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The 2213 and 2215 have a high efficiency regulated power supply which does away with the need for a heavy power transformer. There are no line-voltage adjustments. Just plug the instrument into a power socket supplying anything from 90 to 250 volts, 48...62 Hz, switch on and you are ready to measure.

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These scopes have it all. Dual trace. Delayed sweep for fast, accurate timing measurements. Single time base in the 2213, dual time bases in the 2215. An advanced triggering system, automatic focus and intensity. Beam finder – and much more.

Interested? Then why not telephone your nearest Tektronix office or circle the enquiry number for further information.

Performance Specifications
Bandwidth
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Light Weight
6.1 kg (13.5 lbs), 6.8 kg (15.0 lbs) with cover and pouch.

Sweep Speeds
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* Prices subject to change without notice.

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Regional Telephone Numbers: Maidenhed 0628 73211, Manchester 061 428 0799, Livingston 32766, Dublin 85096/850796

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Wireless World, Vol 84 No 5 May 1982

MAY 1982 70p

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Sinclair ZX81 Personal Computer - the heart of a system that grows with you.

1980 saw a genuine breakthrough - the Sinclair ZX80, world's first complete personal computer for under £100. Not surprisingly, over 50,000 were sold.

In March 1981, the Sinclair lead increased dramatically. For just £69.95 the Sinclair ZX81 offers even more advanced facilities at an even lower price. Initially, even we were surprised by the demand - over 50,000 in the first 3 months!

Today, the Sinclair ZX81 is the heart of a computer system. You can add 16 times more memory with the ZX RAM pack. The ZX Printer offers an unbeatable combination of performance and price. And the ZX Software library is growing every day.

Lower price: higher capability
With the ZX81, it is still very simple to teach yourself computing, but the ZX81 packs even greater working capability than the ZX80.

It uses the same microprocessor, but incorporates a new, more powerful 8K BASIC ROM - the 'brain-power' of the computer. This chip works in decimals, handles logos and trig, allows you to plot graphs, and builds up animated displays.

And the ZX81 incorporates other operations normally reserved for an IBM - the facility to load and save named programs on cassette, for example, and to drive the new ZX Printer.

Kit:
£49.95

Higher specification, lower price - how's it done?
Quite simply, by design. The ZX80 reduced the chips in a working computer from 40 or so, to 21. The ZX81 reduces the 21 to 4.

The secret lies in a totally new master chip. Designed by Sinclair and custom-built in Britain, this unique chip replaces 18 chips from the ZX80.

New, improved specification
- ZX9A microprocessor - a new, faster version of the famous Z80 chip, widely regarded as the best ever made.
- Unique 'one-touch' key word entry: the ZX81 eliminates a great deal of tedium typing. Key words (RUN, LIST, PRINT, etc.) have their own single-key entry.
- Unique syntax-check and report code identity programming errors immediately.
- Full range of mathematical and scientific functions accurate to eight decimal places.
- Graph-drawing and animated display facilities.
- Multi-dimensional string and numerical arrays.
- Up to 25 FCFOR/NEXT loops.
- Randomise function - useful for games as well as serious applications.
- Cassette LOAD and SAVE with named programs.
- 1K-byte RAM expandable to 16K bytes with Sinclair RAM pack.
- Able to drive the new Sinclair printer.
- Advanced 4-chip design: microprocessor, ROM, RAM, plus master chip - unique, custom-built chip replacing 18 ZX80 chips.

Built:
£69.95

16K-byte RAM pack for massive add-on memory.

Kit or built - it's up to you!
You'll be surprised how easy the ZX81 kit is to build: just four chips to assemble (plus, of course, the other discrete components) - a few hours work with a fine-tipped soldering iron. And you may already have a suitable mains adaptor - 600 mA at 9 V DC, nominal unregulated (supplied with built version).

Kit and built versions come complete with all leads to connect to your TV (colour or black and white) and cassette recorder.

Available now - the ZX Printer for only £49.95

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alphanumeric and highly sophisticated graphics.

A special feature is COPY, which prints out exactly what is on the whole TV screen without the need for further instructions.

At last you can have a hard copy of your program listings - particularly useful when writing or editing programs.

And of course you can print out your results for permanent records or sending to a friend.

Printing speed is 80 characters per second, with 32 characters per line and 9 lines per vertical inch. The ZX Printer connects to the rear of your computer - using a stackable connector so you can plug in a RAM pack as well. A roll of paper (85 ft long x 4 in wide) is supplied, along with full instructions.

How to order your ZX81
By PHONE - Access, Barclaycard or Trustcard holders can call 01-200 0200 for personal attention 24 hours a day, every day. BY FREEPOST - use the no-stamp-needed coupon below. You can pay by cheque, postal order, Access, Barclaycard or Trustcard.

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<tr>
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<th>Qty</th>
<th>Item</th>
<th>Code</th>
<th>Item price</th>
<th>Order</th>
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<tr>
<td>Sinclair ZX81 Personal Computer kit, Price includes ZX81 Basic manual, includes 8K RAM plus mains adaptor</td>
<td>12</td>
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<td>Ready-assembled Sinclair ZX81 Personal Computer kit, Price includes ZX81 BASIC manual and mains adaptor</td>
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<td>Mains Adaptor(s) (800 mA at 9 V DC, nominal unregulated)</td>
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<th>Component</th>
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WIRELESS WORLD MAY 1982
A great many words have been written in the last year or two on the amorality and expediency of engineering. On the one hand, some engineers have come to believe that the responsibility for rendering the bellicose ambitions of political leaders capable of realisation lies squarely with the designers and makers of lethal hardware – engineers themselves. If it were not for the compliance of engineers, they say, the means to wage war in the modern manner would not exist. Those who do not embrace this belief (or who choose to disregard its implications) point out that if "defence systems" – a weasel expression, referring to all military equipment, including that which by no stretch of the imagination can be seen in a posture of defence – were not available, then one "side" would subdue the other and impose its own ideology on the defeated. The solution to this problem, the holders of this view assert, is for each camp to arm itself to the teeth at an increasing rate, threaten to irradiate the planet if provoked, but only to do so if the other side does it first. The unspeakable, irredeemable folly of such an attitude is almost too obvious to warrant argument: its holders would scarcely deny that this method of preserving life and liberty is hardly compatible with the pursuit of happiness.

It is perfectly true, as apologists for the arms race often point out, that some of the effects of the insane compulsion to accumulate weapons are not all that aversome as their raison d'etre. "Spin-off" has provided most of the advances in, for example, electronics in the last few decades. Innovation and development are accelerating at such a rate that it is barely possible to see five years into the future, assuming there is one. But to what effect? After the expenditure of so much effort over so many years, with neither East or West yet persuaded that an unstable equilibrium is a poor way to avoid catastrophic failure, are we being asked to believe that the possession of home computers, video games and digital wristwatches makes the whole thing worth while?

Some of the greatest scientists and engineers in the world, in both East and West, have laboured their entire working lives to produce lethal machinery, the whole point of which is that it shall never be used. Hospitals, schools, universities are closed or run down so that more weapons can be bought or made and the only benefits in our own field that we have to show for all this misdirection of effort and resources are a few gadgets. Admittedly, communications have improved immeasurably in response to the stimulus of military requirement, but a good deal of the improvement is taken up by the provision of entertainment. It is a specious argument, which takes no account of the time scale involved: even in the absence of military urgency, the "improvements" and engineering advances would most probably occur in their own good time, and whoever is to say that that sooner is better than later when the pace of progress outstrips our understanding of it?

Much that has been written on this theme has not dwelt on the inconveniently large question of waste. Materials, the efforts of gifted men and women, irreparable earth resources, time and the wealth of nations are all squandered to produce equipment which, if employed in the manner for which it was written, would have failed in its purpose. And this while millions of people in all continents are deprived of the simplest staples of life.

The contrast between profligacy in the highly developed and privation in the primitive is too stark for us to contemplate the continuation of useless armed posturing into the indefinite future: for that is the outlook – either a sudden and complete end to humanity or an interminable attitude of menace between East and West. Scientific Americans has pointed out that there are now more than three TNT – equivalent tons of nuclear explosive for every single person on earth. It has been said before on this page, and it will be repeated, that engineers in all the developed countries have made the confrontation possible. It is therefore to engineers who are in the best position to bring it to an end, by simply refusing to work on armaments. Call it rebellion or simply common sense, but since politicians the world over seem bent on killing us all, it is the only way to avoid collective suicide.
This article examines aspects of the appreciation of orchestral sound, with particular reference to the transfer characteristics of halls, their auditorium and its influence on timbre in various directions and on our sense of orientation. New subjective criteria are proposed. The Kingsway Hall is used as a model in the discussion.

by Denis Vaughan*

Horseless balcony in the Kingsway Hall is only 17m wide, giving early reflections back at the orchestra.

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Musical qualities

In no easy task to prepare a preferential list of musical qualities in sound. Gelblilde and other conductors, and several recording engineers and producers have approved the following list, which should only be regarded as tentative, and wide open to improvement:

- power - the principal difference comes from the difference of balance in sound reaching us at any point, the difference is small as loudness and intensity: a softer sound will seem farther away. We apply this in tests to estimate the direction of stage from one impulse.

- interpretation as a change of angle of apparent direction changes. The ear ability to detect the arrival of an impulse, whether first or later reflections, is generally poor. Our ears are applied to the detection of sound coming from all directions shortly after the original sound.

- intimacy - an adequate supply of frequencies between 11 and 15kHz arriving early at the ear between 54° and 44° horizontally, and below 60° vertically.

- warmth - a strong bass-heavy frequency response curve, with a plateau in the tenor octave (125-250Hz) upping off smoothly towards the top.

- sonic tone - a growth in the reverberation reaching a peak about 100 milliseconds after the original sound, then dying away smoothly over about 1.8 secs.

- localization of sound is based on three angles. Move a small clock around close to your head, and you can hear that in some upper/front balcony seats, where richness is present, any lack of the other qualities is much less noticeable.

- one reason why richness - and not a long reverberation - tops the list is because a variety of reflections coming from many angles close up each other gives our ears a full frequency coverage. Within the aural limitations of space, any one direction, the deficiencies can be made good only by receiving sound from all sides. In Avery Fisher Hall in New York, you can hear that in some upper/front balcony seats, where richness is present, any lack of the other qualities is much less noticeable.

- horizontality to the side at 90° the balance is more even. The upper frequencies become as much as 15dB stronger than the frontal spectrum and the various peaks at lower pitches are smoother, thus reducing the range between the extremes to only 15dB as opposed to the 22dB range of the frontal spectrum. But the sensitivity which we have at 90° for 12 and 13kHz starts to disappear already at 54° and 90°. Figures 4 and 5 summarize the table of Fig. 1 graphically.

- you may have noticed another aural characteristic. We tend to identify bass notes as coming from below our ears; also, the higher we sit in a hall, the warmer the sounds. I believe that we react similarly to loudspeaker placing. Surprisingly above our heads we can hear a strong peak at 8 and 9kHz, as shown by Fig. 6. In fact we can only hear 8kHz as coming from that direction, no matter where the sound source. But further up the spectrum level of 10kHz, we hear very little from overhead. Therefore in a low room or a hall, we perceive very little illumination, delicacy or texture in the sound. Figure 7 is the graphical representation of Fig. 6.

- WIRELESS WORLD MAY 1982

- Denis Vaughan

ORCHESTRAL SOUND, HALLS AND TIMBRE

Horseless balcony in the Kingsway Hall is only 17m wide, giving early reflections back at the orchestra.

These analyses have brought several surprises. First of all come our hearing capacities.

- The Left-hand column of Fig. 3 shows that, with 400Hz as Q, there is a strong peak at 3kHz of 12dB and a deep trough at 10kHz of -10.5dB. We hear certain upper-high frequencies (except 14 and 15kHz) frontally very much weaker than those at 3kHz.

- These two keys to richness, namely timbre and impulses, are demonstrable in the home with a system which I hope will be developed in the phonographic industry, as soon as the field of the external ear is completely measured. The system would need at least ten loudspeakers: one large, one on the floor to represent the orchestra, and the smaller ones set around the room above and below the ear level, with the appropriate timbre applied to each speaker.

- One more reason to explain the richness is the amazing capacity for quickly perceiving separate impulses in sound. Tests have shown that all listeners prefer orchestral sound impulses which do not arrive simultaneously in both ears - hence the preference for stereo over mono. This scoring effect of the impulses is called 'binaural dissimilarity'. In a concert hall, it is the extent of the initial time-delay gap between the original sound and the first reflection - often about 40ms in a medium-sized hall - which gives much of the quality of the character to the acoustic. (Intimacy has been associated with this gap, but my list suggests other requisites.) Ours appreciates these reflections most when they arrive close to horizontally from the side. My timbre lists show that the timbre of a hall is influenced for us by the angle at which we hear the strongest first reflection, and then by the shape and materials of the hall, or room, and the reverberant spaces beneath it.

- When we receive a lot of early reflections, one shortly after another, those impulses come in an appeased form in slow motion rather than the thumping of music on a horse. This sequence of impulses we perceived as being much richer than an instantaneous reflection. A digital delay unit demonstrates this quickly, by making two or three string instruments sound like a rich chorus. Halls are preferred where the sequence of impulses, whether first or later reflections, dies away quickly. It is called a 'smooth decay curve'.

- Home simulation

These two keys to richness, namely timbre and impulses, are demonstrable in the home with a system which I hope will be developed in the phonographic industry, as soon as the field of the external ear is completely measured. The system would need at least ten loudspeakers: one large, one on the floor to represent the orchestra, and the smaller ones set around the room above and below the ear level, with the appropriate timbre applied to each speaker.
the speakers are disguised as occasional tables.

Long reverberation

Until such a time as a 'decaphonic' system in the true sense of the word is introduced, it is not likely why reverberant halls will be favoured for recording. Present systems use mainly microphones which pick up frontally frequencies that we can never hear (with our 3kHz 1kHz through, and general cut-off in the ear canal above 1kHz). Also the loudspeakers are usually placed at angles where we cannot perceive several other frequencies very well, showing a 20dB range difference at the 3kHz and 1kHz readings. The simplest way of covering up these two aural discrepancies is to add reverberation to the mix to fade and thus beautify the sound.

This has the unfortunate effect of robbing the interpreter of a number of breathtaking dramatic effects, because he can no longer achieve a quiet silence, and so the common 2.5s of reverberation has died away. That would never have been done for Verdi, Toscanini or Callas.

Instead we should seek out a true and satisfying way to give us global (300) natural, full-frequency spectrum, concentrating on our most sensitive area, between 40° and 140° laterally. Even most headphones are unnatural (save those with a 'true' equalizer) in that the earphone is in whole of our own aural frequency filter system. The great advances in recording practice stereoengineers (Sinual recording) fall back at this point.

Architectural prerequisites

The quest for the physical conditions necessary to produce good acoustics to off- tone in a concert hall was sparked off by the decision of my home town, Melbourne, Australia, to spend 35 million dollars (!) to build a 35 metre square, virtually all-concrete hall for that purpose. Of the many indications given to me, two of the most revealing were from Villem Jorden and Derek Sugden. Jorden could not obtain 'lateral efficiency' in a hall wider than 27 metres, and observed that the smaller halls had smaller widths. Sugden stated:

A hall must have 'presence' so that you not only perceive clarity in a reverberant field but the music will have 'weight'. A powerful sound in the first 100 milliseconds is necessary. This can be achieved preferably with a width of 18 metres, and if this is not possible then deep balconies must be used, or the technique of putting the audience in terraces and providing large surfaces for lateral reflections. There must be rapidly following early reflections to avoid achieving intimacy or presence.'

A third useful piece of wisdom came from Derek Sugden's former chief engineer, Kenneth Wilkinson:

A hall can be recorded in many halls thought empty and America and have found that halls built of mainly brick, wood, or plaster, which are older, always produce a good, natural, warm sound. Halls built with concrete and hard plaster seem to produce a thin, hard sound and always lack a warmth and bass. Consequently, when looking for halls to record in, I always avoid modern concrete structures.'

This statement is endorsed by most of the other large record companies.

First reflections

In all the famous orchestral halls, the first lateral reflections come from the side balconies faces. Their timing is easily controlled by the width (1 foot = 1s). So a normal seat in the Leipzig Gewandhaus, with only 12.5m between the balcony faces, had an initial time delay gap of around 4ms. Vienna Musikverein with 15m had 49ms, Boston Symphony Hall (717/919m) 56/66ms, and the Amsterdam Concertgebouw (19m) 37/43ms. These figures give a very good idea of the relative clarity, intensity, and density of sound in each of the above halls.

As upper-high frequencies fall off audibly through atmospheric absorption after about 15 metres, Leipzig and Vienna must have the best quality. London's, the Kingsway Hall, is easy to see where it satisfies the main requirements. Its full width is at the upper limit, 27 metres, with inner wall set on pillars at 19 metre width. But the width between side balconies is only 7m (larger); diagonal walls beside organs, at the orchestra at a height of 3.5 metres. To be honest, I think that such a horseshoe would bring any large symphony orchestra good acoustic liquor. It all gives the players confident inspiration, in the orchestra side, and at the right angle, to allow them to obtain good ensemble. The unbroken surface allows easy bass reflections come back to the microphones (not too strong, mind you) because the long bass waves are reflected away from them, and from a shape resonant to their own. It might be worth copying this reflecting shape in Abbey Road, Columbia, Philharmonic, Wallis, Boston and Warfield, to name a few of the 100's of halls.

The shape is reminiscent of those marvellous small Italian theatres.

In recent years, the Kingsway lease has been shared by EMI and Decca, also re- leasing it to RCA and other companies. Unfortunately, some very effective downstages and many upstairs covered with felt cloth. At one moment its reverberation time with an orchestra present is about 2.5 seconds.

Hall background noise

Poor Wagner cannot have guessed that in Tristan and Isoldé, by giving his singers on the rock a solid wind solo which lasted more than four minutes, he was condemning one of his greatest interpreters - Furtwangler - to recording a duet for English Horn and Pizzicato Viola. Unfortunately, collaboration between EMI and London Underground is not yet such that the traffic can 'get through' to such nether regions. The rumble of the new trains can have a really annoying effect, even on the most distant. When I was Kingsway a not so good hall, was Kingsway not such a good hall. Moreover the cavernous storerooms and art deco benches of the hall, which undoubtedly contributes to the warmth of the sound there, develop the note rumble with a great deal of clarity. In the old days it was cruelly revealed by digital recording technology, and the Audion in particular. All the old wind instruments, even when-no one is it.

The presence of 80 musicians is something which he simply cannot achieve which gives the indispensable and audible human element to the music, with myriad small high-frequency extra-musical sounds. The ease of tone and spaciousness achieved in British music, is one of the factors which make Decca and Furtwangler's 'Tristan' have to my ears yet to be bettered on disc. Both recordings managed to reduce the echo that was present during the sessions, and which is an integral part of the gentleness of the music. An honest hall, and the background noise behind the music is the antithesis of this spell-binding, breathless truth; unfortunately I fear that Dolphy techniques for so far, in their valiant battle to eliminate this and the microphones, have eliminated some of this integral part of the music. Digital recording is proving to be one of the better ways, but has yet to reduce the human element in a performance, and the comment of the acoustic on this human element.

'Singing' decay curve

It is fascinating to know just why the string sound at the beginning of the third movement of the Beecham 'Sinfonia' fade away. As I write this article, I went down on my hands and knees, and with the generous help of the Kingsway caretaker, measured the sound from the stage, the orchestra area, and the side tunnels. Unfortunately, his memory suggests that the stereo microphones were hung down for 'Singing' and 'Winning' (which does not help). As the effective larger reflections start about 18ms after the original sound. Boston's singing tone is based on growth up peak in the decay curve, the peak rising from the timing of the last reflection from the tunnel. The decay usually begins from the timing of the last reflection from the tunnel. By Sugden's standards of 'Singing' and 'Winning' has quite a way to travel as it will decay well within the first 105ms, because the large reflections continue to return up to 14ms, making the music sound fuller than the very first reflections. It is probably a combination of all three.

For the Beecham sessions, with the orchestra facing the organ, the microphones were about 2 metres in front of the stage. For an instrument just under the microphone this gives the following sequence of delays in the reflections from various parts of the hall after the original sound:

- Front, 14ms; upper stage front, 30ms; side balconies, 48ms; back balcony, 54ms (first frontal reflection); ceiling, 73ms (larger); side wall down stages, 71ms (larger); arches between side pillars and inner walls, 89ms; wall down, 100ms (larger); back wall downstairs, 111ms; side wall up, 113ms (larger); back wall up, 147ms (larger).}

Such an unusual layout, not in the higher, where the reflection can only come back to the microphone with the help of a secondary surface, such as side wall upstairs/downstairs. As the microphone is placed on the organ top, I imagine the effective large reflections start about 18ms after the original sound. Boston's singing tone is based on growth up peak in the decay curve, the peak rising from the timing of the last reflection from the tunnel. The decay usually begins from the timing of the last reflection from the tunnel. By Sugden's standards of 'Singing' and 'Winning' has quite a way to travel as it will decay well within the first 105ms, because the large reflections continue to return up to 14ms, making the music sound fuller than the very first reflections. It is probably a combination of all three.

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Reversal

It would be interesting to know whether sharpened listenings with refined equipment can detect the differences in recordings made in Kingsway the other way round, with the orchestra on the other side of the organ. Many recent opera recordings use this setup, which puts the singers in a better relationship to the orchestra, and allows them to move as though on a stage. It also allows the full depth of the voices to develop, in the essential 8-10 metre distance to the main orchestral microphones.

But this way round, the reflection pattern for the orchestra is changed. The low front of the stage and the small upper stage must substitute for the 3.5m high curve of the long back balcony face. The frontal, early-deep backfiring at microphone height at 5m has been replaced by a very early maximum at about 10-11m. The material ought to be noticeable to keen listeners as this new reflection is behind the microphone.

Awareness

Perhaps the foregoing analyses of several aspects of hearing will help listeners towards a greater appreciation of colour and texture in sound. The measurements of timbre are far from complete, and more details are due to be published next year, covering the whole of the upper right hemisphere of our field of hearing.

When stereophony was introduced, many of the observers mentioned it was the first system available to our bodies - giving the greatest importance to the spatial and directional factors. Intensity and virtually dismissing timbre differences as unimportant. It remains to be seen whether in fact timber is not the Cinderella of the trio, ready to blossom into the most beautiful attribute when it is identified, recognized and espoused for its true worth.

Further reading

Analyses of musical qualities and hearing. J. Sound and Vibration, 1980, vol. 69


Langmuir thin-film trough for molecular electronics

Collaboration between scientific instrument makers Joyce Loebi and a number of research establishments, especially Durham University, BSRE Malvern and ICT, has resulted in what is believed to be the world’s first commercial ultra-thin film “growing” equipment. The technology is monolayer molecular layers of a class of materials floated on a liquid surface, usually water transferable to a solid surface by passing it through the liquid. The material originally used by the pioneer of this technique – Irving Langmuir of General Electric back in 1917 – was the soap-like fatty acid salt sodium stearate, but other materials and their deposition on solid surfaces were subsequently investigated by Langmuir and Blodgett, one result being the development of glass anti-reflection coatings. Chief property of the materials used is a rod-like molecule, one end of which is attracted to water and the other end repelled so they stand end-on (assuming the material is correctly composed). But the trough is aimed as a possible new applications of L-B films that are largely out of microelectronics technology. Such layers, one molecule thick, are becoming important in what is called molecular electronics – the "science of clever chemistry and electronics". Applications include insulating layers in 10^-10 metre gallium arsenide devices and as a resist in electron-beam lithography. Organic layers may have application for gas detection, while biological molecules such as antibodies and enzymes may make field-effect devices feasible for in vivo monitoring. In integrated optics they offer a route to the precise building of multilayer films to one tenth of an Angstrom unit, perhaps with the molecular addition of metallic atoms to raise response to radiation.

"Molecular Lego", as it has been dubbed, also has potential application to energy conversion devices, photosynthesis, magneto-optics, three-dimensional memory devices, and to display devices, where high electric fields may allow a high-speed alternative to current technology.

Molecules are compressed in the Langmuir trough with a constant-perimeter multilayer area boundary which encloses the monolayer and prevents film contamination. A sensitive microbalance with sensor in the liquid surface monitors differential surface tension, and links through a control system to the barrier drive. A motor-driven micrometer screw automatically drives a substrate in and out of the liquid. Constant surface pressure is provided by a differential feedback system to maintain film integrity. A pre-determined number of monolayers can be programmed by a control unit using a range of dipping speeds, and a two-pen recorder charts surface pressure and area during deposition.

The trough is made by Joyce-Loebi, a subsidiary of Vickers Instruments, of Team Valley, Gateshead.

Enter WW 500 on reply card for further details.

WIRELESS WORLD MAY 1982

NETWORKING SMALL COMPUTERS

Simply transferring a program or data from one computer to another by telephone is not too great a problem, but if a number of remote computers are to work together regularly in a network, the added complexity software is required to organize and convey information efficiently. This article describes such software designed for Pet microcomputers and outlines networking generally.

by Philip G. Barker*

* number of the owner at site Y and then transmit information to him/her. In the context of data exchange, transmission takes place as if the two microcomputers were linked together directly. No intermediate data storage is available so error detection and correction procedures have to be incorporated in the software used for receiving the data. Messages passing over the communication network are susceptible to corruption by noise or aliasing as if the network failed to respond to the transmitter, data transfer is inhibited.

In Fig. 1(b), the microcomputer owner at point X can store a material in a mainframe at site V or Y and then retrieve. Provided that the computers at points Y and Z can meet all the necessary access control requirements, they too can gain access to the data. With this kind of network, information can be shared and distribution to other geographical locations is simplified.

Details of using a microcomputer as an interactive terminal, in conjunction with the public switched telephone network* 1, 2, and of using a microcomputer as an intelligent terminal have been presented. In reference 8, algorithms for information file transfer between a mainframe and microcomputer are discussed in detail. The use of a main-frame, low-level (source-language) programs or data. Using the software described, communicating programs between one microcomputer and another (via a main-frame) is reasonably straightforward but a decision has to be made regarding whether the programs are

![Fig. 1. In (a), the public switched network is used to link two computers together directly. Messages passing over the network are susceptible to corruption by noise or aliasing if the receiver fails to respond to the transmitter, data transfer is inhibited. Data from any of the three microcomputers shown in (b) may be downloaded in a mainframe computer and retrieved later. Using this type of network, certain codes can be imposed to restrict access of information from the mainframe to those microcomputers owned by knowledge of the code.](www.americanradiohistory.com)
to be transmitted in machine-code or source-language form.

Factors influencing the ease with which programs may be communicated are
- the level of language used
- the availability of internationally accepted language standards and the ability of programmers to keep within limitations imposed by these standards
- compatibility of the computers used.

These factors alone are probably sufficient to justify transmitting program files in source language form rather than as machine-code memory images. In this context we have been examining the problems associated with transmitting both Pascal and Basic programs over the p.s.n. between microcomputers and mainframes. Some interesting results have been obtained—a few of which are described here.

Files transmitted between the two computers consist of a contiguous set of characters. Certain special characters interspersed in the sequence, for example end-of-line $0D$, impose a simple record structure on these files. That the files may not be physically stored in this way in either the source or destination computer is of little consequence as far as this article is concerned.

### Loading Basic from secondary storage

Once a Basic program has been transmitted from a remote computer and stored locally on a secondary storage medium such as a tape or disc drive, it is a simple matter to load the program into memory for subsequent execution. How the program is loaded will depend on the type of microcomputer used. To illustrate the purpose of this article, specific descriptions pertaining to the 8000 series Commodore PET microcomputer are included.

The function of a loading program is to recognize Basic statements contained in a secondary storage file, convert them to the appropriate format, and store them at the correct location in the memory space available. Functional requirements of such a program for the PET are summarized in Fig. 2(a), where it can be seen that the storage area for Basic programs starts at $0400$ and ends at $07FF$ where X KiB of memory is available. Obviously, the loading program at the top end of the memory will slightly reduce the amount of space available for other programs.

One of the loading program's main tasks is to convert the incoming source code to a code which can be stored in the computer's memory, the two forms of which are represented in Fig. 2(b). When the source code is stored, each statement consists of a two-byte pointer, a two-byte encoding of the statement number, a sequence of bytes representing the original source line and a byte containing the 'end-of-line' marker. Further details on how Basic programs are stored in memory can usually be found in the computer's manuals.

Once a statement has been converted, it has to be placed in the correct memory location. Both conversion and insertion are usually carried out by routines built into the computer's operating system, which in the case of the PET are locations $0C34B$ to $0C34F$, and there is no reason why these routines may not be used in the programs concerned. But for most readers, copying the relevant r.o.m. information into r.o.m. will be more practical than altering the system's r.o.m. A simple assembly language program will serve this purpose. The loading program's basic structure is as follows:

*Step 0:* borrow code from the operating system

*Step 1:* initialize Basic (usually using NEW)

*Step 2:* read input file (get next source character)

*Step 3:* if 'end-of-line', go to step 6

*Step 4:* if 'end-of-file', go to step 8

*Step 5:* store source character in Basic buffer then go to step 2

*Step 6:* prepare for operating-system enabled mode

*Step 7:* convert source statement held in buffer, enter into Basic memory area, then go to step 2

*Step 8:* pass control back to Basic commended mode with a 'READY' message.

As was suggested earlier, step 7 will probably be carried out by a 'borrowed code', and the remaining steps will be implemented by the operator, see Fig. 2(c). An assembly-language program for the above algorithm — for Basic source files on cassette — is shown in Fig. 3, and a complementary flow diagram is shown in Fig. 4. When invoked, the initialization code copies $94$ bytes, starting from $0C34B$, in the slot reserved for it through manipulation of the assembler location counter. When this is completed, the loading operation starts. The program uses a subroutine called TREAD to transfer a block of data from cassette into the relevant buffer area. In turn, this routine makes use of the operating utility code commencing at $0F855$. Characters are then

---

*The 'decimal sign' indicates that the number immediately following it is in decimal form. This is not the standard method of indicating hexadecimal numbers, but is familiar to most users of the microcomputer concerned. — Ed.*

---

**Fig. 2.** The function of a source-language loading program. These diagrams, although specifically relating to the PET, are typical of most microcomputers. Underlined sections in (b) indicate the positions in memory of the Basic statement numbers.

**Fig. 4.** This assembly-language program, a modified version of the program shown in Fig. 3, is included on a disc-based system.
The loading programs can be located in e.p.r.o.m. or in any part of the memory space available for program loading. When sitting these programs, two important factors must be considered:

- that the programs do not overlap themselves while running (this is usually caused by locating them too near the low end of memory), and
- that they do not interfere with any of the operating system support software that may be partly in r.a.m. (for example, the MOS support uses r.a.m. above $7E8$ in 3040 disc-based 32-PET systems).

Each of these constraints can be avoided by using an appropriately structured e.p.r.o.m. However, if the loading programs are to be stored in r.a.m., their security and effectiveness depends on finding a suitable memory space into which they may be loaded and run. Unfortunately, disc loader 1 is too large to fit the cassette buffer area, $027A$ through $03B$, but its main body and the first section of the two input routines (DKREAD) can slot into this area; DKREAD could now reside at the high end of r.a.m. above $7E10$, the exact location depending what other software is present in this area. Because the version of the loading program for handling tape-based source files is too large to be stored in cassette buffer 2, with the DKOPEN routine, it would also need to be positioned somewhere above memory address $7E10$.

Similar arguments apply in the case of disc loader 2, too. A new subroutine could be used to ask the operator for the name of the file to be loaded and then automatically position the tape ready for loading. A routine of this type is essential in a loading program designed for handling source programs from discs.

To enable the loading program shown in Fig. 6 to handle disc files, two additional subroutines are needed: one to open the disk file, DKOPEN, and another to read and close it, DKREAD. Implementations of each of these are presented in Fig. 5. DKOPEN fulfills the requirements outlined above, that is, it prompts the operator for the name of the file to be loaded, verifies its validity and then returns an appropriate message. The DKREAD routine emulates the action of the tape cassette thereby mimicking the number of changes necessary to the code listed in Fig. 3. Indeed, only three changes are required: the reference to TREAD in line 21 must be changed to DKOPEN and that to TPREAD (line 63) must be altered to DKREAD. Finally, the device number in line 62 must be changed from 1 to 8.

As a means of checking that tape cassette emulation was a reasonable approach to use, a second version of the disc loading program was written using a different approach. This involved reading the whole of the disc file into memory, storing it, and then presenting it as an internal file. Other than the slight modifications needed for the new input method, no major changes to the logic of the program shown in Fig. 3 were required and no detectable difference in performance between the two disk-loading programs was observed. Furthermore, as can be seen from the following table their load size differed by only five bytes.

<table>
<thead>
<tr>
<th>Tape</th>
<th>Disk</th>
<th>Disk</th>
</tr>
</thead>
<tbody>
<tr>
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<td>257</td>
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<td>115</td>
</tr>
<tr>
<td>554</td>
<td>554</td>
<td>554</td>
</tr>
</tbody>
</table>

Note: DKOPEN/READ Table size differed by only five bytes.
Teledon videotex in UK

The first private viewdata system based on teledon video transmission was introduced in Britain by Poulter Computer Media, a new company in the Poulter advertising and marketing group. Developed by the Cambridge Department of Communications, Teledon is an easy-to-use system to enable text and high-quality animated images to be transmitted to tv sets. It was chosen for audio-visual presentations where a chart might take 10 or 15 minutes.

Secret of Teledon is the picture description. The transmission coding that describes the image content by co-ordinates — two for lines and rectangles, three for arcs, more for polygons, hence the name alpha-geometric. Images can also be described by scanning point-to-point, and they are reconstructed to whatever resolution the receiving equipment allows. Claims made for it are that it is equipment compatible, it can convert to alpha-geometric and if it is said to be more CCDT videotex attributes than any other scheme. Teledon is in widespread use in Canada, USA, and Europe. More than 100,000 papers have been bought by Siemens.

Dedicated to a b-hybrid system. Unmatched components in Steve Kirby's article in the March issue, page 54, are p-p hybrid in Fig. 2 shows the EBU proposals for 625-line signal and nominal analogue timing for reference. The 625-line and 525-line grids will be used by the EBU Special Group V1. V1 in which the system of the 525-line standard has taken place.

COLOUR RANGES

Fig. 1. Coding ranges for the 8-bit linear p.p. system

Fig. 2. The EBU proposal for 625-line signal and nominal analogue timing for reference with 864 luminance samples for each line.
Tracking vehicles

Disclosure of hitherto secret Home Office guidelines on the police use of radar and other electronic equipment has drawn attention to a form of surveillance that has until now been shrouded in secrecy. The deployment of suspect vehicles by the attachment of a miniature transmitter which can then be located using sophisticated mobile Doppler-type v.h.f. and u.h.f. direction-finding equipment that overcomes the usual problems of accurate df in built-up areas. Equipment of this type is made in several countries, but as recently as February 1967 Rohde & Schwarz specifically described their PA002 and PA005 systems as being "suitable for mobile operation in the field of personal protection or even in trailing "prepared" vehicles." From fixed bases such equipment can locate an urban transmission within to 100 metres. At least one American firm makes mobile equipment that would have little difficulty in following a vehicle at a distant distance.

Mobile communications

The outlook for the use of v.h.f. single-sideband with 5 kHz channeling in the private-mobile radio or in the "radio advisor" is especially bright, and theddit, this incident must have been particularly disconcerting for those promoting a sophisticated system that seeks to high-light and then supersede the radio propa-gation traditions of various marine radio administrations.

Mobile telephone companies have seldom proved eager to introduce new communications or navigation systems unless the costs can be offset by lower marine insurance rates — so that 24-hour relia-bility must be counted a vital consideration.

While we all know how easy it is for press and public demand to bend in the face of an adroit accident, this incident must have been particu-larly galling for those promoting a sophisticated system that seeks to high-light and then supersede the radio propa-gation traditions of various marine radio administrations.

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Where static was not too bad, the highly professional radio officers and coast station staffs were probably not any sur-prise, and another "snafu" on the part of the licensing authorities — although it was already clear that pressure on the transatlantic radio frequencies was more intense in Europe than in North America and only with difficulty was the frequency "1,7 MHz" band retained in Europe. At that time the major ITU conferences were held every four years.

Detailed older sources make it clear that conclusions about the remarkable 500-150 MHz Euro-Asia to Africa paths by transoceanic "radio librarians" were premature. In 1967 Cycle 21 had been reported by Ray Cracknell, ZZ2JX in Zimbabwe, Fred An-derson, K6BHP in California, and Fred Finerlin, SVD1H in Athens (QST, De-cember 1968). They show that the high-dimen-sion, ionized zones exist not 10 miles north and south of the magnetic dip equa-tor capable of providing stations in the same frequency range to communicate with each other.

In more recent years, the use of lower frequencies has shown significant increases in the number of noted "radio librarians". In 1977 Cycle 19, reported by Jeff Kline, W2JZG, in New Jersey, and Mike Pearson, W2WUQ, in New York, shows that the high-dimen-sion, ionized zones extend to 150 miles north and south of the magnetic dip equa-tor capable of providing stations in the same frequency range to communicate with each other.

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MICRO CONTROLLED LIGHTING SYSTEM

Hardware for the input side of the lighting system — the control desk. Modular construction is suggested to allow for variations in total system size.

The input portion of the lighting system — the control desk — transforms the positions of the numerous faders into data in the processor memory. To maintain processing speed and hence the interactive nature of the system input and output operations are designed so that no processor or data bus time-outs are required. This is readily achievable in the output to the dimmers by ensuring that the access time to each dimmer is less than 410 ms (the maximum data bus access time permitted by the processor) and the use of a mapped-memory input technique was chosen. However, the analogue-to-digital conversion of the fader positions is inherently slow, and no method of increasing the transfer conversion speed is required. Three possible methods can be considered.

1. Allocating a slow a-d converter to each fader which continuously tracks the analogue level of the fader and then the processor addresses each converter in turn to obtain data. The large number of faders in a lighting desk means that this would probably be a very expensive solution.

2. Using an a-d converter which is fast enough to perform a conversion in the maximum access time of 410 ms. The practical conversion time must be much shorter than this to allow for the multiplexing of the faders and the sampling of the analogue levels. The cost of high-speed converters and multiplexers means this solution is also expensive.

3. By using a slow a-d converter and the faders addressed via a 4-10-bit line decoder by a 4-bit digital address bus. One a-d converter was allocated to each of these 16 fader modules; however, the converter and sample-and-hold circuit used have a total conversion time of 26 ms at a conversion rate of 21 kHz, which is much too slow. However, the input to the fader multiplexers can be sampled at a higher rate of 1.5 kHz, which is well within the maximum access time of 410 ms. This would give an input to the fader multiplexers at a constant rate of 1.25 kHz, which is well within the maximum access time of 410 ms.

The input circuits can be split into three parts — an analogue multiplexer which connects the faders to the a-d converter, the converter itself and associated sample-and-hold and timing circuits, and the shared memory with access control logic.

Analogue multiplexer module

The fader connected to the analogue bus is determined by a four-bit code, and address decoding is performed by a 4-10-bit line decoder (74154), Fig. 11. As mentioned in the first article, this requires the multiplication of stored data. For any reasonable input memory time to the processor and the shared memory bus time-out restrictions, it is usual to use a 4-bit microprocessor clock in the Quasar development system. This allows the full range of the fader to be represented by a 2-bit twisted ring counter, comprising two D-type flip-flops (7474). This type of counter was chosen for its simplicity and that all states can be detected by two-input NAND gates. The first state of the sequence enables the sample-and-hold circuit, the second state is used as a write request for the memory access logic, and the final state is used to clock a third D-type flip-flop. The output of this flip-flop is used as the start conversion pulse of the a-d converter. The end of conversion signal (EOC) goes low, and is used to hold the counter in its reset state. The positive-going edge of EOC clocks a 4-bit counter (74161) used to gate the shared memory block of memory and the analogue multiplexer. The data outputs are always enabled, by holding OE (pin 2) low. The LF298 sample-and-hold circuit has more than adequate accuracy at 6 uA sample time. The sample-and-hold converter reference voltage is used to bias the fader potentiometers. To reduce processing time, fader coding times are first checked to determine if they are zero (i.e. channel not in use) only if they are non-zero will further processing be performed. Contact and end-resistance in the potentiometer gives a small drift, offset, even when the channel is not being used. Hence a bipolar voltage reference is supplied to the faders to give a small "deadband" for which the output code is zero. These references are obtained by buffering and inverting the converter reference voltage by a 7474 dual op-amp.

Shared memory and access control

The memory can be accessed by either the microprocessor or the a-d converter, and hence the data and address busses must be multiplexed between the microprocessor and converter. It differs from conventional direct memory access techniques in that the converter and processor have separate buses and operate independently, Fig. 13.

The shared memory contains the AM27507 (16-word 31-bit Schottky RAM cell) which receives and transmits the data inputs and outputs and the a-d converter only writes to this memory while the processor only reads from it, no data bus multiplexing is required. Data outputs are tri-state which allows direct connection to the processor data busses. Address bus multiplexing is performed by two 74125 tri-state buffers; the appropriate one is enabled for read or write operations. For large systems standard 250 ms memory chips are used instead of the AM27507, but they will require additional data bus multiplexing.

The eight high-order bits of the processor address bus are compared with a bit pattern set by eight wire links to determine the page location in the memory map of the input data addresses, Fig. 14. This is achieved in the same manner as the output address decoding described in Part 1. When the processor needs to read from the shared memory, a read request signal is generated before the system enable signal (L1) goes low, achieved by AND-ing the address decoder output, MIO and WR signals. The output is latched by the 8085.
**16-CHANNEL DATA ACQUISITION SYSTEM**

The article concludes with a continuation of the circuit description, its operation and a sample program for scanning through sixteen channels.

Figure 8 is the timing diagram for the scanning sequence. On power-up, the Reset line is brought low for approximately 150 ms via $R_1$ and $C_1$ to reset the address latch $R_2$ and the address-enable flip-flop $IC_1$.

To select a channel and start an A/D conversion, the BASIC statement below is executed:

```
PRINT #1, "##"
```

where $DN$ is the device number (0-30) * is the ASCII character "##" $n$ is the ASCII equivalent of the required channel "0" to "F".

When the system receives a device number (DN) corresponding to that tested on the address switches ($S_5$ to $S_8$ in Fig. 7), the 962.5448 will initiate a timing sequence, as shown in Fig. 8 (point to scale). The r.o.m. (IC2) decodes ASCII information to binary data, its contents being outlined in the Table 1. Four outputs of the r.o.m. give the binary data obtained by converting ASCII "##" - "F" to binary 0000 to 1111 and additional outputs are used to detect a "##" character and a carriage return (CR) - data outputs 06 and 05 are used for this purpose.

When the first "##" character is sent (2 in Fig. 8) the * line goes low (3) and the RXST and RXRDY are pulsed (4) and (5) in accordance with Fig. 5. As the data is removed (6), * detect goes high and sets the address enable FF - QF goes high (8). The next data byte is presented (9), representing one of 16 address channels, and as RXST goes high (10), CLK goes high (11) and latches the address latch (12), RXST and CLK then go low (13) and (14), and data is removed (15).

A Carriage Return is now presented at the data bus (16) and the CR detect (or GO signal) goes low (17), and starts conversion in the AD7555 (to be discussed later). This signal also resets the address enable FF (18), while RXST pulses (19) and (20), CRD is removed (21) and GO is returned high.

The result of all this activity is that one of 16 channels is enabled in the AD7506 (16 channel multiplier) and a conversion cycle of the appropriate channel is started.

**Talking sequence (conversion cycle)**

The AD7555 is a 4½-digit A-to-D conversion subsystem. A free-running clock (DMC) strobes out the b.c.d. data from the AD7555 in a 4½-bit-wide bus. In this application, the DMC signal is controlled by the 962.5448 handshakes signals to transmit the information to the GPIB. Each b.c.d. data byte is signalled by a digit line which goes low when that byte is being outputted, D0 going low for the most significant digit (sign and first digit), D1 for the next significant digit, etc., and D5 for the least-significant digit. In this application, D5 going low is used to send a carriage return code on the IEEE-488 bus. Although this loses one digit of resolution, it considerably eases the interface circuitry.

Figure 9 highlights the conversion timing sequence. Upon reception of a GO signal (2) (from the listening sequence in Fig. 7) HOLD goes high (3) which instructs the AD7555 to start conversion: the free-running DMC clock is also enabled (4). Upon comparator crossing at the end of phase 0 (the beginning of the quad-slope A-to-D conversion procedure) SCC goes low (5), enabling the 1.024MHz clock to pin 12. At the end of the conversion, SCC returns high (6) and on the next DMC rising edge (7), DAV goes high and remains high for two DMC pulses (9). During this period, the internal buffers are updated with the latest data. After this DAV returns low (10) and brings HOLD Low (11). This is known as the master reset and disables the free-running DMC clock. From this point control of DMC is taken over by the TXST handshake during read-back.

At this stage, the data presented by the AD7555 is the most significant digit; TXRDY is high, indicating that data is ready; and SRQ has been brought low (12) telling the controller that a conversion has been completed and the new data is ready.
## BOOKS


The advantages of microprogramming over hard-wired control logic systems are described from a historical viewpoint. The book covers the treatment of the theory, practice, and applications. A microprogrammed control possesses an advantage in the speed of programming, but the extent that it is lower than that of the machine-code instruction; an add, for example, requires four microinstructions. Microprogrammed control possesses the advantages in terms of economy and reliability of the possibility that the control connection set or architecture of a computer by altering the microprogram. WIRELESS WORLD MAY 1982


Differences in emphasis between digital processing of signals and the digital control of processes are stressed in this book, which is a suitable level for final-year degree students and engineers. It is divided into four parts: **I. Introduction: Control System**, **II. Control Analysis**, **III. Microcomputer Control**, and **IV. Microcomputer Design**. WIRELESS WORLD MAY 1982


European f.m. radio and television transmitters are listed in this comprehensive listings of stations. The book, first published in Holland, presents the necessary information to enable a listener to identify stations in the long, medium and short wavebands, giving frequency and wavelength, power, coverage, and details of their transmitters and their place names. In the case of television and f.m. radio, there are columns to indicate channel number, aerial polarization and whether the station transmits stereo. A number of appendices list the addresses of broadcasting stations and DX clubs and there is a five-language glossary of radio and television transmitters and a table giving the characteristics of TV transmitters. WIRELESS WORLD MAY 1982

---

**Parts List**

Integrated circuits

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<th>Code</th>
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<tr>
<td>74C175</td>
<td>28</td>
<td>10k (1%)</td>
</tr>
</tbody>
</table>

Potentiometers

- R1: 500 ohm, 1 turn
- R2: 200 ohm, 1 turn

Capacitors

- 1µF, 470V
- 0.1µF, 100V
- 0.01µF, 1000V
- 0.001µF, 1000V

Diodes

- 1N4148, 1N4149
- 1N4001
- 1N4148
- 1N4149
- 1N4001

### System Performance

As discussed, the a-to-d converter is operated as a 7-bit unsignet negative, but only 4 bits are used. The a-to-d conversion time varies from 1.3 seconds for full-scale negative input, to 1.7 seconds for full-scale positive input. The conversion time can be reduced by a factor of ten by operating the a-to-d converter in the 4½ digit mode. Some minor changes in circuit values and pin-straps are necessary. Change R4 to 36kΩ and C3 to 0.22µF.

- Disconnect wire from pin 22 of ICS to pin 2 (IC8) and pin 25, (IC3).
- Connect wire from pin 23 (IC8) to pin 21 (IC4) and pins 2, 5, (IC3).
- Disconnect pin 8 (IC3) from +5V and connect to GND.

The 4½ digit mode conversion time is 0.35 seconds when information is transmitted on the bus.

### Service Request and Status Byte

Bit 6 of the status byte, shown in Fig. 11, contains the service request bit (needed in the case of serial polling, high when a service is requested. The rest of the status byte contains information as to why a service was requested. In this case there is only one reason, an end of conversion caused by bit 4 (high). The four least significant bits contain the address of the last selected channel. The status byte is read during a STRDY and STST periodic sampling sequence by STRDY and STST similar to Fig. 5.

### Books


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**WIRELESS WORLD MAY 1982**
Waveform synthesizer

Here, an X-Y matrix is used to plot a given waveform. The waveform to be synthesized is divided into a number of time domains and the voltage at the end of each domain is set on a diode-chain potentiometer. If the length of the time domain is less than half the period of the maximum frequency present in the waveform and the number of discrete levels is large, accurate reproduction of the original can be achieved. This circuit lends itself to computer control and expansion.

By varying the 555-clock frequency, the output waveform frequency may be adjusted proportionally. A 7493 counter converts the clock signal into 4-bit binary to drive a 4-to-16-line decoder, which in turn drives 16 output transistors through 1:1 buffers. Each transistor output is fed to a common point through a resistor. For certain waveforms, an integrating capacitor may be connected across the output to filter out steps and switching pulses.

P. D. Somerville
Crawley
Sussex

NiCd battery protection

Essentially a fold-back current limiter with a low-voltage detection capability, this circuit draws less than 300 µA and drops less than 0.35V on full transmit load. The low loss on load, important in many battery applications, is due to the use of germanium as the control element. Only one control transistor is shown in the simplified diagram although two in parallel are used. The germanium control transistor Tr1 is held on by a silicon transistor, Tr2, whose base current flows through zener D1 and R2. With a 12V battery D1 is 9.1V. In the event of an overload or short circuit the p.d. across Tr1 rises and on reaching 0.6V is detected by silicon Tr2, whose emitter-base connected across the emitter-collector of the germanium control transistor. Tr3 turns on, raising the junction of D1 and R2 to battery voltage. This action turns off Tr1, and they remain off while any load is connected. A similar action occurs if the voltage on or off load falls below 1V/Cell, i.e. below 10V. In this case the battery voltage fails to support a current through Tr1 (requiring 0.6V) and D1 (requiring 9.1V) and Tr1 starts to turn off, initiating the same fold-back action. C1 is included to damp the fold-back loop. A low-value resistor R2 is used to control thermal run-away of Tr1.

J. B. H. Stead
Salisbury
Zimbabwe

Wideband f.m. demodulator

Operation of the demodulator relies on the linear relationship between power consumption (Ip, where Vp is fixed) and operating frequency of c.m.o.s. logic circuits. A 4011B D-type flip-flop is used because the internal clock elements have a high clock rate capability which extends beyond the normal range of usage. Measurements indicate that the demodulator will work satisfactorily from d.c. up to and beyond 20MHz.

The flip-flop is clocked by logic level transitions and the resultant current flow converted to an output voltage by the current mirror and output components. The current mirror ensures a minimal interaction between supply voltage and current in the flip-flop — a higher performance mirror could be constructed using spare devices in the 3046 array if required. The resistor is chosen to suit the maximum input frequency (the output can swing the full supply voltage, limited only by quiescent device consumption and Vp, saturation) and the capacitor provides low-pass filtering to remove input frequency noise. Values shown have been used with a 10.7 MHz f.m demodulator prior to "birdy" filtering and stereo decoding.

G. C. Hammond
Whitestone
Nuneaton

Constant-current supply

This circuit is extremely simple, uses no special components, yet has a very wide range of output currents, 2mA to 100mA in six ranges. The only limitation to output is component ratings. It also has a performance that is comparable to more expensive equipment.

Tr2, Tr3 and IC2 comprise a constant-voltage supply that can be varied from 0 to 100V by varying Vref. When testing this section, no change in the output voltage could be detected on both analogue and 3½-digit voltmeters with change of supply voltage from 150V to 250V and with sudden application of a 100mA load. Tr4 and IC3 comprise the constant-current section, R6 is the current sensing resistor. By choosing the appropriate value of R6, or switching different values, the required current range is obtained.

The voltage drop across R6, which equals Vref 2, was chosen to be about 0.7V so that the error in voltage measurement will not exceed this value plus the drop in the amplifier circuit, a total of less than 1V. A multi-turn potentiometer to obtain Vref 2 enabled accurate current adjustment.

Capacitors C1 and C2 suppress oscillations that would otherwise occur; D1 and D2 protect Tr3 and Tr4 from possible negative voltages that may occur due to switching transients. Switching R2 during operation proved to be of no harm, but IC2 may need some extra protection if intermittent loading with outputs greater than 30V is used frequently (a diode between pins 3 and 7 might help). Ed.

Honore A. Ela
Gulf University
Egypt

Glitch detector

Using two fast monostable multivibrators, such as e.g. MC10198's, it is possible to detect extremely short glitches. These devices provide a very short pulse, but although the pulse is short, it is at least twice as long as anticipated glitches. As the timing diagram shows, normal pulses are rejected using an AND gate.

D. Vainetto
Castelletto
Italy
DIGITAL-FILTER DESIGN

In the next few years digital filters will be increasingly used in place of their analogue counterparts, not only on account of their accuracy and versatility but also their rapid development. B.M. G. Cheetham and Hughes introduce the basic theory in this article, give design techniques for a useful class of filters, and describe their implementation by special-purpose microprocessor in a third article.

by B. M. G. Cheetham and P. Hughes

The importance of digital filters as devices for processing digital signals is rapidly increasing now with the introduction of special-purpose microprocessors and integrated circuits specifically designed for signal processing. Using the natural processing power of such circuits, digital filters are able to perform operations corresponding to those of analogue filters. For example, the Int-2920 analogue signal processor with its analogue/digital converters acts as a one-chip replacement for an analogue filter.

In addition to their uses in emulating the frequency responses of established forms of analogue filters, digital filters have a wide range of other applications which take advantage of the much greater power and flexibility of numerical processing as compared with analogue methods, and which may not easily be described as having a particular type of frequency response. Digital filters may not originate from analogue sources, and numerous generated and encountered in many applications. In developing the basic theory of digital filters, therefore, it is best to consider them as general devices for processing sequences of numerical data rather than as digital realizations of analogue filters. But before doing this, this article briefly considers the sampling process often used to produce digital signals and introduces notation for representing such signals.

Voltage levels as electrical pulses at the sampling instants, and low-pass filtering to remove frequencies above and below the Nyquist limit. In practice, the sampling rate employed for analogue to digital conversion is normally considerably greater than twice the highest frequency of interest to ensure that the analogue low-pass filter required may be relatively simple and inexpensive.

A digital signal may be subjected to numerical operations such as addition, subtraction and multiplication by passing the digital representation (a sequence of numbers referred to as samples) through some form of digital processing system. Such a system could be a program implemented on a mainframe scientific research computer normally used to process blocks of stored digital signal samples for analysis some time later. Alternatively, the system may be a piece of special-purpose hardware consisting of some digital integrated circuits or a microprocessor. With such a dedicated hardware system the processing may be carried out in real time so that an output signal is generated as an uninterrupted stream of values with a fixed delay between each input sample and its corresponding output sample. In this case the digital system, with associated analogue to digital converters, may act as a direct replacement for an analogue system such as a filter or a modulator.

Digital filtering processes can be designed to carry out a very wide range of operations on digital signals. A digital filter is a processing system which generates the output sequence (y(n)) from an input sequence (x(n)) at time nT for −∞ < n < ∞. This is a difference equation of order M or N, which is one of the filters in which a signal is said to be recursive as previous output sequences are used in the calculation of the present output sequence. Coefficients of the delay taps are fixed (time invariant) multiplication constants which characterize the effect of the filter. The design of a useful digital filter requires the production of a filter description, a method of implementing the description, and an example for a class of digital filters is given in a subsequent article.

Consider the digital filter described by the first-order difference equation

\[ y(n) = x(n) + by(n-1) \]

where b is a constant. This filter is shown in diagrammatic form in Fig. 1.1. If only bounded input and output sequences are allowed, it may be shown that the filter described by the difference equation is stable in the sense that the sequence (y(n)) and (x(n)) produce outputs (y(n)) and (x(n)) which remain bounded and have a definite response to \(\lambda x(n) + \mu y(n-1)\) will be \(|\lambda| < |b|\), for all values of \(\lambda\) and \(\mu\).

Fig. 1. First-order digital filter applies numerical operations to sampled input signal (x(n)) to produce output signal (y(n)).

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The impulse response of a filter therefore provides a complete characterization of its behaviour, allowing the response to any input signal to be deduced from these two equations.

Alternative characteristic

An alternative method of characterizing a digital filter is to specify its effect on sinusoidal input over a range of different frequencies. A fundamental property of fixed linear systems is that their steady-state response to a sinusoidal input is a sinusoidal output of identical frequency but modified amplitude and phase. Define a sinusoidal sequence of angular frequency \(\omega\) as the sampled sequence of a sinusoidal function of frequency \(\omega\). Then for \(\omega = 2\pi n T\) for example (\(\omega\) is a constant), the response of a filter to sinusoidal input is completely characterized by the ratio of the output sequence to the input sequence, shown as

\[ M_{\text{in}} = \frac{y(n)}{x(n)} = |H(\omega)| \angle \phi(\omega) \]

Hence the modulus and argument of the complex transfer function \(H(\omega)\) may give the gain and phase shift of the filter output relative to a sinusoidal input of radian frequency \(\omega\). Bearing in mind that

\[ y(n) = x(n) + by(n-1) \]
The z-transform of the sequence \( x(n) \) is defined as the infinite sum

\[
X(z) = \sum_{n=-\infty}^{\infty} x(n)z^{-n}
\]

for a complex variable \( z \). Notice the similarity between this expression and equation 1, setting \( z = e^{j\omega} \) gives \( X(e^{j\omega}) \) as the Fourier transform of \( x(n) \). The z-transform of the impulse response \( h(n) \) is \( H(z) \) and hence the setting of \( z = e^{j\omega} \) in this case gives the Fourier transform already defined as \( H(e^{j\omega}) \). The equation above may therefore be thought of as a generalization of the Fourier transform. Also, the z-transform of the delayed sequence \( x(n-1) \) is \( z^{-1}X(z) \) as each coefficient of \( z^{-1} \) is shifted along one place. In general the z-transform of \( x(n-k) \) is \( z^{-k}X(z) \). Also notice that the z-transform of the impulse \( (\delta(n)) \) is \( 1/z \).

Applying the z-transform to the output of a digital filter as defined by equation 1 gives

\[
Y(z) = \sum_{n=0}^{\infty} a_nX(z) = \sum_{n=1}^{\infty} h(n-z)Y(z)
\]

which may be rearranged and expressed in the form

\[
Y(z) = \left[ \sum_{n=0}^{N} a_nz^{-n} \right] \left[ \sum_{j=1}^{\infty} h(jz) \right]X(z)
\]

The expression in square brackets above is equal to \( H(z) \) as if the input sequence \( x(n) = (\delta(n)) \) then \( Y(z) \) becomes equal to the z-transform of the impulse response. Hence \( H(z) \) may be expressed directly in terms of the multiplier coefficients, and the frequency response may be obtained directly from this expression by setting \( z = e^{j\omega} \). This may be verified for the simple filter defined by equation 2 where \( H(z) = 1/(1-\beta z^{-1}) \) and hence an expression for \( H(e^{j\omega}) \) identical to equation 7.

The transfer function of a filter, \( H(z) \), has now been expressed as the ratio of two polynomial expressions in \( z^{-1} \). The roots of which are the poles and zeros of \( H(z) \). Hence

\[
H(z) = \frac{M}{N} \left( \sum_{i=1}^{M} a_i z^{-i} \right) \left( \sum_{j=1}^{N} b_j z^{-j} \right) \quad (8)
\]

assuming \( a_0 = 1 \), where the poles are \( p_i \) and the zeros by \( z \). Expanding by partial fractions (assuming there are no repeated roots other than at \( z = 0 \))

\[
H(z) = \sum_{i=1}^{M} \frac{M}{\prod_{k=1}^{M} (z-p_k z^{-1})} \quad (9)
\]

which expresses \( H(z) \) as the weighted sum of sequences whose z-transforms are \( z^{-i} \) and \( 1/(1-\beta z^{-1}) \). Clearly \( z^{-1} \) corresponds to a delayed impulse \( (\delta(n-i)) \). By referring back to the example of a first-order filter whose transfer function is \( 1/(1-\beta z^{-1}) \) it may be deduced that \( 1/(1-\beta z^{-1}) \) is the z-transform of an exponential sequence of the form

\[
\ldots, 0, 1, \beta, \beta^2, \ldots, \beta^i, \ldots \quad (9)
\]

The roots of a polynomial may of course be complex numbers and therefore the sequences above may be complex. As complex roots occur in conjugate pairs, the sequence obtained for \( h(n) \) is always real. A non-recursive filter, i.e. one with \( N = 0 \), will have an impulse response with \( h(n) = B_0 \delta(n) \) for \( \delta(n) \) the unit step function and zero otherwise. Such an impulse response is termed finite duration for this class of filters.

For a complex variable \( z \), the frequency response may be obtained by expression \( H(z) \) in terms of the multiplication coefficients, and the frequency response may be obtained directly from this expression by setting \( z = e^{j\omega} \). Consequently zeros close to the unit circle correspond to frequencies for which \( H(e^{j\omega}) \) is close to zero. Poles close to the unit circle produce large values of \( H(e^{j\omega}) \), the closer the pole, the larger the modulus. Such poles can also affect \( \phi(z) \) resulting in severe phase non-linearity.

The design of digital filters with specified frequency responses is often carried out by locating zeros and poles at appropriate points on the z-plane. Design techniques exist for both recursive and non-recursive filters: refer for details to any of the standard references, some of which are listed below. Non-recursive filters are peculiar in having a certain number of arithmetic operations which could make them more difficult to implement. Recursive filters are perhaps still more commonly used, and therefore the next article will introduce a design procedure for this class of filters.

**Further reading**

A CHARTER FOR ISOLATION

I was impressed by the first editorial "A Charter for Isolation" in the December issue:

"It saves us, says Hartley, with a 'conception of our engineer in no more than a high-grade technician, a functionary not fully professional...

This conforms to a view held in this country in a previous age - 1930-50. But it surprises me that you did not correlate the holding of this view with the photo on page 27 of that issue, where "engineer practice climbing on three short poles". By our definitions, if British engineers still spend time climbing poles then we would have to say they are technicians.

The engineering profession downgraded itself for too long to be accepting such jobs, even in training, besides who can afford such at present. It is true that their survival salaries of US $22,000 or the hambachts? J. D. Ryder, formerly Dean of Engineering, Michigan State University.

THE DEATH OF ELECTRICAL CURRENT

Ivor Can't's letter in the February issue only serves to illustrate the deficiencies in his knowledge of mathematics and conventional EM theory and the confusion of his own theory.

Can he not see that \( E = \nabla \times B \) is wrong and \( H = \nabla \times E \) is right for mathematical reasons? This is not just a matter of notation, it does not correctly describe the true physics of magnetism but at least it is dimensionally sound.

His difficulty with step waveforms on transmission lines becomes clearer. Of course the conduction and displacement currents are both present in the line together, but only the wave advances. The displacement current \( dI/dt \) is associated with the wave front only \( (d = \text{const. elsewhere}) \). If the wave reaches a (correct) resistive terminus \( dI/dt \) ceases, the step is terminated and the resistor absorbs the energy in the wave. It is precisely because the displacement current flows across the transmission line that the wave is called a transverse EM wave and the displacement current is distinct from the conduction current. The energy associated with the displacement current is stored and can be recovered later (cf. radar pulse generation). It can be seen from Mr. Can't's own illustration (fig. 3, p. 68 March, 1979) that the E vector \( dI/dt \) and the displacement current vector \( dI/dt \) are at right angles, therefore \( E \cdot H \) is purely reactive. This is analogous with reactive power \( \text{VA} \) where current and voltage are 90° out of phase. The \( H \) vector associated with the conduction current is also at 90° to the \( E \) field and again no energy is dissipated, the power is lost in the direction of the conduction current. In a third case, the transmission line is resistive and there is a component of the \( E \) field along the line in a direction opposite to the current flow. Here some of the power is dissipated.

Mr. Can't is further confused with regard to electric charge. The existence of electric charge is not a theory; it is a fact like the sun and coals in South Wales. Since one of the manifestations of electric charge is electric potential, any theory of electromagnetic theory that dispenses with electric charge must be rejected. Is it the objective of

ED theory to explain the various manifestations of electric charge?

Mr. Can't's mathematics is wrong; he does not understand the application of vectors to TEM waves and he does not distinguish fact from fiction. I'm sorry if he believes his version of Maxwell is correct - it isn't. If he was right he would be the only physicist on the planet who believes some changes would indeed be needed and radio would not work.

Dermot O'Reilly, Antwerp, Belgium.

RECHARGING DRY CELLS

With reference to the letter from Mr. D. F. Caulfield (Letter, August 1983) I should like to offer my findings on the subject, and also explain much information from the author.

I have been using the same SP2 cells for about 11 weeks, five days a week, approximately 1 hour per day. At first I would recharge them (using the circuit and method due to Mr. Caulfield) for an hour or two, twice a week but now I need to re-charge every day for about 3-5 hours to get an hour's use from the cells. Although I am convinced that the method is feasible in practice, I do not seem to have had the same success as Mr. Caulfield, and so I would like to hear from Mr. Caulfield his recommendations about charging, i.e., with how long for.


LINEAR POWER AMPLIFIER

Operation of the output transistors at an appropriately constant low voltage, as recommended by D. Rawson-Harris (Letter, Jan. 1982, p. 400), can be used to give a class-A amplifier which remains to a considerable extent the efficiency of a class-B amplifier.

The low-voltage transistors are operated in class A from a low-voltage supply, perhaps +5, 0, -2 as suggested by Mr. Rawson-Harris, and this supply is carried up and down by a class B amplifier of gain +1. The class A amplifier produces noticeable crossover distortion; but as the effect of the distortion (or error) is only a small modulation of the almost constant voltage of the class A transistor its effect on the performance of the complete amplifier may be expected to be very small. An outline of the system is shown in the diagram.

As a piece of engineering the system cannot be rated very highly: Peter Walker's Quad amplifiers are much simpler, and their distortion is so low that they sound like a piece of wire. But the economics of producing an amplifier may be different for the amateur constructor and experimenter, and this alternative class-A system may prove to be of interest. It has been used in some expensive Japanese amplifiers, but may be new to many World Wide readers.

To cope with increased demand WE HAVE MOVED

GP Industrial Electronics Ltd.
Unit E, Huxley Close
Newnham Industrial Estate
Plymouth PL7 4JN
Tel: Plymouth (0752) 332961

WIRELESS WORLD MAY 1982
CLANDESTINE RADIO

Pat Hawker’s review in the January and February, 1962 issues ably covers an arm of interest to a number of amateurs who are mentioned in the many books dealing with Resistance and Intelligence activity in World War II. Inevitably, in a collection from many sources, errors appear and among many statements of fact, one finds items which are the opinions or speculations of a particular source. Some corrections should be made here. I would like to contribute to a valuable summary.

SOF began to design and make radio equipment before mid-1942, particularly the Type A Mk I. William Hayward, the designer, was the completion of the B Mk I. This set was produced by the Coles company of York, England, in quantity believed to well over 1,000. Many were shipped to Resistance workers in other areas of Occupied Europe, but details of where and how many are not available. The modulated form of the A Mk I, like that of the later B Mk I, was to be assembled in essential to variable-frequency transport and, as well service by substitution.

The demand for a single-piece unit of the smallest size led to the re-engineering of the earlier Type 115 to the Type 125, which had become available. Volume production from about the end of November 1942, I believe, over 600.

The “A” series was designed for short-range or local circuits. It was not designed in particular, as a long-wave set, typically used, positively banned, and entirely powered by a pedestrian set. The station was in two main groups. The technical tendency of a contract line led to the usual of use of the “A” set. It was a not uncommon in the mid-1950s.

The NEW ELECTRONICS

I am afraid that my own experiences with inventions is a closely similar to that described by Mr. Jasgot in the January issue. I have no echo of my own comments and experiences as I read through the usual JFR, reports on the many post-war usage.

I guess to find an interview with a few simple words about inventions, not to mention the many difficulties but to ensure that his understanding of the fundamental principles are adequate. In the situation, stick, pointed textbook answers are not expected but the right thing is achieving a certain answer is expected. At this stage of the interview the interviewees are likely to be reasonably frequent and have done a good job on telling themselves, so that the situation for both parties looks good.

My opening question starts with a battery feeding a capacitor through a resistance which can be used in series. Assuming the capacitor is discharged at time zero, how shall we compute the voltage across it? (with all the time we do not get to the second part (adding a series inductor or the third part (replacing the battery with a sine-wave generator). Perhaps the interviewee had performed too many operations. He probably was not too serious at all and guidance. Nevertheless one hopeful belief is that the first network with a sinusoidal input produced squelchers.

It is difficult explaining to the MD, that in spite of all possible paper qualifications of those already interviewed, further interviewing will be necessary.

N. A. Ham, St. Albans, Herts.

INTENTIONAL LOGIC SYMBOLS

In reply to Christopher Hudson, (Letters, Feb-Mar 1982) the question as to whether a NAND gate is performing the function of positive NAND or negative OR is to me as far as I am aware, a question of the same form as the cube of a block is half full or half empty.

One can say it is the fewer of the two facts about the truth table says so, but as before, I suppose that the designer of the circuit can have either completely different, although more frequently I think of a gale in terms of its truth table. The design of the gate does not have to be said in order to determine an intention, how can there be logic symbols?

Logic I and 0 are two states of complete equality of importance. In some expressions, a ‘clue’ on a flip-flop for example, may be responsible to one state rather than another, the binary state of the flip-flop, in no way depending on the signal feeding it.

Mr Hudson does not define what he means by the assertive state, I only can assume that he means the state which asserts the presence of the signal. In the case of the flip-flop ‘clear’ inputs, one could have assumed that the active and logical low-flip-flop connected to the same signal. How can the signal itself be thought of as having an assertive state? Mr Hudson illustrates the point himself in the mess he gets into over his Fig. 2. Essentially I say 1 or 0, or the select are equally assertive and I maintain that, far from being unusual, it represents the logical symbol.

In a practical design which may start out in the draft design as Fig. 1(a) may finish up in Fig. 1(b). The question is, is the two-input NOR performing the function of low-assertive NAND or high-assertive NOR? If Fig. 1(a) represents the intention then it is performing both. Should we draw it as 1? Why not, we are already being asked to show the outputs on flip-flops, tens or a few more symbolic logic symbols as before except that identical devices may have different symbols, that a connection may be broken with a naming ceremony in between and even to accept that an inherently unsymbolic device like a two-gate latch should be drawn as so to make it look asymmetric, (see, Camera, pp. 1198, December 1966) all state name the logic symbols.

The AND and OR names are a useful aid to memory as to the truth table of the symbol described. The predominance in practical logic of I and 0 as the only symbols is due to simplicity of the concept to the point where the naming of the symbol is a secondary consideration.

Logic symbols are an attempt to restore the original simplicity. Mr Hudson’s letter is in my opinion, a demonstration that he does not understand how to do so.

The whole nature of symbolic logic symbols explain the fact that one is forced to live with negative and positive expressions of a function both AND and OR because we can redefine the OR function as the complement of the AND function. In other words the type of function that does not need a name, it is only necessary to define whether it is an assertive symbol or not an assertive one, hence an inverter. This is most easily achieved by putting the symbol in question with an assertive symbol, thus nothing need be committed to making a choice.

By way of a field test I introduced my 10 year old son to this subject, he had no trouble at all. We then followed the waveforms on any gate combination I gave him. (Previous knowledge of logic symbols it is necessary to define eight types of gate, with true symbol being an inverter). The simple example of a truth table and full definition. Symbolity is the name of the game.

L. Hayward

Twins PARADOX OF RELATIVITY

I refer to L. J. Higgins’ letter (April 1981) in which he discusses the ‘fundamental flaw’ and also of imagining a person in a spaceship, traveling at a velocity fraction.

The first is easily disposed of, since the assumptions of both the constancy of light and the constancy of the local clock of the person in question, but the second is perhaps less obvious and is the point of the paradox.

It is, as far as I can see, mass is carried around with it, and if such an object is moving relative to you, it is, inevitably, velocity-invariant as well.

To turn the derivation of the famous equation into a different, in the basis that the light postulate is true.

But we must be cautious here because there is no alternative but to accept that the light postulate is false.

The fact that the experiment can actually produce a real effect in a vacuum is in itself a great piece of evidence. The pure vacuum is indeed a miraculous coincidence. Should anyone question the fact that E = MC² is not linked to material particles. In the absence of matter there is still a mathematical equation, I would point out that the mathematical equation is a mathematical equation that is, the formula is a mathematical equation.

L. J. Higgins suggests that these misprints and small typos about atomic experiments were entirely justified and invented.

There are many other experiments, where the matter has never, or at least, not been created. We are left with the distinct risk that this experiment is unique and there exists neither atomic nor experiment, no experiment.

A simple alternative has been provided to replace the theories. The hope that the two atomic sciences will emerge from behind their wall of icy silence and discuss the matter and that which has not been observed by I. C (Letters, Feb-Mar 1982) or Alex Jones, Watson - Diment.

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While these may at first seem attractive from an engineering or practical point of view, a circuit of this type can cause a good deal of confusion, particularly if the frequency is not exactly tuned. For instance, a 7400 NAND gate split up in a circuit such that part is used as a NOT circuit and the other part as an OR, and the remainder as inverters. Under these conditions we would expect the results in three different drawings for the same type of circuit, since the technique of testing the circuit drawing to a particular chip pack would have to be considerably different depending on the use.

In addition, an increasing number of complex devices have inputs in which clock high and low levels are not critical, so while some design is required to be not too sensitive to an input but not only a physical function which is never mentioned. If the wave form at all, it is the same as the other would respond in a new idea to the problem of confusing the wave form which would then yield the Newtonian energy equation as its result.

However, in reality the force is known to the lesser velocity C and hence the drawback of the force with a velocity which is modified by a second-order term - coincidentally identical to the Lorentz transform.

Electric beam and linear particle accelerator experiments prove quite conclusively that mass is velocity-invariant. If, as Mr Dow would have us believe, mass increase can be derived from E = MC² then either the mathematics or the derivation is in error. And it can be falsified by experiment.

L. Hayward

Wireless

TOOTHLESSNESS OF RELATIVITY

The first is easily disposed of, since the assumptions of both the constancy of light and the constancy of the local clock of the person in question, but the second is perhaps less obvious and is the point of the paradox.

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L. J. Higgins suggests that these misprints and small typos about atomic experiments were entirely justified and invented.

There are many other experiments, where the matter has never, or at least, not been created. We are left with the distinct risk that this experiment is unique and there exists neither atomic nor experiment, no experiment.

A simple alternative has been provided to replace the theories. The hope that the two atomic sciences will emerge from behind their wall of icy silence and discuss the matter and that which has not been observed by I. C (Letters, Feb-Mar 1982) or Alex Jones, Watson - Diment.

WIRELESS WORLD MAY 1982

I disagree with your correspondent, C. Hudson, even in the complex field of logic design.
LETTERS

AMATEUR LICENCES IN GERMANY

Just in case nobody else objeets, may I correct A. S. Symes statement for your February issue.

Licence Morse Amateur bands

B 60 letters All amateur bands, most mode incoherent telephony except 1851-1832 and the new 10, 18, 24 MHz bands

C none v.h.f./h.f. only

H. Rosstäubli, Cologne, W. Germany.

POWER TRANSISTOR FAILURE

I have some pulse-width-modulated switching output power amplifiers which deliver up to 80 a at 700 v. All the transistors have failed. There have been some reported problems with thermal stress and gate-to-case shorts but these are not applicable. I believe that the cause of the problem is the high dV/dt which occurs at the turn-off instant of the transistor. The circuit contains a large inductance and relatively low capacitance which causes the voltage across the transistor to rise sharply at turn-off. This results in a high current which exceeds the maximum rating of the transistor.

In some cases the transistors have failed by becoming shorted across one another. In other cases, they have failed by becoming open circuits.

I am interested in any information that you may have on this problem and would appreciate any suggestions for a solution.

Dr. B. G. Black, Manchester, England.

ORIGINS OF THE HIGH-POWER TRANSMITTER

It is now 90 years since Nicola Tesla delighted the Prime Minister of Europe with demonstrations of high-frequency discharge in gases. To obtain a voltage sufficiently high, he used what is now recognized as the resonant transformer with tuned primary and resonant secondary, to step up the voltage obtainable from a high-frequency alternator and power transformer. To the more critical eye of today, Tesla's circuit with its two spark gaps may seem a true over-complication; but he was also a man with a simpler apparatus and was able to produce a high-power frequency generator. 

Readers of your columns with the circuits of early wireless transmitters, for example, that of Poldie designed by Fleming in 1900, would undoubtedly recognize some sort of similarity. It may be that Tesla, or some other person, was to be given credit for the basic concept.


DORADO SOUNDBOARD DESIGN

Bernard Jones thoughtful letter (January, 1982) prompted me to re-examine my 1974 articles on loudspeaker design*, and in particular Fig. 18, the attention of this figure was to illustrate how a treble horn could be given a degree of directivity in the horizontal plane by a simple device, namely the addition of a slightly inclined front edge to the horn. The question posed was how could one predict the nature of this device. A simple solution is to consider the horn as an equivalent diffuse transmission source. Assume also for simplicity that it is a Gaussian distribution, and the component geometrical dimensions, in particular the mouth area, are included in a compound Poisson distribution. The error probability is then

\[ P = \frac{4\pi}{3\sqrt{2\pi}} \left( \frac{m}{2\pi} \right)^{3/2} \left( \frac{S}{m} \right) \]

where \( m \) is the number of the component values of the receiver and \( S \) is the number of measurements.

Dr. G. J. Dingle, 1909.

CARDIAGE AMPLIFICATION

Good grief, Mr Fret (Letters, September), how can you expect us to get your diagrams (2) and (3) without first suggesting the concept of pickup arm rigidity as an over-riding design concern of if you want to introduce figure-of-merit on the basis of bearing friction! It's not quite so simple a device as the infamous thermal transformer, or the vacuum tube, perhaps the APT design team should develop a new concept.

Keith Howard, Tunbridge Wells, Middlesex.

WIRELESS WORLD MAY 1982

Dr. Garrett concludes his review of receivers for optical fibre communication with the theory of digital reception and gives practical achievements with p-i-n diode/f.e.t. receivers

by Ian Garrett

This says where there exists there must be in optical power between the zero and one bits in terms of the noise (variances) and Q, which is related to the signal-to-noise ratio (in fact, 4Q²). The equation gives the value of Q needed for a given error rate. For P = 10⁻⁶, small changes in Q produce large changes in the error rate. For P = 10⁻⁵, Q errors arise from the far tails of the noise distribution and the small deviations are in the signal mean. That is why accurate models of noise statistics are important in optical systems. In fact the Gaussian approximation used here is successful at predicting the error rate at moderate signal-to-noise power, but is poor at giving the correct signal threshold level and the optimum average received power.

The theory of optical receivers enables calculation of m, Q, and N, in terms of the component values of the receiver. One can then predict the sensitivity of the receiver and model how it is affected by changes in receiver or system parameters. Details of analytical formula lies in the bibliography, and is only very the simplest case is considered here. If the received optical power is above a one-pulse and zero during a zero pulse, the pulse energy for a one-pulse is \( E_1 \) and for a zero pulse is \( E_0 \). The photocurrent (i) is then \( ngp/E \) during a one-pulse and zero during a zero pulse. When the equal power is received, the receiver front-end is a typical circuit shown in Fig. 9 with the bandwidth for noise analysis.

The output of the receiver is amplified by a limiting filter (H0) resulting in an output voltage \( V_{out} \), which under certain conditions can be

\[ V_{out} = \frac{i}{g} \]

The noise sources which contribute to \( g \) and \( i \) are the amplifier thermal noise, the amplifier fluctuations, thermal noise, and the shot noise on the lower order. The mean square noise voltage at the receiver output may be expressed as

\[ V_{out}^2 = (\Delta f/N)^2 \frac{2}{g} (A_{eq} + Z') \]

where \( Z' \) is the time base, \( f' \) is the current density, \( Z' \), and \( Z' \) are the noise density and the noise density.

Graduating from Trinity College, Cambridge in 1965, Ian Garrett completed a postgraduate research in the University of Reading Laboratories in 1968. He joined the Post Office Research Department, Ericsson British Telecom Research Laboratories, as a Research Fellow working on the theory of chemical reactions. In 1971 he became group leader responsible for the separation of compound semiconducting films and crystals. Since 1976 he has led a section responsible for optical transmitters and receivers and integrated optical devices.

WIRELESS WORLD MAY 1982

Fig. 1. in the filtered output pulse from an optical receiver, the shaded region indicates the variance (mean-square noise-voltage, shown to depend on signal level. Mean levels m, and m, correspond to one and one bits (spaces and pulses). Pulse is slightly displaced to show some energy is outside the bit-time T.

短期内这个文章到此为止，因为我们是使用自然语言阅读的，所以可能没有完整的文章。
More detailed treatments listed in the bibliography take into account the shape of the received pulse in the structure to neighbouring bit-times because of dispersion, and other system impairments, and give detailed expressions for Z in terms of the receiver components. Here consider a simple case first and then look at some of the results of the detailed theories.

Consider a p-i-n diode which has unity gain only. The quantum noise is insignificant, so from equation 2:

\[ I_{noise} = \sqrt{2kT_0B_c} \]

as from equation 1:

\[ I_{p-i-n} = 20 \log_{10} \frac{I_{noise}}{I} \]

With typical component values, Z might be 10^9. So with Q = 6, we need 12,000 photodetected electrons per one-pulse, in agreement with the earlier rough calculation. Using discrete components, a unity-gain photodiode has a receiver sensitivity typically 10 to 15 dB worse than an avalanche diode. However, by hybrid integrating the p-i-n diode with the first amplifier stage using a gallium arsenide a.m.f.s., the input capacitance of the receiver can be reduced so that Z falls to 10,000 or less. Our receiver noise parameter Z is proportional to C/\gamma, at high data rates C is the total input capacitance (photodiode, gate-source and stray capacitance) and \gamma is the transconductance. In state-of-the-art receivers, C is around 0.5 pF and \gamma is 20 ms. Such receivers have a sensitivity of -44 dBm at 160Mbaud and -40 dBm at 294Mbaud, at 1.3um wavelength, and sensitivity at 1.55um, better than that of a.p.d. receivers. The p-i-n-f.e.t. hybrid approach also offers advantages of low-voltage operation, no need for feedback to control the avalanche gain, simpler device technology, and probably greater reliability. Typical photodiodes, for use in p-i-n-f.e.t. receivers are shown in the first part of this article. The receiver uses a high impedance (integration) front-end amplifier for the lowest possible performance, although a trans-impedance amplifier could be used with a slight penalty. The integrating characteristics of a constant (typically 1000 times the bit period) to be equalized, which can be done by differentiating with a capacitor-resistor arrangement. Fig. 11 shows a typical receiver module.

More details on this technique can be found in the receiver the broken line connections and the peak detector and voltage regulator are only necessary if an avalanche photodiode is used to control the gain. Noise model of the receiver shows principal noise sources and equivalent filters (see text).

Fig. 10: In this typical circuit for an optical receiver the broken line connections and the peak detector and voltage regulator are only necessary if an avalanche photodiode is used to control the gain. Noise model of the receiver shows principal noise sources and equivalent filters (see text).

Look now at how the sensitivity is reduced by the reverse bias leakage of the photodiode. Fig. 12 shows some theoretical results for the mean number of photoelectrons required per bit time and optimum avalanche gain A as a function of the number N_d of dark current electrons per bit-time. Parameter x is the excess noise exponent of the a.p.d. and Fig. 13 is calculated assuming Z=10^9, typical of a receiver using discrete components at a few hundred Mbaud, and with zero optical power on zero-pulses and no pulse spreading.

It can be seen that when the dark current is negligible, we need about 300 to 1500 photons per bit-time, depending on the noise properties of the photodiode. When the dark current is large, the number of photons per bit-time which is needed is roughly proportional to the square root of the number of dark current electrons. The noise properties of the dark current are important. This is hardly surprising as the dominant noise is then the shot noise on the dark current, and both are subject to the excess noise of the photodiode. The optimum gain decreases markedly once the dark current becomes significant.

Clearly it is important to minimize N_d and to a lesser extent to reduce x. The leakage current of 160 nA gives N_d = 1000 at 1Gbaud, which is large enough to limit the useful gain and the overall noise sensitivity.

Clearly it is important to minimize N_d and to a lesser extent to reduce x. The leakage current of 160 nA gives N_d = 1000 at 1Gbaud, which is large enough to limit the useful gain and the overall noise sensitivity. At lower data rates the effect would be greater still.

Fig. 13 shows how x and n vary with extinction ratio e and pulse spreading (extension ratio) to the mean power, the zero-pulse divided by the mean power on one-pulse; if it is not zero the optical power on the zero level contributes to the noise level.

The pulse spreading is represented by x, the normalized r.m.s. width of the fibre impulse response, assumed to be gaussian. The pulse originally launched into the fibre is then reduced by having the light blocked and then occupying half the bit-time, and the dark current is assumed to be zero. Notice that the receiver sensitivity is strongly affected by pulse spreading and by zero extinction, and the optimum gain is reduced by zero-level noise and by fibre dispersion, the effect being greatest when x is small.

This type of calculation, which assumes gaussian noise statistics, tends to over-evaluate the optimum gain although subjective magnitudes are predicted more accurately. Obviously, combinations of appreciable pulse spreading, extinction ratio and considerable dark current (N_d=10000) reduces the receiver sensitivity very much, and also reduce the optimum avalanche gain to near unity.

Future developments

There are some obvious approaches to improving the sensitivity of present optical receivers. The p-i-n-f.e.t., currently the most suitable for the important wavelength range 1 to 1.6 mm, can be improved by reducing \gamma, which would be desirable for small-area photodiodes (30 mm diameter), very short f.e.t. gates (0.5 mm), and by increasing the transconductance. The mixed compound InGaAs may be a better f.e.t. material than GaAs in the future because of its high gain and speed. Nevertheless, particularly if it can be cooled, and it would also permit monolithic integration of the f.e.t., the photodiode, and eventually other receiver components. Between 5 and 6 components could be designed here. Avalanche photodiodes could offer other improvements, the least over present day p-i-n-f.e.t.s, if a low noise material could be found. Recent work on CdHgTe looks promising, though it is at an early stage of development yet.

A third possibility is to amplify the optical signal before detection, using a Fabry-Perot or a travelling-wave amplifier. These devices would be based on photodiodes and injection lasers; their biggest problems are noise due to spontaneous emission which can be reduced with a very narrow- band optical filter, and gain saturation in the case of the Fabry-Perot. An optical amplifier is an almost essential component for optical integration of any useful complexity, so there is considerable incentive to overcome these problems. Finally, one may consider coherent optical transmission systems with heterodyne detection. The outstanding problems here are: developing an optical source and local oscillator with sufficiently narrow line-width; tracking the local oscillator; obtaining spatial coherence of the signal and local oscillator when they are mixed on the photodiode; and controlling the phase relation of the receiver optical signal. The pay-off for overcoming this daunting list of problems is not only improved performance within the sensitivity (30 to 15 dB), but also the familiar advantages of using the frequency domain, which allow more quantitative information on the carrier which is present optical communication systems is lost.

Further reading


Receiver Design for digital fibre optic communication systems, by D. S. Pensonic.


In brief...
Satellite tv gets go-ahead

On the fourth of March, the Home Secretary, William Whitelaw, announced in the House of Commons that the country should make an early start with direct broadcasting by satellite (DBS), with the aim of having a service in operation by 1988. Because of the importance of making this early start, the Government had conducted a wide-ranging inquiry into the matter, involving two channels initially, though this could be increased later to the maximum of five channels permitted by the European convention. The information service would be transmitted at powers sufficient for individual homes to receive it with a high-reception equipment with some expenditure on reception and distribution costs. The system is to be financed privately, and there were indications that there were interested parties in the aerospace and electronics industries who were ready to pay a premium, as far as the programme was concerned.

As far as the programmes were concerned it had been decided to award DBS channel 2 to the BBC as they had already formulated proposals for the programmes for this channel. One channel would be a subscription service, focusing on the entertainment of feature films and major sport events, and another on news events not presently available for transmission through other channels. A second service, which would draw on the best programmes from around the world, and would probably be financed by a supplementary licence fee, would be broadcast on channel 3, with the second on a standby and a third on the ground ready for launching. The Home Secretary said that the IBA and commercial television companies had also shown some interest in programmes on DBS, and “their plans were less advanced. Additionally, more time might be needed to devise the right framework, which would be likely to involve a licence fee.”

But the IBA say that their proposals for satellite broadcasting are as well prepared as any from the BBC, and could be transmitted on DBS before a terrestrial service. They say that the Home Office study document on DBS last year, the IBA has argued, was far too brief, including in particular the “quality of the service and the need for the uniform standard of programming” for the system. IBA engineers have spent two years working on the development of a satellite tracking system, which they claim is ready for transmission on a mobile basis, and they believe that the IBA could be ready to transmit on DBS within two years.
Sweden in space by 1984

Sweden’s Space Corporation is likely to be given the green light to conduct its first space research programme, more than double the 1970-80 figure. About half of this will be contributed to the European Space Agency where Sweden has become more actively involved in the programmes of research. But its national programme includes its own space research where the largest project in the Viking satellite, to be launched by Ariane in 1984 for North Pole magnetosphere studies, as well as the industrial Tele-X project. Due for launch in 1986 from Goynay Space Centre, South America, Tele-X is an experimental telecommunication satellite that will have pre-operational direct broadcast application. It will provide high-speed digital communication for inter-office links, a teletype service to enable trainee in vehicles, and propagation measurements in the 20-30GHz band for high-speed digital data communication, as well as wideband services.

Monitoring oil spills is the chief application of the Corporation’s other main program – in remote sensing. Marine surveillance from aircraft determines oil thickness and volume, a microwave radiometer while a laser fluorometer classifies oil type, this information being transmitted to oil control vehicles. Remote sensors also monitor water ice distribution and thickness, atmospheric pollution and map vegetation, deserts and lake water to study seasonal changes.

The Corporation manages the European station which receives, processes, stores and distributes images from satellites in the Earthsat scheme, and regularly collects data from Landsat. The station conducts ionospheric sounding to improve meteorological data density (see WFW February issue, page 37).

Where is Chernobylskiy?

The position of the Russian electronics engineer Boris Chernobylskiy who, as we reported in October 1981, was being harassed by the KGB, is giving his wife Elena great cause for alarm. A telephone call and an arrest on a relatively trivial charge (biting a policeman) Chernobylskiy was sentenced to one year’s imprisonment and to five-year suspended sentence.

Ministry of Defence is of the view that the sentence was unduly severe, and is now discussing the case with the indium five-year sentence. His wife was in fact hospitalized while in prison, and then was taken ill in a hospital. She is not well. She is not well. She is not well. She is not well.

On entering the program one is given the system options and prompted to reply to either Yes (yes) or No. Next the addresses are searched to ensure that the program starts loading, starting from 0000. If the e.p.r.o.m. already has data in the first 256 locations the start address is set at 0000. The program does not even check whether it is intended to reside at some other address. The start address is displayed on the monitor screen. When sufficient information has been given the program requests you to press the e.p.r.o.m. which shows the ease of using the e.p.r.o.m. mode 0. (Anther numbers in the control register will cause all kinds of trouble.)

The program will be useful since it is often referred to as the software for the program. The "loop left" is loaded with the value of the loops at location A and decremented on starting at the first e.p.r.o.m. address i.e. when CAP is set to the address at 14. In a case of 0000, this will now return from a value greater than 1, so the same addresses must be programmed again. The start address is then set to zero. You are now reading an e.p.r.o.m. whether dumping the contents into r.a.m. or checking a program cycle, the loop facility is not needed as the program will exist when both CAP or e.p.r.o.m. reach the respective addresses. You can have the program emptying that is the smaller number of locations will cause the program to exist. The last three locations

by H. S. Lyes

access memory addresses determine the area of the system memory that will be written to or read from. The e.p.r.o.m. starts first and the correct place is added to. This is not to be done with 2708s as already explained. The control word is either 80 (port B is output, so e.p.r.o.m.) or 82 (port B is input, so read e.p.r.o.m.) which shows the ease of using the 8255 in mode 0. (Other numbers in the control register will cause all kinds of trouble.)

The shorthand CAD and CAP were useful since they are often referred to. The software for the program is the "loop left" is loaded with the value of the loops at location A and decremented on starting at the first e.p.r.o.m. address i.e. when CAP is set to the address at 14. In a case of 0000, this will now return from a value greater than 1, so the same addresses must be programmed again. The start address is then set to zero. You are now reading an e.p.r.o.m. whether dumping the contents into r.a.m. or checking a program cycle, the loop facility is not needed as the program will exist when both CAP or e.p.r.o.m. reach the respective addresses. You can have the program emptying that is the smaller number of locations will cause the program to exist. The last three locations

Scratchpad data defined. Location of the scratchpad is at the option of the programmer.

| 0, 1, 2, 3 | Device code in ASCII |
| 4, 5 | EOT control and blank |
| 6 | 'read' |
| 7 | 'program' |
| 8 | 'pulse-out' |

| 1 | Loop = 1 except for 2708 = hex equivalent of 200 |
| 2 | Normally blank, except during verify |
| 3 | Accumulator, could be used to check 'space available' |
| 4 | delay = pulse time |
| 5 | r.a.m. start address |
| 6 | r.a.m. finish |
| 7 | e.p.r.o.m. start |
| 8 | e.p.r.o.m. finish |
| 9 | 8255 control word |
| 10 | Current address data (CAD) |
| 11 | Current address (e.p.r.o.m. (CAP) |
| 12 | Loops left |
| 13 | Error status - in hex (could be converted to ASCII if screen display is required) |

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Programming. This is more difficult, since the e.p.r.o.m needs to be given a program pulse for a defined time. An external voltage is required, about 20VDC to the control register at X503. The starting address of the e.p.r.o.m is placed in the address ports A and C. The control pin-profile is OR-ed with the address in port C and the data received in e.p.r.o.m. from the address of port B. This is stored in the area of memory pointed to by CAD using the indexed mode of addressing. CAD and CAP are checked to make sure they are not outside limits and only then will they be incremented until the e.p.r.o.m data is placed in system r.a.m.

The time taken is short, but is not possible to run a program from a e.p.r.o.m. in the programmer without some considerable delay and a dedicated program to do it. In my system a facility exists to move some of the system r.a.m. having the new start address on d.i.i. switches. Thus by moving a toggle switch the r.a.m. can be made to behave though it was a programmed e.p.r.o.m., residing at the same address as the e.p.r.o.m. will in the finished system. This may be write-protected if desired. Ensure that only one device is enabled when shift-

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### Fig. 7. In the prototype programmable board a diode in the ground returns any current from the programming board together with e.i.t. socket, d.i.i. switch and programming pulse jack socket. The diode in the regulator's ground lead raises the voltage. The current limiting at 50mA is used with care, which should never be less than 26V and with no overload. The diode is at the junction of the two elements at 5 or 25.2V, depending on the program to be programmed.

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Take care in the design of a close-fitting lid on to prevent the presence of u.v. burns to eyes or skin. It is a nice cue to note to include an interlock which breaks the power from the board if the lid (or any other cover) is removed later. Arrange the address routines as a subroutine so they may be used in later designs.

Infrequent users may find some advantage in making use of a 37-way D - connector and a small plug-in p.c.b. with the socket on it. This is only plugged in when an e.p.r.o.m. is to be programmed or read. The diagram shows the wiring for the d.i.i. switches connected to pins 18-21, Fig. 6 is essential that u.v. lamps are suitable for the low-power duty that is required. Protect the wiring with this p.c.b. from the heat conducted to one piece of copper laminate is ideal for the purpose as it may be connected to 0V.

Erasing e.p.r.o.m.s. It is essential that e.p.r.o.m.s are correctly erased before programming is started. This means exposing them to a "hard" ultra-violet light for a period of 5 and 20 minutes, depending on the strength and duration of the suitable source. So-called u.v. tubes with fluorescent coatings inside glass will not be satisfactory; this rule also applies to the tubes and soft tubes used to generate art. The correct tubes are usually small, made as a quartz and contains a quartz and permits the transmission of the mercury-vapor excitation of 253.7 A. Although satisfactory erasers are available commercially, you may be tempted to make your own using a replacing tube.

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### April 25

**The Computer Fair, at Earl's Court, (sponsored by Practical Computing and Your Computer).**

Details from Exhibition Manager, IPC Exhibitions Ltd, Surrey House, 1 Thershway Way, Sutton, Surrey, England.

**April 25**

Artificial satellite of navigation: IAEE conference. Imperial College, London SW7.

Details from: Dr. T. S. Durrani, Department of Electronic Science and Tele communications, University of Strathclyde, Glasgow G1 1XW.

**April 30**

Up-to-date applications of dataview systems: IEIEEE-colloquium.

**May 4**


**May 4**

Human factors in word processing: IEIEEE-colloquium.

**May 6**


**May 7**

Digital effects: IEIEEE Younger Member's lecture. Ship Hotel, Duke Street, Reading, Berks.

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Although I recommend that the output waveform is checked. The I.e.d. is illuminated when the output is at high potential, which should be typically 26V to ensure that the minimum swing of 2V is met. Reset logic prevents unwanted voltage appearing on the e.p.r.o.m. when an output port is connected to a programmable device and could be used to perform some other function. Personally I like to have ports at logic 0 meaning no output.
Within 80ms a mass of 1/4kg can be moved a distance of four inches and stopped to within a quarter micron of a specified point — this article shows how.

In any positioning system the most crucial components are the prime mover and the transducer used to describe the position and velocity of the element under control. Here, the main features of disc-drive positioners, including feedback loops and control circuits, are described.

With the exception of fixed head and Winchester-type disc drives, the read/write heads are mounted on a rigid platform called the carriage. This carriage has one degree of freedom radial to the drive spindle and is restricted by guideways, usually in the form of rails or bars, in most cases, the carriage runs on ball bearings, one or more of which is spring loaded to take up play and ensure that the bearings roll instead of skidding. Not all carriages run on ball bearings — some run directly on the guideway — but the way in which four types of those that do are constructed is shown in Fig. 1. Rotary positioners, such as those used in Winchester disc drives, will be described in a subsequent article.

In multi-platter drives, the heads are usually mounted side-by-side between the platters to reduce the overall height of the pack and minimize the weight of the carriage. The part of the carriage to which the heads are attached is often called the T-block because more often than not it is T-shaped. For convenience, the two sides of the T-block are designated A and B, and each side will have upward and downward facing heads. So in this case there are four read/write head labels: A-up, A-down, B-up and B-down. A and B heads designed for opposite directions are similar in appearance but if they are mistakenly interchanged, slipper servomechanisms will be affected, so the head type is usually clearly marked. Slots in the T-block allow radial adjustment of the heads.

As the heads are in two rows, it is vital that the centre line along which the carriage travels is precisely on the disc radius. Figure 2 shows why. Alignment fixtures provided with the drives allow the heads to be accurately aligned and, equally important, keep the head adjustment standard between drives using interchangeable discs.

Motive power

There are three main methods of driving the carriage —

- hydraulically
- by moving coil
- or by electric motor.

Hydraulics. The first moving-head disc drives stored data at very low density by modern standards, so if large amounts of data had to be stored, large discs had to be used. Some of these discs measured several feet in diameter. The carriage was equally large, and the only practical way of moving it was by hydraulics. Much research into hydraulic systems for applications such as aircraft and missiles has already been carried out so the design of a system for driving the carriage of a disc drive was simplified.

Figure 3(a) shows the essentials of an hydraulically powered positioner, in which the pump is driven by the spindle motor or by a separate motor. The carriage is required for rapid seek, when the peak-flow requirement is greater than the pump can deliver; the analogy with a power-supply capacitor is clear. Fluid pressure is regulated by a bypass valve, the fluid equivalent of a zener diode and a series of solenoid-operated valves with calibrated orifices are used to move the carriage at different speeds. Some drives with hydraulic positioners would move from their position in the computer room, because of the reaction from fast carriage acceleration, and had to be moved back into place from time to time. Behe­

moth drives had two parallel spindles with opposed positioners between them to cancel out this effect, Fig. 3(b).

Moving coil. As head and medium design improved the storage density increased, allowing the platters to be made smaller. This made the carriage smaller and lighter so less power was required to move it. At the same time, advances in semiconductor technology brought down the price of power transistors. It thus became feasible to use a moving coil to drive the carriage, with the further weight reduction of the carriage that the principle allows being used to reduce access time.

A typical coil has a diameter of three inches and works in the radial flux from a permanent magnet weighing about 50 pounds. Smaller drives use a copper wire coil on a glass fibre former, but larger units may use self-supporting coils wound from rectangular-section aluminium strip. Aluminium has a higher strength-to-weight ratio than copper, and this consideration outweighs the disadvantage of higher resis­

Fig. 1. Four methods used for mounting disc-drive positioner carriages. Common purpose of these is to allow only one degree of freedom, ideally along radius of the disc.

Fig. 2. Mounting read/write heads side-by-side in multi-platter drive reduces height of the disc pack and hence weight moved by the positioner, but alignment between carriage centre line and disc radius becomes more critical. Here, the heads are aligned at track A and the error caused by carriage track radius misalignment becomes apparent at B.

* B.Sc., M.Sc., Digital Equipment Co.

by J. R. Watkinson

Fig. 3. Essential elements of an hydraulic positioner are shown at (a), in which the pressure from the fluid pump is regulated by a bypass valve and control signals from the disc drive logic operate solenoid valves in the control block. Accumulator permits high peak-flow rates without large pressure fluctuations. In (b), two opposed positioners are used to cancel out reactions caused by fast carriage acceleration.

Disc drive positioners

Fig. 3(a) shows the essentials of an hydraulic positioner are shown at (a), in which the pressure from the fluid pump is regulated by a bypass valve and control signals from the disc drive logic operate solenoid valves in the control block. Accumulator permits high peak-flow rates without large pressure fluctuations. In (b), two opposed positioners are used to cancel out reactions caused by fast carriage acceleration.

Electric motor drive. There are two main types one is as shown in Fig. 5. In the first, the motor drives a lead-screw which moves the carriage as it turns. In some cases a stepping motor is used, where the stable positions of the rotor correspond to the positions of disc cylinders.
The motor in the second type drives a drum which imparts linear motion to the carriage through flexible steel wires. These two types are normally used only in small drives.

Detenting
When the carriage is held at rest with the heads correctly aligned above the disk tracks, it is said to be detented. Early drives used mechanical detenting where pawls on a detent actuator move to engage a rack on the carriage. Figure 6 shows a two-phase detent mechanism, where the spacing between cylinders is one half the rack pitch. Mechanical detenting can be found on both hydraulic and moving coil positioners, and the pawl will be operated by a ram in the former case, or by a solenoid in the latter. The teeth on the rack are symmetrical so that after the detent has engaged, some forward drive can be applied to take up any backlash without fear of the pawl jumping out of engagement. The detent actuator is a fine piece of precision engineering, and as such is expensive. Recent drives take advantage of the falling cost of electronic circuitry and employ electrical stepping, where the carriage is held by a feedback loop using a position transducer. Should for any reason the position loop fail itself off track, the position transducer generates an error voltage which will drive the carriage until the error is cancelled. When operating in this way the carriage servo system is said to be in detent mode, track following mode, fine mode or linear mode, depending on the specific documentation consulted. During a seek, the servo system changes to velocity mode, also known as coarse mode. These are the two major operating modes of the servo.

Transducers
The purpose of a transducer will be one or more of the following:
- To count the number of cylinders crossed during a seek,
- To generate a signal proportional to carriage position,
- Or to generate a position error proportional to the distance from the centre of the desired track.

Fig. 8. Optical velocity transducer. Four quadrature signals are produced from two-phase transducer. Each of these is differentiated, and the four derivatives are selected one at a time by analog switches. This process results in a continuous analog output voltage proportional to the slope of the transducer waveform, which is itself proportional to carriage velocity. In some drives one of the transducer signals may also be used to count cylinder crossings during a seek and to provide a position error for detenting.

Sometimes the same transducer will be used to provide all three signals. For this reason, transducers are best classified by principle of operation, rather than by function.

Magnetic transducers. These are of two types:
- Moving coil
- Moving magnet
- Carrier wave

The first two types simply give an output proportional to the rate of change of flux. The only difference is whether the coil or the flux moves. Moving-magnet types often have the coil concentric with the actuator, which provides good noise shielding. Moving-coil types sometimes have a bucking coil connected in phase opposition to cancel out induced noise. These two types of transducer only generate a velocity signal, but have the advantage that no precision alignment is necessary, a working clearance is all that is required.

The third type is illustrated in Fig. 7. The path of the transducer is completed by a rack on the carriage, often the same one as is used by the detent actuator. As the rack moves, the reluctance of the two limbs will rise and fall, and so the secondary coils are wound in opposition to each other, the output will be alternately in and out of phase with the input. A phase-sensitive rectifier gives a binary output which can be used to count cylinder crossings during a seek. As no accurate position error or velocity information can be extracted, this type of transducer is restricted to use in mechanical detent drives, in conjunction with a magnetic-velocity transducer. Adjustment of carrier-wave transducers is critical, as the signal becomes rapidly attenuated if the distance from the rack is too great, but the transducer may be damaged by the rack teeth if the clearance is too small.

Optical transducers. These devices consist of gratings, one fixed and one movable. The relative positions of the two will control the amount of light from an I.E.D. or bulb which can pass through to one or more photo-transistors. Referring to Fig. 8, it can be seen that this class of transducer falls into two categories:
- Moiré-fringe
- Parallel-grating.

In a Moiré-fringe transducer the bars on the moving grating are not parallel with the bars on the fixed grating. Relative movement causes a fringe pattern which travels at a right angle to the direction of motion. This results in sinusoidal modulation of the light beam.

In the second type, all the bars are parallel so the sensor's output is a triangle wave. In both types of optical transducer, the spacing between the two gratings is critical.

Whether the waveform used for counting cylinder crossings is sinusoidal or triangular is not important, so the choice between the two transducers is governed by whether a position error or a velocity signal is required. The slope of a sine wave is steeper in the zero region than an equivalent triangle wave so it is more useful for detection of position error. Conversely, the constant slope of a triangle wave is easily differentiated to produce a velocity signal. Because the differential of a triangle wave changes sign twice per cycle, a two-phase output can be generated to give a continuous velocity-output signal. The stationary grating has two sets of bars with a 90° phase relationship and the resultant

V. W. W. M. 1980
Fig. 11. In example (a), dissipation in the positioner is continuous, causing a heating problem. The effect of limiting the scheduled velocity above a certain cylinder difference is shown in (b), where heavy current only flows during acceleration and deceleration. In between, only enough current to overcome friction is required. Back to e.m.f. causes the curver acceleration slope.

waveforms are referred to as sin and cos, even if they are triangle waves. The two waveforms and their complements, known as sin — cos, are differentiated and the four differentials selected in turn at times when there is no sign change. This process of commutation is achieved by f.e.t. analogue switches controlled by comparators looking for points where the input waveforms cross. The result is a clean output signal proportional to velocity.

Where one transducer has to generate all three of the required parameters, Moire type gratings are preferable because of their better position-error detecting performance. A certain amount of ripple on the velocity output derived from a sinusoid has to be accepted.

Optical transcoders often contain additional light paths to aid carriage-travel limit detection. The resulting signals may be used during the head-loading sequence to position the heads at cylinder zero, as the sine or triangle outputs are cyclic and do not give an absolute cylinder address. Mechanical deterrent drives pose the problem of finding an absolute reference to the cyclic output from the rack transducer. One solution is to drive the carriage forward slowly until it contacts the forward stop, and then to preset the cylinder count to two or three cylinders more than the maximum.

Seeking

A seek is a process where the positioner moves from one cylinder to another. The speed with which a seek can be completed is a major factor in determining the access time of the drive. The main parameter controlling the carriage during a seek is the cylinder difference:

cylinder difference = desired address — current address.

The cylinder difference is a signed binary number representing the number of cylinders to be crossed to reach the target cylinder, direction being indicated by the sign. The cylinder difference is loaded into a counter which is decremented each time a cylinder is crossed. The counter drives a d-to-a converter which generates an analogue voltage proportional to the cylinder difference. As shown in Fig. 10 this voltage, known as the scheduled velocity, is compared with the output of the carriage-velocity transducer. Hence any difference between the two results in a velocity-error voltage, which is then used to reposition the carriage hence cancelling the error. As the carriage approaches the target cylinder, the cylinder difference becomes smaller with the result that the run-in to the target is critically damped (long a — distance) to eliminate overshoot.

Fig. 12. Voltage-dependent feedback around the operational amplifier permits a piecewise linear approximation to a curved velocity profile. This speeds up short seeks without causing dissipation problems on long seeks.

Fig. 13. Staircase from a d-to-a. smoothed by adding a sawtooth waveform.

Fig. 14. Comparison of velocity error with a sawtooth waveform resulting in a guide width modulated output which can be used to reduce dissipation in the servo amplifier.

Carriage acceleration, a, is = actuator current, i, and

$$a = \frac{2 \pi}{\sqrt{R}}$$

where $t$ is the seek time. Dissipation is $PR$, which is proportional to $a^2 R$

$$a^2 R \times \frac{2 \pi}{\sqrt{R}}$$

Average carriage velocity = 1/2t, therefore, dissipation

As a result, it is necessary to limit the maximum velocity of the positioner very accurately or severe overheating of the coil or amplifier may result.

A consequence of the critically damped run-in to the target cylinder is that short seeks are slow. Sometimes further non-linearity is introduced into the velocity scheduler to speed up short seeks. The velocity profile becomes a piecewise linear approximation to a curve by using non-linear feedback. Figure 12 shows the effect of using a shaper or profile generator, as this device is known.

Servo amplifiers

In small disk drives the amplifier is usually linear in all modes of operation, resembling nothing more than an audio output stage. As the scheduled velocity signal comes from a d-to-a. converter, the deceleration ramp is depicted by a staircase waveform. When the staircase is compared with the actual velocity signal, the resulting velocity-error signal contains an a.c. component due to the steps. This increases e.m.a. dissipation and can cause an audible output from the coil — a problem that is sometimes solved by adding a saw-tooth waveform, at the same rate as the steps, to the shaper output. This approach is shown in Fig. 13.

Larger units employ pulse-width modulation to reduce dissipation in the servo amplifier. The duty cycle is established typically by comparing the velocity error with a sawtooth waveform. A simplified example of this process is shown in Fig. 14. Appropriate electromagnetic radiation is caused by p.w.m. servo systems, but this is generally of no consequence as no data transfer takes place during a seek. In track-following mode, p.w.m. servos revert to a linear amplifier configuration, which is why the term linear mode is often used to describe the detented state of the positioner.

The input of the servo amplifier normally has a number of analogue switches which select the appropriate input according to the mode of the servo. As the output of the position transducer is a triangle or sine function, the sense of the position feedback loop has to be inverted on odd numbered cylinders, to allow detenting on the negative slope. In some cases a different velocity transducer is used when the heads are being retracted from the pack. Figure 15 shows a typical servo-amplifier input-selection circuit.

Fig. 15. Typical servo-amplifier input stage. In velocity mode, the shaper and velocity transducer drive the error amplifier. In track-following mode, position error is the only input.

In this photograph of a moving-coil transducer, the magnet under the coil can be seen clearly.

Fig. 16. Alignment disc has flux patterns displayed alternately about the centre line of the reference track. In the resulting oscilloscope waveform at (a), the head is too close to the spindle, and at (b), too far from the spindle, and at (c), in the correct position.
DESIGNING WITH MICROPROCESSORS

Linking a microprocessor with a printer directly is wasteful; much time can be saved by sending data to a buffer for reading at a slower rate. Professor Zissos concludes his series with two articles on programmable I/O chips, this first on basic concepts, and the second on design procedure and implementation.

by D. Zissos and Jane Fleus

every new item of data before it accepts: the pulse on handshake line h2 can be used directly for this.

In summary the step-by-step operation of the handshake system in Fig. 2 is as follows. The source monitors status line h1 to determine whether the port is full or empty. If empty, it outputs the next item of data and pulses line h2, which strobes the data into the port and sets the status flip-flop (hl = 1). The receiver, which monitors the status line h2, then strobes the data into its port. The handshake is closed when the port is full, and the source pulses h2 again.

Fig. 1. Fast device feeding a slow device needs buffer stage to avoid microprocessor wasting time.

Fig. 2. Handshake signals are exchanged before data is transferred from source to buffer and buffer to acceptor. Source monitors status line h1 to see if port is empty; line h2 then strobes data into port. Read operation is initiated by the acceptor when h1 is high.

To implement a handshake system requires two interfaces, one to coordinate the activity of the source with the activity of the buffer, and the second to coordinate the activity of the acceptor with that of the buffer. Fig. 4.

Because most commercially available microprocessor systems are normally provided with ports which are already interconnected to them, we need only consider interfacing peripheral devices to the ports. Therefore microprocessor-based systems with 8 ports can be represented by the two block diagrams in Fig. 5. A paper tape reader and printer act as source and acceptor because their action is easy to visualize — they can be clearly replaced by any other device, equipment or process.

Fig. 4. A handshake system requires two interfaces, one to coordinate source/buffer activity and the other acceptor/buffer activity.

Fig. 5. Microprocessor-based system with input port and source (paper tape reader), top, output port and acceptor (printer), bottom.

Next article — Design steps and implementation.
CEPSTRUM ANALYSIS

This final part of the review gives uses in speech analysis and machine diagnostics, as well as calculation with an FFT analyser using the digital form. Part 2 gave an application to signals containing echoes (March), while part 1 derived the cepstrum as the spectrum of a logarithmic spectrum.

The applications of the cepstrum to speech analysis are mainly connected with its ability to separate source and transmission path effects, provided they have different frequency contents. This is usually the case with speech where the source spectrum is very flat, containing a large number of harmonics of the voice pitch, but is modified by the resonant characteristics of the vocal tract, the so-called formants, which determine which vowel is being uttered. Fig. 13 shows spectra and cepstra for the vowels “ah” (a) and “eh” (b) and illustrates how the differences mainly lie in the low frequency part of the cepstrum, which is dominated by the formant characteristics. Non-voiced sounds, such as many consonants and whispered speech, do not give peaks in the cepstrum corresponding to the voice pitch, and one of the earliest applications of the cepstrum was to separate voiced and unvoiced sounds and to measure voice pitch.

It is also possible to edit in the cepstrum to remove one effect completely, for example the voice, and thus simplify the tracking of the formants. Fig. 14 from ref. 11 shows a typical situation, a three-dimensional representation of the section “ea” from the word “Montreal.” The picture is confounded but by short-pass liftering each of the spectra to remove the voice components, as shown in Figs 15 and 16, only the formants are left and the picture becomes much clearer.

The cepstrum can be used for efficient encoding and transmission of speech. Most of the intelligence is contained in the low frequency part of the cepstrum so that this is transmitted, along with information as to whether the speech is voiced and if so the voice pitch. At the receiver the speech is reconstructed using the low frequency information to generate a filter characteristic sensitive to the transmission path of the signal from an internal source to an external measurement point.

The cepstrum technique has been proposed to aid detection of missing blades in turbines. Such blade anomalies give rise to a large number of harmonics of the shaft rotational speed in measurements made both internally and externally on the casing in the vicinity of the affected blade row. Even though the harmonic pattern can be seen by eye, the whole family of harmonics is reduced in the cepstrum to one component which is much easier to monitor.

Similar reasoning is applicable to gear-box diagnosis; tooth anomalies have a very similar influence on gearbox vibration signals, as do blading anomalies on turbine signals. A very detailed discussion is given in reference 13 of the application of cepstrum analysis to gearbox diagnosis and hence the discussion is limited to a couple of typical examples.

Fig. 13. Spectra and cepstra for “oa” (a) vowel and “eh” (b) vowel.

In gearbox vibrations deviations from exact uniformity of each toothmesh show up partly as harmonics of the shaft speed and also as sidebands around the toothmeshing harmonics caused by modulation of the teethmesh signal by the lower rotational frequencies. The sideband spacing thus contains valuable information as to the source of the modulation and can be extracted using the cepstrum. The cepstrum has the two advantages of being able to detect periodicity not immediately apparent to the eye, and of being able to measure it very accurately because it gives the average sideband spacing over the whole spectrum.

The first advantage is illustrated in Fig. 14 which shows spectra and cepstra for two truck gearboxes, in good and bad condition respectively, running on a test stand. The good gearbox shows no marked spectrum periodicity, but the spectrum of the bad one contains a large number of sidebands with a spacing of approximately 10 Hz. The cepstrum gives this spacing very accurately as 10.4 Hz and thus excludes the possibility that it was the second harmonic of the output shaft speed 5.4 Hz.

Fig. 15. Cepstrum liftering (a) log power spectrum of vowel (b) magnitude of cepstrum

Fig. 16. Short-pass liftered scan spectrum of “ea” in “Montreal”.

It was traced to the rotational speed of second gear, even though this was idle, because first gear was engaged.

References
11. Thrane, N. Application of a long memory FFT analyser in speech analysis, B&K application note 0604-E.
Appendix A

Calculation using FFT analyser and calculator.

even though the analyser basically performs a forward transformation of 1024 real data points, the results can be modified in the calculator so as to obtain the inverse transform of up to 1024 real or complex values thus giving the possibility of calculating both power spectra and complex cepstra. The actual algorithms used are more generally applicable and so are detailed in Appendix B.

The digital version of eq. 5 for the power spectrum is:

\[ C(n) = \frac{1}{N} \sum_{k=0}^{N-1} |X(k)|^2 = \frac{1}{N} \sum_{k=0}^{N-1} x(n) \exp(-j2\pi nk/N) \]

where \( n \) stands for a \( 2\pi k \) in the summation interval and thus the index, \( n \), runs from 0 to 1023. Likewise \( X(k) \) represents the frequency \( k \) component of the power spectrum and in principle also runs from 0 to 1023 even though only the values from 0 to 512 are calculated. Because of the implicit periodicity all the calculations by the FFT process the values from 512 to 1024 however represent the negative frequency components (from -512 to 0) and can usually, be derived from the positive frequency values. As \( X(k) \) is a real even function, the inverse transformation can be replaced by a forward transformation (Appendix B). In general only one-sided power spectrum is given, and the simpler calculation method of Appendix B will be advantageous. With this method, only one-sided spectrum is transformed, and the real part of the transform gives the desired spectrum. Another advantage of this method is that the envelope spectrum (amplitude spectrum of the one-sided spectrum) of Fig. 4 may be obtained at the same time. In fact, the program itself automatically calculates and displays it as the instantaneous spectrum, which can be viewed on a linear amplitude scale. The envelope spectrum is:

\[ G(k) = \frac{1}{N} \sum_{n=0}^{N-1} x(n) \]

where \( G(k) \) is the one-sided power spectrum.

The formula for the complex cepstrum is:

\[ C(n) = \sum_{k=0}^{N-1} \frac{X(k)}{k} \]

Because the logarithmic spectrum is a continuous even function, the calculation method of Appendix B may be used. Note that the inverse function \( X(k) \) must be unwrapped to a continuos function of frequency in place of the principal values modulo 2 \( \pi \) which are calculated from the real and imaginary parts of the complex spectrum. Moreover the log amplitude must be scaled in nepers (natural log of the amplitude) to correspond to the radians of the phase spectrum.

The analysers in general are a.c. coupled, so the available frequency range in the power spectrum is not calculated. It is therefore necessary to insert a value before calculating the cepstrum. In practice best results are obtained by setting the zero frequency component equal to the value of the neighbouring line.

As the FFT algorithm used in the Analysers types 2031 and 2031 is open-ended for signals with no d.c. component, it is advantageous to subtract the mean log spectrum value before calculating the cepstrum. This optimizes the signal noise conditions in the cepstrum and is particularly valuable when editing and transformation in both directions is to be performed. In calculation of the complex cepstrum it is advisable before attempting to unwrap the phase spectrum to first scale the data such that it gives a linear slope to the phase spectrum. This should be done to ensure that maximum possible extent possible in the time signal before transformation, and then in the phase spectrum itself by varying the linear component until the number of "jumps" over 2\( \pi \) is minimised.

Appendix B

Calculation of inverse Fourier transform

The forward and inverse discrete Fourier transforms, as calculated by the FFT analyser, are defined by:

\[ X(k) = \sum_{n=0}^{N-1} x(n) \exp(-j2\pi nk/N) \]

where \( X(k) \) is the discrete complex spectrum and \( n \) the sampled time function and \( N \) number of samples in the time record.

The Fourier transform implemented in the analysers types 2031 and 2031 is designed to be used forward transformation of real-valued time signals, but by using some of the properties of the Fourier transform, as listed in tables, it can also be used for forward and inverse transformation of any complex signals.

The inverse transformation of the three types of signals real-valued, real and even, and conjugate even are described in the following.

If the signal is real and even, the inverse transformation can be replaced by a forward transformation (Appendix B). In general only one-sided power spectrum is given, and the simpler calculation method of Appendix B will be advantageous. With this method, only one-sided spectrum is transformed, and the real part of the transform gives the desired spectrum. Another advantage of this method is that the envelope spectrum (amplitude spectrum of the one-sided spectrum) of Fig. 4 may be obtained at the same time. In fact, the program itself automatically calculates and displays it as the instantaneous spectrum, which can be viewed on a linear amplitude scale. The envelope spectrum is:

\[ G(k) = \frac{1}{N} \sum_{n=0}^{N-1} x(n) \]

where \( G(k) \) is the one-sided power spectrum.

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Because the logarithmic spectrum is a continuous even function, the calculation method of Appendix B may be used. Note that the inverse function \( X(k) \) must be unwrapped to a continuous function of frequency in place of the principal values modulo 2 \( \pi \) which are calculated from the real and imaginary parts of the complex spectrum. Moreover the log amplitude must be scaled in nepers (natural log of the amplitude) to correspond to the radians of the phase spectrum.

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B. Conjugate even spectrum

Any complex spectrum can be inverse-transformed by transforming the real and imaginary components separately by the procedure B1. However, this requires two Fourier transformations, the second to store memory capacity for the intermediate results. In the situation where a spectrum is conjugate even, i.e. corresponding to a real time signal, the following procedure can be used. This requires only one transformation and a minimum of storage space.

\[ X(k) = X(k) \]

\[ X(k) = -X(k) \]

\[ X(k) = X(k) \]

The calculation procedure, illustrated in Fig. B3, is as follows.

Algorithms

Conditions

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**TEACH YOURSELF**

As an introduction to digital electronics suitable for beginners is given by a kit from Cambridge Learning covering such subjects as boolean algebra, gating, flip-flops, shift registers, ripple counters and half adders. Problems, with solutions, and a appendix covering basic principles are included in the manual. AT £19.90, the kit comprises logic elements, a 'solderless' breadboard, a handful of other components and, of course the manual - all in a pocket-sized folder (14cm-wide pockets). A power supply of 4.5V battery is required. Small kits comprising only in digital electronics are also proposed. Cambridge Learning Ltd, Richmond Lodge, St. Ives, Huntingdon, Cambs PE17 4EY.
UNINTERRUPTIBLE P.S.U.
No-load to full-load voltage and frequency fluctuations of this uninterruptible power supply and regulator's output are ±1% and ±0.1% respectively. Maintenance-free batteries, normally under charge, drive the 240V/50Hz output during momentary or total mains failure and large mains fluctuations from 0 to 270V and from 40 to 70Hz have little effect on the output. This switch from mains to battery back-up is not apparent at the output. Surge currents up to five times the nominal rating are provided for starting induction motors, etc. These units can supply up to 250VA to 24VA, handle 100% overloads for 30 minutes and include comprehensive overload protection. T.H.D. is 2%. Compac Systems Ltd, Welton, Brough, N. Humberside HU15 1PT.

12-BIT D-T-A
Linear error less than 12-bit microprocessor compatible digital-to-analog converter is 0.001%. The HS93H has its input reference organized as independent 4-bit elements each with its own resistor-loading enable input. Output voltage is programmable in ranges from 0 to 5V to ±10V and an internal reference is available; output-settling time is 5ns based at 5V. A-4 pin D.I. package is used and the device operates on 5V and ±15V supplies. (UK) AEC, 12 Park Street, Camperdown, Stroud, Glos. GL1 3QH.

ACRYLIC FILTERS
The Acrylic Filters in a variety of water treatment systems are available in all grades, amber and blue filters in two designs. These filters are made of high quality acrylic material and have a long life expectancy. They are easy to install and maintain. A wide range of sizes is available to meet different requirements. (UK) J. A. Rich, 14 Christchurch Road, Letchworth, Herts.

ATOMIC SOURCE FOR VACUUM DEPOSITION
A new atomic source for vacuum deposition systems has been developed by the Atomic Source Development Group at the University of Florida. The source is based on the atomic force microscope and provides high sensitivity and accuracy in the deposition of thin films. (UK) J. A. Rich, 14 Christchurch Road, Letchworth, Herts.

CALIBRATED STROBOSCOPES
This type of instrument is used in every industry and has medical applications, yet we are surprised few new designs. Fischer-Miller has introduced a strobeoscope which it claims has features usually associated with units costing twice as much. Retailing at £919 excluding v.a.t., the WM10 has a range of applications from medical imaging to industrial inspection. (UK) B. J. Williams, 14 Christchurch Road, Letchworth, Herts.

FLUX-DENSITY METER
A small meter for checking magnetic fields up to 19.99 kilogauss (0.0-10) in three ranges is manufactured by Redcliffe. Readings - down to ±1% on the most sensitive range - are given on a 3 1/2-digit LCD and must be set to within ±1% or errors may occur. The measuring coil is housed in a light-tight case for increased accuracy. (UK) B. J. Williams, 14 Christchurch Road, Letchworth, Herts.

IONSOURCE FOR VACUUM DEPOSITION
A new ion source for vacuum deposition systems has been developed by the Ion Source Development Group at the University of Florida. The source is based on the atomic force microscope and provides high sensitivity and accuracy in the deposition of thin films. (UK) J. A. Rich, 14 Christchurch Road, Letchworth, Herts.

MANAGEMENT APPLICATIONS
Balance sheets, so crucial to management analysis, and profit calculations by break-even point analysis are easily accomplished with the PC-1500. By using the integral clock, calendar and alarm functions, this computer can also be used as a schedule reminder. (UK) B. J. Williams, 14 Christchurch Road, Letchworth, Herts.

HOBBY APPLICATIONS
Many popular computer games can be played, including Blackjack, utilizing the random number function. Use the clock and alarm for speed games. The Computer Graph will draw virtually any pattern.

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