technicians Full Technological Certificate with some appropriate experience; or who are qualified or about to qualify to First Degree level in Electrical/Electronic Engineering or related disciplines.

Your salary while training will be £6,652 per annum. On the satisfactory completion of training, your salary will be £8,421 and will rise by annual increments to £10,461 per annum; further progression to £12,966 per annum is possible.

Employment benefits include a free life assurance and personal accident scheme, a contributory pension scheme, generous relocation expenses and subsidised mortgage facilities.

IBA
BROADCASTING
AUTHORITY

*An Equal Opportunities Employer*

For a fully illustrated booklet and application form, please write to Mike Wright, Personnel Officer - Engineering Regions, IBA, Crawley Court, Winchester, Hants. SO21 3QA. Or telephone the Personnel Office between 9 am and 4 pm Monday to Friday on Winchester 822574 or 822273.

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Your experience and qualifications could take you to one of the more pleasant Middle East countries where vacancies currently exist for:

Fully trained
ELECTRONIC TECHNICIANS

With a minimum of five years experience in servicing, maintenance and repair, including defect diagnosis, of various types of military ground based electronic equipment. These unaccompanied posts include free accommodation, medical care and free air travel to the UK for frequent leave periods.

Attractive salary with bonus and allowances normally free of UK Tax. For further information write to: Company Personnel Manager, Airwork Limited, Bournemouth - Hum Airport, Christchurch, Dorset BH23 6EB.

BOX NOs.

Box number replies should be addressed to:

Box No.....................
c/o Wireless World, Quadrant House The Quadrant, Sutton, Surrey SM2 5AS
Graduate
Electrical/Electronic/Telecommunications Engineers-
Research and Development to support Emergency Services

The Directorate of Telecommunications, London, is responsible for the extensive facilities used by the police, fire, prison and associated services in England and Wales. Graduate Engineers ensure that the Emergency Services derive maximum benefit from the use of modern technology in areas such as communications.

The training and experience given to Graduate Engineers—ranging from the initial interpretation of a non-technical statement of requirement through to the design, development and contract definition—is carefully planned by a senior engineer and covers the training requirements of the IEE for corporate membership. You must have a good honours degree (preferably at least upper 2nd class) in electronics, telecommunications, or electrical engineering or an allied subject approved by the IEE.

Your starting salary will be £7900 or £8900 depending on experience. Completion of training (usually one or two years) leads to a salary scale rising to £10,930. Salaries include £1250 Inner London Weighting. Promotion prospects.

For further details and an application form (to be returned by 3 February 1984) write to Civil Service Commission, Alencon Link, Basingstoke, Hants, RG21 1B, or telephone Basingstoke (0256) 68531 (answering service operates outside office hours). Please quote ref. T/6/939.

Home Office

Electronics Appointments

£6,000 - £16,000

Analogue, Radio, Microwave
Digital, Microprocessor, Computer
Data Comms, Medical

Design, Test, Sales and Field Service Engineers—
to use our free confidential service and improve your sal-
ary and career prospects. UK and overseas. contact

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Lowestoft College of Further Education
Department of Maritime Studies

Lecturer Grade 1

To teach
Electronics, Telecommunications and
Nautical Aids

Up to TEC Level V standard
Candidates should hold appropriate academic qualifications and have recent industrial experience in one of the above subject areas.

Salary: Burnham Teachers in FE establishments
Lecturer Grade 1 £3,849-£9,735
Further particulars and application form may be obtained from The
Principal, Lowestoft College of Further Education, St Peter's Street,
Lowestoft, Suffolk NR32 2NB (also please).
Closing date 14 days from advertisement.

Test Equipment Design Engineers

Rediffusion Consumer Manufacturing design and manufacture
a full range of advanced specification colour television
receivers and monitors.

We are looking for experienced Electronic Design Engineers
to help us maintain our industry lead in sophisticated
computer controlled test gear for production testing of our
products. Future test equipment will be an interesting mix
of digital and analogue circuitry aimed at increasing
the automation of the production testing operation.

If you are able to conceive, design and implement production
test equipment with minimal supervision, we'd like to hear
from you.

These positions are based in our Chessington Engineering
Centre but some visits to our factories in the North East and
Lancashire will be required at infrequent intervals. Salaries
are obviously dependent on qualifications and experience, but
will reflect the importance of future test gear projects to the
Company's long term development.

Interested?... Then write or phone:

Harry Brearley,
Rediffusion Consumer Manufacturing Ltd.,
Pullers Way South,
Chessington, Surrey, KT9 1HJ.
Telephone: 01-397-5411.

UWIST University of Wales

MSc/Diploma Course in Electronics
M Eng Course in Systems Engineering
(Automation, Robotics and
Information Systems)

Applications are invited for places on the above
full-time, one-year courses commencing in October 1984.

Further details and application forms (returnable as
soon as possible) may be obtained from the
Assistant Registrar, UWIST, PO Box 68, Cardiff CF1
3XA.
Teleco is a proven innovative company providing Measurement-While-Drilling (M.W.D.) services to major oil companies worldwide. As a result of highly successful technical advances coupled with increased international growth, we are experiencing a period of expansion. Presently we have vacancies for—

**ELECTRONICS TECHNICIANS**

The successful candidates will possess practical experience of digital and analogue systems as well as having formal qualifications such as ONC or equivalent C & G qualifications in Electronic Engineering. Applicants should realise that this is a shore based.

Included in the total package of company benefits are competitive salary, contributory pension scheme and good working conditions. Applicants should realise that relocation to the Aberdeen area is essential. Removal assistance will be provided.

Interested applicants should write enclosing a C.V. stating salary requirements for the attention of—

Miss F. Skinner, Personnel Co-ordinator

**TELECO OILFIELD SERVICES LTD.**

Barclayhill Place, Portlethen, Aberdeen AB1 4PF

Agency enquiries are not requested.

---

**LABORATORY ENGINEERS**

**BBC Engineering Research Department**

**Kingswood Warren, Tadworth, Surrey**

Research Department has vacancies for Laboratory Engineers in two separate areas of work:

1) Duties include work with mobile units which are concerned with investigations into aspects of UHF and VHF transmitter propagation and reception, and with the development of new broadcasting services. Although based at Kingswood Warren, Laboratory Engineers must be prepared to travel and work for periods anywhere in the U.K., this includes some week end working. Candidates must be able to drive.

2) Duties include the construction and testing of experimental equipment and some design and investigation work concerned with one or more of the following areas of research: video, sound and data origination, processing, recording, distribution, transmitting and receiving equipment using analogue and digital techniques. The work may also involve the use of microprocessors and the manipulation of associated software.

Please indicate any preference for either of the two areas of work.

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