wireless world

APRIL 1981 60p

70 years of publication
Active cross-over networks
Low-noise amplification

Opto-electronic contact breaker
Soldering blind just burns up profit.

Given that some metallic substances are more easily soldered than others, and that there are significant differences both in the speed with which they can be soldered and in the strength of adhesion of the solder to their surfaces, it is clearly necessary to make absolutely sure that the procedure used to solder components is correct. Testing for solderability greatly reduces the risk of failed joints and that can mean appreciable savings on rejects.

Multicore, the world's leading authority on soldering, has developed a simple-to-use piece of equipment designed to assess solderability. It is called a MUST - Multicore Universal Solderability Tester - and it really is a must if you want to avoid the costly problems of inefficient soldering.

The built-in microprocessor takes the complex force/time curve and reduces it to just two values, making the application of the sophisticated test method to quality control particularly simple.

The MUST can be used to evaluate the solderability of any plain or plated metal in sheet, strip or wire form. It is, however, ideal for use with electronic component terminations, metal clad laminate, printed circuit boards and plated-through holes.

It can be used for the Edge Dip Test that appears in IPC-S-801, EIA RS-178 and EIA RS-319 Method 2 for evaluating quality of wetting, and for the Globule Test as described in many national and international standards including IEC 68-2-20, BS 2011:2T and DIN 40046 to measure wetting speed. This speed, together with the wetting force, may also be measured by the quick and easy addition of a wetting balance.

The Multicore Universal Solderability Tester could make a big difference to your soldering operations - and to your profits. For the eye-opening facts use the reader reply service, cut the coupon or contact Multicore direct.

The biggest name in solder worldwide

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Please telephone me.

Name

Position

Company

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<table>
<thead>
<tr>
<th>April 1981</th>
<th>Latest Test Equipment</th>
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<tbody>
<tr>
<td>ANALOGUE VOLTMETERS</td>
<td>19000 Series, 0-50V, 0.001% Rms. £595.00</td>
</tr>
<tr>
<td>RF Voltmeters</td>
<td>10 MHz, 10 kHz, 100 Hz, 10 Hz, 10 mHz. £600.00</td>
</tr>
<tr>
<td>DC Voltmeters</td>
<td>500 V, 250 V, 25 V. £60.00</td>
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<tr>
<td>DC Testers</td>
<td>1180R, 1180R. £1180.00</td>
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<tr>
<td>Frequency Counters</td>
<td>1000 Hz, 100 kHz, 10 MHz. £295.00</td>
</tr>
</tbody>
</table>

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# Electronic Brokers - Europe's Prem U Equipment

## April 1981

### Latest Computer Equipment

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<tr>
<th>Model</th>
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<tr>
<td>PDP11</td>
<td>Digital Computer System</td>
<td>£1295</td>
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<td>PDP11/40 System</td>
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<td>PDP11/60 System</td>
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### PRINTERS

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<tr>
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<tr>
<td>Drafting/Plotting</td>
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### TERMINALS

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### SDI Kits

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1980 saw a genuine breakthrough - the Sinclair ZX80, world's first complete personal computer for under £100. At £89.95, the ZX80 offered a specification unchallenged at the price.

Over 50,000 were sold, and the ZX80 won virtually universal praise from computer professionals.

Now the Sinclair lead is increased: for just £69.95, the new Sinclair ZX81 offers even more advanced computer facilities at an even lower price. And the ZX81 kit means an even bigger saving. At £49.95 it costs almost 40% less than the ZX80 kit!

Lower price: higher capability

With the ZX81, it's just as simple to teach yourself computing, but the ZX81 packs even greater working capability than the ZX80.

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

And the ZX81 incorporates other operation refinements - the facility to load and save named programs on cassette, for example, or to select a program off a cassette through the keyboard.

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 14!

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!

Kit or built - it's up to you!

The picture shows dramatically 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.

New Sinclair teach-yourself BASIC manual

Every ZX81 comes with a comprehensive, specially-written manual - a complete course in BASIC programming, from first principles to complex programs. You need no prior knowledge - children from 12 upwards soon become familiar with computer operation.

New, improved specification

• ZX8A micro-processor - new faster version of the famous Z80 chip, widely recognised as the best ever made.

• Unique 'one-touch' key word entry: the ZX81 eliminates a great deal of tiresome typing. Key words (RUN, LIST, PRINT, etc.) have their own single-key entry.

• Unique syntax-check and report codes identify 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 26 FOR/NEXT loops.

• Routines for games as serious as serious applications.

• Whole range of BASIC keywords and built-in functions.

• Feature of BASIC errors being automatically corrected.

• Automatic error-proofing for common errors.

• 16K-byte RAM pack.

• Advanced 4-chip design: microprocessor, ROM, RAM, plus master chip - unique, custom-built chip replacing 18 ZX80 chips.

If you own a Sinclair ZX80...

The new 8K BASIC ROM used in the Sinclair ZX81 is available to ZX80 owners as a drop-in replacement chip. (Complete with new keyboard template and operating manual.)

With the exception of animated graphics, all the advanced features of the ZX81 are now available on your ZX80 - including the ability to drive the Sinclair ZX Printer.

Coming soon - the ZX Printer...

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alphanumerics across 32 columns, and highly sophisticated graphics. Special features include COPY, which prints out exactly what's on the whole TV screen without the need for further instructions. The ZX Printer will be available in Summer 1981, at around £50 - watch this space!

How to order your ZX81

BY PHONE - Access or Barclaycard holders can call 01-200 0200 for personal attention 24 hours a day. Every day. BY POST - use the no-stamp-needed coupon below. You can pay by cheque, postal order, Access or Barclaycard.

Either way - please allow up to 28 days for delivery. And there's a 14-day money-back option, of course. We want you to be satisfied beyond doubt - and we have no doubt that you will be.

Sinclair ZX81

Sinclair Research Ltd, 6 King's Parade, Cambridge, CB2 1YU. Tel: 0223 69300. Fax no: 214 463000

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

Designed as complete module to fit your Sinclair ZX80 or ZX81, the RAM pack simply plugs into the existing expansion port at the rear of the computer to multiply your data/program storage by 16!

Use it for long and complex programs or as a personal database. Yet it costs as little as half the price of competitive additional memory.

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Mode: CA1, CH2, Dual, Add, Subtract
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The next seventy years

The artist Pablo Picasso once said: "Age only matters when one is ageing. Now that I have arrived at a great age, I might just as well be twenty." Wireless World feels much the same. Being the oldest radio journal in the world and having reached this month the Biblical age of three score years and ten, we can justly consider ourselves — in terms of electronics journalism — to have arrived at a great age. And we might just as well be twenty because it is in the nature of a periodical publication to renew itself with each issue. It doesn't matter whether one has produced 1,500 or only 15 previous issues; the next edition is always a completely new book — a new product belonging uniquely to its own moment in history and reflecting its own world at that moment. We did our reminiscing about the past on our 50th and 60th birthdays. Now, already 15 years into the era of the integrated circuit, we are as curious about the future and what it holds for us as any young person just starting to look at electronics as a possible career.

If we survive the next 70 years, what could we be looking back on in 2051 AD? Here a little humility is called for. At the periodical survives (and not necessarily on paper) it may well be a very different animal from what it is now. Electronics may no longer exist as a definable area of technology and industry. Just as radio spawned electronics, which then proceeded to absorb its parent, the same thing may happen again — several times over. On this principle one might look at other branches of science and technology with which electronics is already combined and speculate if they are capable of such absorption. Optics, perhaps, chemistry, biology...? Or one might even consider the complete fragmentation of electronics into a variety of other technologies and interdisciplinary activities, some of which don't yet exist.

Extrapolation from present trends does take us a little way — greater complexity and higher performance in electronic products, more devices on a silicon chip, changes in microprocessor architecture and so on. This is the gadzooing approach which envisages a world increasingly full of clever robots, wrist-watching radios, flat tv screens and information centres in the home. But it doesn't allow for the possibility that a completely new, seminal device will be invented that will transform the technology — just as the valve transformed radio communication and the transistor opened the way to integrated circuits.

Several laboratories are now exploring the possible use of biological structures as transducers and energy converters. Could this lead perhaps to a stochastic, rather than deterministic, principle of information processing and transmission, analogous to that in the animal central nervous system?

But it is unrealistic to consider a technology in isolation from the society which produces it. You can say with truth that scientists and engineers discover and invent things which change our lives. These individuals, however, are part of society and subject to its pressures. You can say with equal truth that the technology we have is a symptom of the kind of society we are: it develops in particular directions in response to material, emotional and spiritual needs. Broadcasting, hi-fi and other electronic diversions are technological responses to the needs of the "nuclear family" for entertainment and even "company" in homes that are becoming socially isolated from communities. As in the past, technology will continue to be both cause and effect.

1911, in which we were founded, was the fearful year when Rutherford did the historic experiments that led him to postulate the atomic nucleus and the picture of the atom we have now. Since then our physicists have been discovering ever more fundamental particles and our view of matter and energy has been greatly elaborated. During the next 70 years there could be a discovery or insight that would unify our observations and even depart from the traditional line of thinking started by Descartes. Such an event would not immediately alter the practice of electronic engineering but would certainly affect profoundly the work of the applied scientists who research into physical processes to create new devices.
Opto-electronic contact breaker

Compact and maintenance free switching for electronic ignition systems

by J. R. Watkinson, B.Sc., M.Sc.

The conventional automotive contact breaker is still widely used in modern petrol engines despite its shortcomings. Superior alternatives have been available for several years, but car manufacturers have been slow to remove the weak link in the ignition system. This design is simple, cheap, reasonably easy to install, and provides a maintenance free unit which will drive almost all electronic ignition systems which operate with mechanical contacts.

Although many electronic ignition units are available, and several well designed constructional circuits have appeared, most of them are triggered by the existing contacts and use either inductive or capacitive discharge to improve the spark and extend contact life. Some designs claim to eliminate the effect of contact bounce, but the effects of contact heel wear and timing scatter still remain.

The circuit in Fig. 1 provides an output which, for low currents, simulates the contact breaker and can trigger an electronic ignition unit without modification. The existing centrifugal and vacuum advance mechanisms are retained, and the only mechanical part which must be constructed with any precision is a chopper disc.

The light source is an infra-red LED with a lens to give a well defined beam, which is received by a spectrally and electronically matched phototransistor. Light falling on a chopper disc which produces a square wave. This waveform is cleaned up before it is used for electronic ignition unit without shortcircuiting the contacts. Some designs claim to extend contact life. The existing centrifugal and vacuum advance mechanisms are retained, and the only mechanical part which must be constructed to suit most other types. Some distributors are modified to fit most other types. Some designs claim to extend contact life.

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More on active crossover networks

Using electrostatic loudspeakers with a common bass unit

by D. C. Read, B.Sc., Hons (Elect. Eng.)

Modifications to David Read’s 1974 active filter crossover design provide for Quad electrostatic loudspeakers or Isophon tweeters, with appropriate alterations in crossover frequencies.

An article in the November 1974 issue of Wireless World showed how some economics could be achieved in a multi-speaker system using active cross-over networks. One such economy was to have a mixed monaural/stereo arrangement using a single bass unit working in that part of the audio band where sounds are non-directional. Sounds in the mid and upper ranges were in the system suggested, produced by smaller speakers fed via the amplifier/active-filter crossover units as described earlier (Wireless World, December 1973). This economy arrangement worked well, with the added flexibility of the active filters enabling best use to be made of the five conventional cone units – one bass, two mid-range, two upper-frequency speakers – variously selected for best operation in the chosen range.

Given greater financial freedom in the choice of the output units, it seemed an attractive idea to apply such a mixed mono/stereo arrangement to a three-speaker system, using a single cone bass unit working between a pair of Quad electrostatic radiators. An obvious benefit of band-sharing in this way was that the use of the single bass speaker relieved the electrostatic units of having to produce possibly loud sounds in that part of the audio spectrum where they are at their lowest efficiency and where, especially at
On the high side of optimum, because I.f. energy below 150Hz produces an air gap and third harmonic distortion in a Quad electrostatic speaker.

The upper part of the response curve section being considered, from 170 Hz to 1kHz in Fig. 1, shows a slope in the same sense as before but at a more gentle rate of about 2 dB/octave. This slope does not contribute usefully to the desired effect as in the previous instance and has to be compensated by an opposing active filter characteristic to maintain the loudspeaker output reasonably constant down to the cut-off point of 170 Hz.

Two considerations suggest the general form of the required filter response curve. In addition, I decided to move the stereo/mono change-over point further down the band, to 100 Hz instead of 160 Hz in the original system, which lead me to a KEF B110 cone units for the mid-range with a single B119 bass speaker. The reason for the change is that in larger living rooms having floor dimensions in excess of six metres square the stereo effect is extended to lower frequencies. As the electrostatic speakers not only gave good output to this lower point in the band but have a resonance shape which helps in the crossover arrangement, it seemed reasonable to make the change.

The filter response achieved to satisfy the three requirements detailed above is shown in the full-line curve in Fig. 2. This shows the variation of voltage with frequency of the output labelled m.f. amp. in the filter circuit diagram of Fig. 3. This output provides the feed for one Quad electrostatic speaker: an identical circuit serves the other channel.

The mono bass speaker — a KEF B19 is suggested but any comparable unit with suitable power-handling capacity would do — is fed via a power amplifier from the channel combining and filter circuit drawn at the bottom of Fig. 3. The response of the output from this circuit is shown by the broken curve in Fig. 2 which intersects with the high-pass filter curve at the new mono/stereo change-over point of 100 Hz.

The active filter itself is a cut-down and modified version of the circuit as originally published in the 1974 article and needs further description. Op-amp IC9 provides the high-pass output with the bridged-T section between Tr2 and Tr3, giving the 2dB/octave compensation up to between 1kHz and 10kHz (with slope controlled by the choice of value for R4. R5 and R3) providing a mixing point and a suitable low-pass response for feeding the common bass unit.

In practice, with the room space and the pocket money to suit, an improvement in their arrangement could be obtained by having four such units stacked in pairs. Frames specifically designed for this purpose are now available. The resulting increased radiation "frontage" and power-handling capability should gladden the ears of any enthusiast. But you might need to make peace with the neighbours first!

At the other end of the scale, with cost an important factor, the Quad units could be replaced, using the original 0.33µF capacitor at the output with low-pass filter only, retaining an anterior conversion. The sloping roof to the now-boarded floor provided the wedge behind my electrostatic speakers. This wedge is now filled with sacks of old clothes from a once-occasional wardrobe (all the family have been equally deprived). I have now achieved an excellent listening room where I can pull the ladder up after me.

The power amplifiers, Fig. 6, use the Hitachi complementary pair 2SK133, 2SK48 and I obtained a kit from Ambit International the details of which are in their second catalogue. The kit for each power amp, is £16.10 supplied with drilled board, data sheet and component location (heat sink £6.52). After many tests on this amplifier, and accepting the no second criterion.

Listening to the various systems with pink noise (i.e. constant energy per octave) and sweeping through the audio spectrum I have become aware that room acoustics significantly colour the results. Having used an anechoic chamber during the speaker development I realised that a large sound absorbing area of an attic version. If you are aware of sound level peaks in your listening room then please feedback.

Continued on page 54.
British Aerospace. Space and Communications Division is developing a spacecraft microcomputer module, a self-contained unit suitable for general application in satellite systems. In addition to the above, the Divi¬
sion is also developing the necessary computer programs which include all the basic executive routines needed to control an SMM system.

Each SMM is a totally self-contained microcomputer. One of the design aspects of particular note is that of flexibility in choice of microprocessor is used. The microcomputer system at the Space and Communications Division currently comprises a Ferranti F100-L, the highest performance 16-bit PDP/11/4 mini computer, all running with compatible software and common hardware interfaces.

A method of interconnecting up to 64 SMMs has been developed such that not only can their processing capabilities be shared for complex computations, but tasks may be transferred to other units should faults arise in individual devices.

It is envisaged that a non-intelligent module which is linked in an SMM system be performed by a two-wire line process which is not possible in the Space and Communications Division.

An addressable serial bus interface circuit (ASBIC) is used as the standard interface for accessories to be added to the SMM system by a two-wire serial data bus designed to interconnect different modules. It is envisaged that SMMs can be produced for $200,000 180,000 black-and-white sets per year.

The SMM development is aimed primarily at the development of electronic systems for spacecraft and satellite use, to take advantage of new technology which is inherently more resistant to radiation damage, with the added merit that it is the only 16-bit microprocessor which has been designed, developed and manufactured within Europe. Throughout the study, liaison was maintained with the European Space Agency (ESA) to ensure the technical solutions proposed were compatible with data handling requirements for satellites specified by ESA.

As a result of the study, British Aerospace Dynamics Group had already acquired considerable knowledge of the factors likely to influence computer operations in space as a result of previous privately-funded technical evaluations. The Group is continuing to invest money in the current research and development work, the cost of which is being shared by the Department of Industry as part of the UK Space Tech¬nology Programme.

The Space and Communications Division will be incorporating SMMs in the next generation of satellite systems they build and is now in the process of evaluating the device with its supporting com¬ponents to qualify for use in a future programme.

In addition to space, it is envisaged that SMMs will be extensively suited for a wide variety of data handling applications.

In the world, it incorporates a real-time clock which can display GMT and local time; it is clear to the operator that data transmission is taking place by square waves on the display. The display is a 16-bit CMOS parallel output display, a fold-out dot-matrix gas phase screen with a capacity of 256 character; there is full text processing capability and the magnetic bubble memory does not lose data when the power is removed.

Microcomputers in space

China standardizes in industry

From a previous policy of self-reliance, China has embarked on a comprehensive programme of modernization including a number of product standards and a building and civil engineering code. Details are included in a report, Export to China, prepared by the Standards Association of New Zealand and available from the British Standards Institute's Technical Help to Ex¬porters service.

Chinese standards are divided into three grades—national, ministerial and enterprise—and the policy for each grade is expanded. De¬tails are given of the types of products covered by the mandatory National Standards. There are two Chinese standards covering labelling requirements for shipped goods and the labels are clearly illustrated. The report includes full addresses of all relevant organizations, cor¬porations and embassies.

As if to underline that such trade is not necessarily one-way, Hsinchu has announced the signing of a contract for the establishment of a joint venture company in Fujian Province, China, for the production of television sets. In¬stead of being taken for export, the company expects to producing 200,000 colour and 180,000 black-and-white sets per year.

Computer in case

Produced by Microdata Computers Ltd, in Hayes, Middlesex, the computer incorporates many features to make it useful for a wide range of applications. It is by no means limited to commercial use, not only is its use possible, but it is also practical use: it can be connected to a wide range of power supply's voltages and fre¬quencies and so may be used almost anywhere.

An ASBIC comprises a single 40-pin ceramic dual-in-line package manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology. The package is not manufactured by Ferranti using collector diffusion technology.
Electronics bosses disagree on industry's priorities

The quality of the transmitted signal of the new national broadcast network is reported to be superior to that of the old system.

Approval and dis-approval for telephones

Although, under the policies of the present Government, it seems likely that the network will be used for providing telephone and other attachments to telephones on telephone lines, it is, however, concerned that there will be no free-for-all. At present the only equipment permitted is that certified by British Telecom in suitable for use as an attachment. This ensures that the equipment is technically compatible with the British network; it presents a minimal risk of injuring other users of the system. It does not interfere with other customers' use of the network and it is reasonably safe and practical. However, when British Telecom lose the monopoly, they will be free to make their own decisions. If more than one telephone is connected to the exchange line entering a person's home or office, under the arrangements proposed by the Government, certification of the suitability of attachments will continue but will no longer be carried out by British Telecom but by an independent and Government approved body which will establish and publish standards for privately supplied attachments and then certify that the attachments conform to the standards. British Telecom warns that it may be possible to attach equipment to telephone lines without the necessary certification.

Electronic Laboratories, University of Kent at Canterbury, Longshore, Kent. Details from Fourth World, 24 Clifton Street, London NW1 (tel: 01-266 4366).

More news from Sinclair

To be launched at the Micros108 '81 exhibition is a new Sinclair personal computer. It will incorporate three of the tubes and the associated electronics in a prototype in projection systems. A monitor for the new national broadcast network is expected to be available in the next few months.

Flad c.r.t. from Sinclair

Clive Sinclair of Sinclair Research Ltd. has recently announced the successful development of a flat c.r.t. which will be incorporated into a miniature t.v. set. The set will include a c.r.t. and radio and may be switched to the nearest international t.v. standards, making it of universal use.

The screen tube measures about 4 x 4 in. and is thinner than a cigarette, lengths between one quarter and a tenth of the power and is half the volume of the tubes in 7” c.r.t. sets on the market. The set can be viewed from the front or the back, viewed from the front the same side that the electrons strike. This gives a brilliance of more than double that of a conventional c.r.t. with the same picture tube. In addition to the horizontal and vertical deflection plates there is a third set between the phosphor and the front face to bring cold beam on to the screen.

The distance for distortion the screen height is reduced by as much as half while the width is kept constant. This narrows the angle of the electron beam on the screen. The screen height is restored optically by using a horizontal deflection lens to give an effective picture height of 3 in. diagonal. Other distortion is eliminated by proper compensation to the modulation applied to the deflection plates.

The tube has been produced in Sinclair's pilot production plant at St Ives and is expected to be mass produced in the Tunes Corporation. Tunes were awarded the contract by Sinclair because of their expertise in automatic production. The company claims that by the end of the first phase of the project the tubes will be producing the tubes at the rate of a million a year.

The Microvision t.v. set which will incorporate the tube is also to be produced by Tunes and should be on the market by mid-1982. Although the exterior design of the set has not been finalised, some design ideas have been produced to show that the set will be about 6 x 4 in. or about the size of a paperback book.

Further developments for the tube depend on the work of the Microvision personal computer which is expected to be out in the market place in the near future. Sinclair say that the Microvision personal computer is high in the application list, as a colour projection t.v. which would incorporate three of the tubes and the associated electronics in a projector about the size of a shoe box to produce a picture on a wall screen with a 50 in. diagonal.

Vehicle speed is computed from the interval in which the two tubes pass over each of the two parallel tubes. Alignment is computed by the driver first of all driving along a straight line laid up into the centre of the carriage way. This line ends at the arrow's tip, from which two rubber arms slope away — the shape of an arrowhead. If the driver has aligned the two arms of the arrowhead simultaneously, if one wheel strikes its arm ahead of the other, the vehicle must be off the centre line.

The micro-computer is both "intelligent" and versatile, making a decision in milliseconds on whether a driver has passed or failed each of the two tests set by the operator. Hence it can programme the device with the speed limit of the road and can also be on the margin of error allowed to a driver on the alignment test. British or metric units can be chosen and the indicator will give separate decisions on speed and alignment. The micro's decisions are flashed on in front of the operator's "pass" or "fail" together with the figures for speed and the number of inches or centimeters by which the car is veering from the centre line. The decisions are also printed out, and a warning buzzer sounds when the error limits are exceeded. The indicator can be set to record results of every vehicle passing, or it can print out for failures only — whichever mode the operator chooses.

The equipment is compact and easy to use. It can be carried round in the smallest of cars. The Speed and Alignment Indicator is a prototype only at the moment, but it can be made and could be sold. In a few years it may be able to as the maximum permissible signal strength or the number of channels on which a satellite signal is assigned. A detailed specification will be issued to potential manufacturers.

The European Communities Commission is attempting to produce a harmonised set of technical regulations. They are studying French proposals for a 27MHz service with a minimum strength of two watts and a maximum of 22 channels.

British Telecom is planning to produce a series of constructional articles for those wishing to build their own telephone exchanges.
Divide by (2n - 1)

Fig. 1(a) shows a divide-by-(2n - 1) circuit which generates an equal mark-to-space ratio output if a divide-by-2 circuit is used in the final stage as shown in Fig. 1(b). With this arrangement, a divide-by-(n - 1) output is available from the divide-by-n counter, but not with an equal mark-to-space ratio. Fig. 2 shows a divide-by-3 circuit, based on Fig. 1, where the divide-by-4 counter is clocked by a positive edge of the input waveform and then by a negative edge. During one complete output cycle the divide-by-4 counter receives four clocking pulses for three cycles of the input waveform. A divide-by-(n - 1), i.e. divide-by-15, output is available from Q1.

With the basic circuit of Fig. 1(a) it is easy to build other odd value counters by inserting the desired divide-by-2n circuit. Also, by combining divide-by-(2n - 1) and divide-by-2n-2 circuits, a counter can be designed to divide by any value of (2n - 1). Some examples are shown in Fig. 3. Note that inputs and outputs between the various exclusive-OR gates must be separated by a counter.

Pre-amp with multisection tone control

The input stage of this preamp, which originates from a studio mixer, will handle signal levels from 500μV to 2V r.m.s. For optimum performance the preset control should feed 5mV to TR1 which, with A1, amplifies the signal to 3V r.m.s. The filters around gyrators A3 to A7 provide low-impedance paths to ground for five frequency bands, and attenuation or gain for these bands is achieved by controlling the low-impedance paths towards the voltage dividers around A2. Balancing the filter potentiometers gives unity gain at A2 because the input and feedback voltage-dividing networks cancel each other. The open-loop gain of the op-amps determines the maximum number of gyrators that can be used. At 15kHz the paralleled gyrator series resistance is 18000 ohms and 33000 ohms, which are bootstrapped by the open-loop gain, should still be greater than the divider source impedances, 267, and prevent unexpected dips or peaks at high frequencies.

H. Rügten
Amsterdam
Holland

One-shot control of immersion heaters

A conventional immersion heater requires two operations, switching on and later switching off. Although simple, the second step is inconvenient and costly if forgotten. This simple circuit is easy to install and obviates the need to manually switch off the heater. A relay forms a one-shot monostable which is thermally rather than electrically controlled. A trigger is provided by the start button which energizes the relay coil, and the heater is powered until the thermostat cuts out and de-energizes the coil. Water temperature, and therefore the duration of the on period, can be adjusted via the thermostat setting. Apart from the relay connections, only one extra low-current wire is required between the start button and the thermostat. This circuit can also be used to isolate equipment from the mains after a power failure.

S. Ho and
D. Wilberley
Manchester
Power supply with stable current limit

One problem with power supply current limits, which use the Vgs drop of a transistor, is their drift with temperature variation. A simple solution is to use a programmable Zener diode for current sensing, which offers less than 50 p.p.m./°C variation in Vref. In the circuit shown

\[ I_{\text{Load}} = \frac{V_{\text{out}} - V_{\text{ref}}}{R_{\text{Load}}} \]

When the voltage at the R terminal of TL431 switches on, base drive for the output transistors is removed and the output current is limited. However, if the output terminals are shorted, the TL431 is turned on but the voltage across it is 2.5V.

Therefore, to take the output voltage to zero, Vg is required which can be any low voltage Zener diode above 2V.

M. S. Suresh
Bangalore
India

"Test your knowledge"

Answers to the December issue multiple-choice quiz

None of the entries received for Test Your Knowledge was completely correct, and the best entries had at least three of the answers wrong. That was one result of the quiz compiled by R. W. Ellingham and B. L. Hart and published in last December's Issue. The stiff test was based on Circuit Designs 3 or a subscription to Electronics for students at the North East London Polytechnic. We offered prizes of Circuit Designs 3 or a subscription to Electronics for ten correct entries opened after 5 January for UK readers and 2 March for overseas.

The answers provided by the authors are given in the panel. As almost all entrants gave the incorrect answers to questions 5, 24 and 34 (no-one got this right), here are their solutions:

Question 5. The assertion is not true. A bipolar transistor consists of two p-n junctions both of which are forward biased when the device is saturated. By suitable biasing it is possible to arrange for the two junctions to be equal in magnitude.

The reason is a true statement. Operation of the b.i.e. depends on the existence of both electrons and holes. Therefore (d) is the correct answer. Most thought (b).

Question 24. See diagram. For neutralization

\[ I = 0 \] when \( V_i = 0 \)

\[ Y = n_1 \frac{V_i}{n_2} \]

\[ Y = \frac{V_i}{R_2} \]

From the diagram:

\[ V_i = 2(-0.2) = 0.4 \text{mA} \] (d)

Question 34. Upper trip level corresponds to the level at which the comparator switches for a positive-going input. Assuming \( V_o = 12V \), the p.d. across the kΩ resistor keeps the input of the comparator below +4V, hence the output stays at +12V, until \( V_i \) increases to \( V_o = (+4-\frac{8}{10}) \text{V/kΩ} \) which is 1.5mA, so (b) is correct, but everyone gave (c).

About half the entrants gave incorrect choices for questions 8, 9, 18, 36 and 37. In Q8, I2 is \( \frac{1}{2}(I_0 + I_1) \) which is 110mA and in Q9 zener current varies between 1mA \( (I_d = 50\mu A) \) and 10mA so the input diode is 5V±5.5mV. In Q18, the solution is found by equating the increase and decrease in charge first across the input C, to give \( V = -E/3 \) then across the output C to give \( E = 13 \times E \). Those who got Q36 wrong gave (e) as the answer but the correct frequency is 50kHz. The period is obtained from 2π/\( 50 \text{kHz} \), due to current mirror action, giving 50Hz. Most entrants realized that the 1500 Hz printed for 50Hz was intended to read 50kHz. The minimum frequency, Q37, is one tenth of that.

Other answers were less frequently wrong, but more consistently so. In the answers to question 11, emitter current was invariably given where collector current wasn't. For question 23, it appears that the transformation ratio was taken to be the square of \( X_1 \) rather than \( X_1 + X_2 \). As the amplifier of question 27 is matched to the source, actual noise power is twice the thermal noise power. That makes the noise figure 3dB, not 0dB.

The equivalent circuit is needed for question 33. For \( V_i \), to be high, the + input at the comparator must be more positive than \( -1V \). This means \( R_1 \times (10V/3) > 1 \).

The answer follows.

Only a few got question 22 wrong, but one that did, Jeffrey Borri of San Clara, California, wrote to correct his answer saying the question could be a "deliciously wicked trick," depending on whether c.m.f.t. was taken for the differential or single-ended output.

At the time of going to press the cut-off data for overseas readers hadn't been reached but prizes for the best UK entries have already been despatched.

**Answers to Test Your Knowledge**

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Radio observation of the 'active' sun

Solar effects on propagation recorded on home-made apparatus

by R. A. Ham

Since 1968 the author has used a simple-radio telescope constantly to monitor the effects of solar activity on radio frequencies. This article is a brief history of some patterns followed by a chronicle of solar events and outlines of the equipment used to make the recordings.

Until the advent of radio it was not realized that the sun, and indeed other stars, emitted radio waves. However, suspicions were aroused very early in radio's history as Sir Oliver Lodge tried to detect radio waves from the sun using a receiver with a coherer detector, and the editor of the Scientific American called upon radio enthusiasts to listen carefully during the total eclipse of the sun on 24 January 1925 and report any strange happenings to radio signals.

Throughout the pioneering days of the short-wave bands for broadcasting both amateurs and professionals were trying to explain why the propagation of radio signals varied between day and night and was often subject to echoing, fading and sudden blackouts.

Scientists such as Oliver Heaviside, Arthur Kennelly and Professor (later Sir) Edward Appleton had shown how the existence and structure of the ionosphere reflected short-length waves around the world. But as more evidence was gathered by astronomers, physicists and radio engineers it was soon realized that streams of particles from a solar event, Fig. 1, could disrupt the prevailing state of the ionosphere and consequently upset the normal paths of terrestrial radio signals.

Solar radio astronomy

Signs of radio being taken as an astronomer's tool date back at least to 1935 when Karl Jansky first detected radio waves coming from the suns in the Milky Way. Later in the same year Dennis Heigh- died a listening noise in the ion band which was later confirmed as being caused by radio waves coming from a solar event. Between 1936 and 1939 this same noise was reported by no less than 24 amateurs using the same frequency, and by Miss Barbara Dunn while using a frequency of 17MHz.

Early in 1942 British wartime operators using similar frequencies recorded an extraordinarily high level of noise which was also found to be the result of a large sunspot group and soon after the war search into solar radio waves and their effects on radio was stepped up.

Simple radio telescope

Having heard the effects of solar noise, the author decided to build a simple radio telescope*, to find out more about the 'active' sun and its effects on terrestrial radio communications. The radio waves from the sun at 143MHz are collected by four 4-element yagis mounted on a wire mesh reflector, Fig. 2, which has a band amplifier mounted on its frame. The amplified signal passes along a coaxial cable to a 2m converter, where the observational frequency, having been changed to 27MHz, is tuned on an FRG-7 communications receiver which in turn drives a

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* The author's radio telescope was featured in "Tomorrow's World" by the BBC and in a scientific film made by Yorkshire Television and networked by the IBA.
At this point a communications receiver and a long-wire aerial were used to follow the noise and for six minutes it overpowered all terrestrial signals down to 6MHz before it slowly faded away back to 136MHz. Fig. 6. Solar noise was also heard at 28.5 and 70MHz on 3, 6 and 28 July. At 07.45hr on 22 August 1976 strong bursts of solar noise were heard at 23MHz and later at 11.53hr while the author was using a low-band mobile radiotelephone another big burst occurred and blotted out the channel for 16 minutes. This burst was also recorded by the author's radio-tele­scope at 136MHz.

The sun often produces the unexpected and having been quiet, apart from two tiny bursts, for 18 days it suddenly emitted a 28 minute burst which covered 50MHz of the v.h.f. spectrum at 13.16hr on 29 July 1973. Another notable burst began on 1 August at 11.46hr and for eight minutes the solar noise was strong enough to overpower static from a local thunder-storm.

Auroral observations

Briefly, an aurora manifests when a stream of particles from the sun collides with the gases of the earth's polar atmosphere causing a temporary ionisation which affects terrestrial radio signals. An auroral reflected signal can be identified by the following characteristics: an s.s.b. transmission sounds like a ghostly whisper, a c.w. signal becomes a low-pitched rasp and the main image on a television screen is accompanied by many distorted images, all frequently changing as the aurora ebbs and flows. Throughout the past decade Mr C. Newton, Auroral Co-ordinator for the RSGB, has organized a large network of radio amateurs who monitor the effects of signals bounces off aurora.

Following a period of large solar burns an aurora manifested in two phases on 8 March 1970. During the first phase, 16.00 to 16.47hr, auroral signals were heard in southern England from amateur stations located in parts of Ireland, Scotland, Wales and Holland in the 2m band. The second phase, 18.15hr to 23.50hr, was more intense and auroral signals from many east-European broadcast stations operating between 65 and 73 MHz were received in addition to the amateur stations heard during the first phase.

A large sunspot group was responsible for the noise storm which began on 2 August 1972 and became very intense on the 3rd. At sunrise on the 4th the solar noise was heard at several radio frequencies and by mid-day it had reached large proportions. It was not surprising that from midnight on the 4th until about 03.00hr on the 5th a spectacular aurora manifested which not only had an umbreffect on v.h.f. radio signals, but its full glory was visible from southern-Eng.
A special watch was kept on the 4m band during the solar activity from 28 March to 2 April 1973. At 16.00hr on the 1st observers in southern England were rewarded with the sight of a strong solar radio burst from the Polish broadcast station at Gliwice, 70.2 MHz. Shortly after, following a burst of auroral signals from 14 European broadcast stations were heard between 49 and 50 MHz.

The auroral events on 15 September and 13 October 1974 were expected because of the migration of sunspots of the new cycle. Sunspot cycle No. 21 began on 11 March, 1970, and culminated on 15 September, 1974. We are sorry that the tutorial article on transient ionospheric disturbance that went with it.

We are sorry that the tutorial article on transient ionospheric disturbance that went with it.

The DEATH OF ELECTRICAL CURRENT

My thanks to your Catt for giving me a good laugh at myself for nearly being duped. His article "The death of electrical current" (December 1980 issue) carefully, and then came to the conclusion that wave-particle duality was the most convincing and cogent defence of artificial intelligence. INTELLIGENCE...
of funds in the Corporation for new de­vices, but the present level of activity, both on a national level in a period of depressed outlook, is 20% below that of ten years ago, but tends to increase anyway.

Some of you may have the impression, "British life will be impoverished without a good, strong-voiced public service broadcaster, inde­pendent of the private sector."

C. L. L. I know a good deal more of your un­equalled work, and I think the British public is well aware of the work you have been doing.

I certainly agree with most of your un­derlying thesis. We are old enough to remember the so­

The main point here is that the BBC not only has the monopoly of the airwaves, but also has the monopoly of the money spent on broadcasting.

This brings me to my third point, being the assessment which we claim that the Corporation is independent at all--and does not "sell programmes directly to the public, in the man­ner of theatres or book shops.

Frankly, I do not follow this line of argument at all. The Corporation is not a technical magazine. The BBC has no independent relationship to the game for profit, and the service which it provides is incendic. -- Theatres and book publishers produce plays and sell books in that in same make a significant contribution to our culture, but they still are mainly in the game for profit. The ultimate object of the creative enterprise.

Perhaps your literal writer might not have noticed that plays by Shakespeare and even independently of the money, the profit at all--and does not "sell programmes directly to the public, in the man­ner of theatres or book shops.

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MAIL ORDER BUSINESS WITH MY WIRELESS WORLD

There has been a certain amount of talk about mail order business using Wireless World as a source of up to date information on component prices and availability.

I have been very happy to do this as a service to our readers, and have done so as much as a service to the reader as is the editorial content. Increasingly, however, the material advertised for mail order is not available. Mail order firms are increasingly making component kits and delaying months before sending goods either because they are grossly undermanned or because they get interest on the banked money.

Outside of your advertisers, Sinclair is honest in saying that goods will be delivered in 10 weeks. It has been a long tradition in the electrical industry that component firms have come by post. Unless this tradi­tion is restored, I fear, for one order by another, those firms operating from the West Country are particularly remiss.

The problem is that the broadcast networks do not in­deed produce programmes that they calculate will sell unless there is a component supply going to fill the gap, and they appear to do so quite successfully so that their calculations cannot be too far off every time. The public, through advertising revenue, mostly for what it wants, but also for what it is sold.

There is no doubt that advertisement revenue would plummet, the networks would go out of business, and the BBC would achieve higher audience ratings.

However, I think that previously-ad­vertised programmes are not the way to go, and that the money earned should be put to other uses.

The service that the commercial networks provide is anything but incidental; it is their major source of income. To the majority of the viewing and public's demand it would not receive the revenue im­possibly small to sell a second-hand copy of the BBC, and our country, better times: let me also say that we are under no illusion that the depression the horror must be drawn in, and that national advantage in delivering a service sim­ilarly important to the BBC.

FINALLY, let me declare that all "public sector", all "government", all "state" are names for government at one level or another. The Corporation is not independent of the state, creative and risk-taking

The BBC operates two television services and six radio networks. It is the medium broadcasting service at a lower cost than ITV-ILR operates one television service and a skeleton sound broadcasting service. But the greater danger facing the public in the event of the demise of the BBC lies in the reduced quality of the services, which are believed by most people that certain wires go to TV.

Those wires are not enough are not enough called "news-reels" of pre-war and post-war events to think of the type of material which would be presented to us by a commercial new­spaper monopoly.

This means a long and detailed business to be added. For example, if Morse is improved by shortening the system, then the sender will per man will not be reduced pro rata with volume. Volume of production may be limited by natural resources other than manpower. It may be that your move is to cut your products, but some reduction in the service which it provides is incidental ... .

The game for profit, and the service which it provides is incendic. -- Theatres and book publishers produce plays and sell books in that in same make a significant contribution to our culture, but they still are mainly in the game for profit. The ultimate object of the creative enterprise.

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manual, so that the system documentation can be prepared by assembling the manual for each module, and adding a section on the complete system.

O'Connor raises the question of the disappearing micro. Now although it is true that many microprocessors have appeared, they have disappeared just as rapidly, there are several that have been with us for many years, and are still on the drawing board for some very expensive changes. The two that are the Z80, the second is the 6502. As the Z8000. Not only have the manufacturers taken care to see that it is a simple matter to change the software for new members of each family, but there is considerable support in the form of hardware and software, both from the semiconductor manufacturers and also from a large number of independent suppliers. I have deliberately left out the Z80 for two reasons - there is little software available specifically for the Z80 and in most applications they run 8080 code and so do not make use of the extra facilities, and their future is likely to depend very much on how fast the Z8000 is accepted. The Z80 might simply be phased out and replaced by the 40-pin version of the Z8000.

The moral from this would seem to be - if you are going to make your product in millions then do what you would do for any other product, i.e. specify an interface that is independent of the type of microprocessor used, place an order for the cheapest components from one or two reliable suppliers, and make sure you buy enough for future space. If the product works well you will have to make another 10 million, then it won't matter if new software is needed. After all, a black box is a black box is a black box is a black box is a black box is a black box is a black box.

The two frequencies can be broken into lower multiples, as shown below.

SC = 4,433,618,75Hz

2LF = 25,65 x 25,644,89Hz

Thus, SC = 2.2 x 25,644.89Hz

New method

It must be pointed out at this stage that 64,489 is prime number and cannot be further divided. Moreover, of the above, it would seem that we could divide by 64,489, multiply by 5 to generate twice line frequency. The problem with this however, is that SC divided 64,489 gives 68.75 Hz and it is extremely difficult to stabilize a single, phase-locked loop, in the way that a twin tuned oscillator gives a stable single frequency as it has wide bandwidth, and it is possible to make a switch Syn. pulse generator

This circuit allows a direct division from PAL/255 sub-carrier frequency to twice-line frequency, or a direct multiplication from twice-line to sub-carrier frequency. This is achieved in both cases using only digital counters and a simple, phase-locked loop. Present methods require additions or subtractions in the frequency domain, which must be performed in digital circuits.

The unit to generate sub-carrier frequency from line frequency has been built and found to work satisfactorily. The greatest use for the circuit will well be found in synchronizing pulse generators, where its low cost and reliability should prove an advantage. The principles described are applicable to any frequency synthesis problems where fractional divisions or multiplications are required.

The colour sub-carrier frequency as used in the 625/50 PAL television system is 4,433,618.75Hz. It is derived from the relationship

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1. Hardware design. 2. Design for testing. 3. Design for producibility. 4. Design for maintainability. 5. Design for process.

The last two areas are often left till the last time. Designing a unit which works correctly is straightforward - designing one that works correctly is straightforward - designing one that works correctly is straightforward - designing one that works correctly is straightforward as the end of short duration altubrances compared to total journey duration.

This is certainly the impression Einstein wished to impose on the world, and it is backed up by the whole of series of tests books since. The effect is quite obvious in the case of Special Relativity, not of General Relativity.

If, as he suggests, the results of SRT are only "apparent", but the Twin Paradox experimentally resolves in Einstein's favour, as numerous test-book writers have had to believe, then Jones's "coincidence" is not only remarkable, but miraculous.

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i.e. 2LF = SC / 25 x 2

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be used to generate 2LF from SC and vice-versa. In the schematic in Fig. 2, 2LF is derived directly from the two dividers in cascade. However, this output has large amounts of jitter, so the p.l.l. and dividers by 64 is included to remove this. This circuit would seem particularly useful in a sync. pulse generator where a suitable p.l.l. is often included anyway for the purpose of genlocking.

In Fig. 3, the p.l.l. serves two functions. Firstly, in conjunction with digital circuitry, it provides the means of multiplication. Secondly, by selecting the time constants of the p.l.l., it serves to prevent the jitter of the dividers being reflected on the SC output.

64.489 divider

As described in the previous section, fractional divisions are obtained by dividing by two numbers in a suitable ratio. In the case of 64.489, a solution is to divide by 64 and 65 in the ratio of 511:489. There are many ways in which such a ratio can be achieved, but the best one is that which gives the least low frequency jitter. To do this the divisions by 64 and 65 must be as near as possible be evenly divided.

Before moving to a detailed description of the divider, background on the programmable counters is necessary. The 9310 is such a counter, in which it is possible to arrange a division of any number from 0 to 64 by programming on pins 3 to 6. It is further possible to cascade the counters and so arrange a division of any number. For our particular purpose a division of 64 and 65 can be achieved as shown on Fig. 4. The programming for each division is shown at the bottom as well as the logic required to switch between the two divisions. When point A is high a division of 64 is performed and a division of 65 when low.

If, as in Fig. 4, the output of the divider is driven by 2 and fed to A, the result will be that the principal divider will alternately divide by 64 and 65, giving an average division of 64.489. The output is also shown to be fed back, through a gate, to the PE terminal of the counters. This is a requirement for this particular counter.

The circuit of Fig. 5 is an extension of that in Fig. 4. There are five 9310s designated IX, X1, integrated circuits X1 and X2 performing the same function as those in Fig. 4. As in Fig. 4, when point A goes high a division of 64 occurs. Instead of there being a separate division by 2, this is performed by X3, itself a programmable counter. X3 and X4 are programmed to divide by 90 and 92 and, since both are even numbers, the Q output of X3 will, regardless of which division is performed, always alternate between 0 and 1.

As stated previously a division of 64.5 is performed by the circuit shown in Fig. 4. This is close to the required division of 64.489. If 11 of the divide-by-65s ("+65") in 1,000 are changed into "-64s" the correct ratio of 511:489 is obtained. This occurs in the circuit of Fig. 5. X3 and X4 divide by 90 and 92 in the ratio of 65. This means that they divide by 4,000,000... or 1,000,001, and point C will thus have eleven pulses for 1,000 occurring at the clock of X3. Furthermore, these pulses derive from the terminal count of X4, and thus a time when Q0 of X3 is high and when B would be low, normally giving a +65 instruction. The "high on C, thus overrides this through the OR gate and forces a "-64" instead. The correct +90,-92 ratio is obtained from X5. A 9310 is not usually used to divide by 11, but it was used in this case to make all the types standard. When X3 is programmed

Fig. 3. Sub-carrier frequency (SC) derived from twice line frequency.

Fig. 4. Alternate divisions of 64 and 65.

Fig. 5. Complete 64.489 divider.

Fig. 6. 756.25 Hz, 378 Hz, and 68.75 Hz jitter components.

Fig. 7. Phase-locked loop used for synthesis of sub-carrier from twice line frequency.

Fig. 8. Complete 4.4 divider.

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as shown, it will divide by 11 and its Q0 output will oscillate between 0 and 1, except at the maximum count, when it will give two consecutive 1s. Q0 will thus be high and low in the ratio of 65:1. It is this point, point D, that is used to command the +90/92 counter.

To summarize, X3 and X2 divide by 64 or 65, depending upon the command appearing at point A. This point will go high ("+64") when either B or C are high. B alternates between low and high and thus, taken in isolation, would alter­nately command division by 64, 65. Point C goes high for just 11 of 1,000 pulses appearing at the output and it does this when B is low, instructing a "-65." On these 11 occasions in 1,000, then, a "-65" is converted to a "+64" making the ratio of the two divisions 491:511 instead of 500:500 or 1:1.

Jitter. If the divider is given an input of sub-carrier frequency it has the following jitter components:

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Jitter (ns-pp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.375kHz</td>
<td>226</td>
</tr>
<tr>
<td>756.25 Hz</td>
<td>111</td>
</tr>
<tr>
<td>378 Hz</td>
<td>1.24</td>
</tr>
<tr>
<td>68.75 Hz</td>
<td>1.13</td>
</tr>
</tbody>
</table>

The first can be easily understood, since the divider for most of the time divides alternately by 64 and 65, meaning that the output pulse oscillates about a true mean as seen in the slope of line A X. Referring to the previous section, instead of the 89th and 90th divisions being 64 and 65 as before, they are both "+64" resulting in an abrupt correction in the output phase (X-B). The count sequence from B-C is similar, except that the 91st and 92nd divisions are altered to both be "-64." Thus A-B and B-C give slightly different average divisions. The counts from C-D, E-F, G-H, I-J, and K-L are identical with A-B, while the alternate ones, D-E, F-G, H-I, J-K and L are identical to B-C. It must be noted that there are six of the former sequences and five of the latter, as described in the previous section. After point L, the entire sequence A-L repeats itself. By a quantitative examination of the plot of Fig. 6(a) it is possible to calculate the various jitter components, their waveforms and peak to peak values.

Alternate divisions of 64 and 65 clearly give an average of 64.5. This differs from the final required average of 64.4-489. Since that 0.011 of an input period (T) this

error repeats itself for every pair of divi­sions and is accumulative. After 88 divi­sions, or 44 pairs of divisors, the error A, the accumulated error will be 44 x 0.011 = 4847 at point X. When the cor­rection is made, (X-B) with a double-divi­sion by 64.4-489 is obtained.

It is clear that the sawtooth plot AXBYC represents the next most significant jitter frequency. Eleven cycles of this jitter appear within 1,000 divider output periods; thus, its frequency is 68,750 x 2.2LF = 756.25 Hz

... or a peak to peak excursions will be 0.497, i.e., with a SC input = 0.497 x 111 ns = 118 ns.

An error of +0.24745 accumulates to point X and a correction is made (X-B) of -0.497 when a double division by 64 takes place. The correction therefore "overshoots" by an amount of 0.0057. As the divider proceeds from B to Y, an error of 45 + 0.011 = 45.011 = 0.495 accumulates. A double division of 64 occurs from Y to C bringing a correction of -0.487. In this case, the correction is insufficient and "undershoots" by an amount of 0.0057. Since C-D is identical to A-B and D-E is identical with B-C, the process of "overshoot", "undershoot" continues, the jitter wave form of Fig. 6(b) being the result. It is continued on page 76.
Phase measurement with an oscilloscope
Avoiding the difficulties of Lissajou figures and time estimation
by I. D. MacArthur

A method of measuring phase angle between two sine waves of the same frequency is described, using a double-beam oscilloscope, which is easy to use up to the full vertical bandwidth of the oscilloscope.

The classical method of measuring phase is by Lissajou figures, as in the example of Fig. 1, a method which suffers from a number of drawbacks. The centre of the ellipse must be accurately aligned with the cross wires of the graticule and then measurements made against the graduations, which are usually on the centre lines themselves. This is tricky and prone to error. Accuracy is poor when the phase angle is near 90° or 270° and the gain of the horizontal amplifier is usually limited, making it impossible to “open out” the ellipse with small signals. The maximum frequency at which measurements can be made is also restricted by the horizontal amplifier — even a very good modern oscilloscope may be limited to about 200 kHz before the relative phase shifts in the vertical and horizontal channels become unacceptable.

It must be stated though, that the Lissajou figure has one big advantage in that it is very useful for checking zero (or 180°) phase shift when the ellipse is closed and any small departures are easily visible.

Another method, shown in Fig. 2, is to measure the times of zero crossing of the waveforms. This method is still probably the best for “a quick look” but has the disadvantages that the two waveforms must be aligned with the centre of the graticule and that the oscilloscope time base must be accurately triggered. One must also choose between the chopped and alternate modes, which both have disadvantages. On some oscilloscopes it is necessary to provide an external trigger.

Sum-and-difference method
Here the two signals are displayed as in the zero-crossing time-interval method, but it is unnecessary to have the timebase accurately triggered, or even synchronized in some cases. Measurements can sometimes be made in the presence of significant amounts of noise.

The procedure is as follows:
\begin{itemize}
  \item Adjust the gain of the two channels to give equal-amplitude signals approximately half the screen height (to allow for displaying a 2:1 signal). The exact amplitude and gain settings are unimportant and the time base need not be synchronized.
  \item Switch the channel selector to A+B (algebraic add) and record the peak to peak amplitude of the resulting sine wave (the difference voltage).
  \item Calculate the phase angle from \[
  \phi = 2 \arctan \left( \frac{2 \text{ difference}}{\text{sum}} \right)
  \]
  or use the graph in Fig. 3.
  \item When using this method one must understand its limitations. When making high-frequency measurements it is vital that probes are equally compensated - best done by connecting both probes to one signal and adjusting for equal amplitudes. The accuracy of the method deteriorates as \( \phi \) approaches 0° or 180°. If the voltage measurement accuracy is 2.5% then accuracy will be about 6.3% at \( \phi = 90° \), reducing to about 10.5% at \( \phi = 12° \) or 16.8%. Accuracy will also be impeded if significant distortion of either sine wave exists; it is useful to synchronize the time base and check the waveforms.

While the sum-and-difference method of phase measurement will never replace an accurate phase meter or vector voltmeter in the eyes of those who can afford them, it does offer a useful technique which can sometimes out-perform these instruments, particularly when the signals are noisy. I have used the technique on a switching regulator to measure 10 mV signals in the presence of 100 mV of noise.

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In 1911, the name of Marconi was almost synonymous with ‘wireless’: marine wireless operators were, as often as not, referred to as ‘Marconi operators’. The growing profession of operating Marconi stations aboard ship demanded a more scientific approach, and the Marconi company responded in April 1911 with The Marconigraph, which carried news of the company’s activities scattered worldwide and of developments in wireless technology. Two years later, for reasons which have been aired before by writers more directly concerned with the event, The Marconigraph became The Wireless World and embarked on its declared life’s work of being “of use and interest” to a rather wider fraternity than had been the case in its previous existence. Sticklers for detail may, with some justification, point out that W.W is not 70 this month, but 68. We feel, however, that the two laurel years should be treated as the total for, while laying no claim to rosette, we think W.W quite as sweet as The Marconigraph.

While the new science and technology was at first naturally associated with ship communications, there is a remarkably close parallel to be drawn between the development of radio (and later electronics) and aviation. Both technologies were emergent in 1911 (Bleriot had landed at Dover only two years earlier and Fleming’s two-electrode valve was only seven years old); both were to advance rapidly in the two years that followed, at which rate and in such widely different fields as communication and aviation, the high-quality reproduction of sound. A great many of the leading figures in high fidelity have written in W.W, and continue to do so, on theory and practice - an asp pect perhaps best demonstrated by the publication of one of the many excellent pieces on wireless described by D. T. N. Williamson's valve amplifier just after World War II, which set a standard to judge the rest by. People still write to us for reprints of these articles.

Our two enduring interests over the years have been radio and television broadcasting and reception, and the high-quality reproduction of sound. A great many of the leading figures in high fidelity have written in W.W, and continue to do so, on theory and practice - an aspect perhaps best demonstrated by the publication of one of the many excellent pieces on wireless described by D. T. N. Williamson's valve amplifier just after World War II, which set a standard to judge the rest by. People still write to us for reprints of these articles.

The Williamson standard was and is upheld by writers such as Jack Dinsdale, Arthur Bailey, Laurie Nelson-Jones, John Lintley Hood and many others on the practical side of our content, and contributors of the calibre of Peter Baxandall, Professor David Bell, Thomas Raddick and the immortal Marcus Squire (Cathode Ray) have educated thousands of readers in the art of electronics.

Coverage of television began with Baird’s first crude experiments, although the tone of some of our reports was a little bemused. It reached peaks in 1947 and 1968 with the publication of one of the first designs for a home-constructed monochrome television receiver (deflection yoke and line-output transformer both being home made) and the colour receiver by Walter Cocking, who made an enormous contribution to the standard of our practical articles over many years. The two receiver designs illustrated some of the reasoning behind W.W projects, in that they were not necessarily the cheapest way of acquiring the receiver, or whatever was being built. One of the reasons for publishing them was that such a series of articles is undeniably the best way of explaining the operation of equipment. Even if one does not undertake the construction, the text is valuable in its own right.

In those days, of course, there were no integrated circuits. Circuit design was not the cost-effective deployment of the vast range of modules one can now select from, but the basic design that still goes on behind closed doors, its outcome being encapsulated in plastic. Integrated circuits have brought with them enormous opportunities for technical progress, but an unfortu­mate effect from a journal’s point of view is that an article describing a piece of digital equipment often reads a little like a knitting pattern. It is not as easy as it used to be to read such articles in isolation.

Nevertheless, we have no intention of abandoning the ground rules laid down 70 years ago, that Wireless World should entertain, educate and be of use and interest to readers in the art of electronics.

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Designing with microprocessors

7 - Wait/go systems

by D. Zissos, Department of Computer Science, University of Calgary, Canada

Previous articles have described the synchronization problem and the most widely used solution involving software wait loops. In this article the wait/go concept is explained and step-by-step procedures for the design and implementation of wait/go systems are described. The design steps are illustrated by means of a fully worked out example.

The wait/go concept

Let us assume that we have a microprocessor which automatically enters the wait state when an i/o instruction is being executed. Let us further assume that when in the wait state it generates a logic 1 on wait terminal w, and that it exits the wait state when the signal on go terminal is pulled high (g=1). The block diagram and state diagram of such a microprocessor are shown in Figs. 1 and 2. If we were to activate the peripheral with the 0 to 1 transition of the wait signal and keep the microprocessor in the wait state until the peripheral had fully responded, we would clearly have no synchronization problems. Furthermore, if the peripheral is an action/status device, the interface reduces to two wires, as we show next.

The two-wire interface

Our starting point is the block diagram of a wait/go system shown in Fig. 3. The signals w, g, a, and r have the following meaning:

Signal w: A '1' on this terminal (the wait line) indicates that the microprocessor has entered the wait state.

Signal g: A signal transition from 0 to 1 on this terminal (the go line) puts the microprocessor out of the wait state.

Signal a: A signal transition from 0 to 1 on this line triggers the peripheral into action.

Signal r: While the peripheral is responding (r=1), when the peripheral has fully responded r changes to 0. No activation is possible when r=0.

A suitable internal-state diagram of a circuit to implement the above interface is shown in Fig. 4. Applying the reduction steps to its equivalent state table in Fig. 5 allows its three rows to merge into one, as shown in Fig. 5(b).

By direct reference to the reduced state table, we obtain the following equations:

\[ g = w + w \cdot (\overline{r}) = r + w \]

The corresponding circuit implementation consisting of two wires is shown in Fig. 6.

Advantages

Wait/go systems are:

Easy to understand. The 'wait' and 'go' are everyday concepts, not requiring specialist knowledge.

Easy to design. The hardware is straightforward and presents no difficulty. Specifically, in the case of action/status devices it consists of two wires.

Easy to implement. Because of uncomplicated hardware.

Easy to program. Software overheads are minimal.

Easy to maintain - because of their reliability.

Wait/go logic

Although present-day microprocessors are not designed to operate in the wait/go mode, they can be made to do so by means of a relatively simple logic circuit, the wait/go logic, the block diagram of which is shown in Fig. 7. Its function is to look for i/o instructions with wait/go addresses, denoted by AW, and to put the microprocessor automatically into a wait state when such an instruction is detected. At this point it passes exit control to the go terminal, that is to the outside world.

A suitable internal-state diagram of the Intel 8080. The m.p.u. signals of the Intel 8080 were described in the first article (May 1980 issue). Reference to these signals shows that the op code and i/o address are loaded into the m.p.u. registers in timeslots M1-DBIN and the following DBIN respectively. It follows that we can identify an i/o instruction by simply determining whether the signals on the data bus in time slot M1-DBIN are 11010011 or not - 11010111 and 11011011 are the op codes for IN and OUT. Similarly, the wait/go addresses are identified by looking at the data bus with the following DBIN signal. A suitable state diagram is shown in Fig. 8.

By direct reference to it, we obtain

\[ S_0 = S_1 + A \]

\[ S_1 = S_1 

\[ S_2 = S_0 + M_1 \]

\[ S_3 = S_2 + S_2 \]

\[ \text{Wait} \cdot \text{g} = A \cdot B \cdot \overline{A} \cdot A \cdot \text{B} \cdot \text{B} \cdot \text{W} \cdot \text{A} \cdot \text{W} \cdot \text{g} \]

The design and implementation of wait/go logic is straightforward, as we demonstrate by means of the following example.

Wait/go logic for the Intel 8080

The m.p.u. signals of the Intel 8080 were described in the first article (May 1980 issue). Reference to these signals shows that the op code and i/o address are loaded into the m.p.u. registers in timeslots M1-DBIN and the following DBIN respectively. It follows that we can identify an i/o instruction by simply determining whether the signals on the data bus in time slot M1-DBIN are 11010011 or not - 11010111 and 11011011 are the op codes for IN and OUT. Similarly, the wait/go addresses are identified by looking at the data bus with the following DBIN signal. A suitable state diagram is shown in Fig. 9.

The corresponding circuit implementation is shown in Fig. 10.
A design problem: PRINT

The problem is to design and implement a wait/go system that would allow the programmer to produce a hard copy of data, which is stored in consecutive memory locations.

Solution

As explained in the previous article, the first three design steps are independent of the microprocessor and therefore common to both solutions.

Step 1: aim of the design. The aim of the design is to expose the reader to wait/go systems.

Step 2: device characteristics. As specified.

Step 3: system design. The block diagram of our solution is shown in Fig. 10. Its step-by-step operation is flowcharted in Fig. 11. As in the case of the test-and-skip system described in the previous article, we shall use index addressing. Addressing modes were described in Part 3 in the August issue.

Table 1: Hex listing of the PRINT problem when implemented using the wait/go mode and the Motorola 6800.

<table>
<thead>
<tr>
<th>Hex address</th>
<th>Hex listing</th>
<th>Mnemonics</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000</td>
<td>CE</td>
<td>LDSX</td>
<td>Load index register with line</td>
</tr>
<tr>
<td>0020</td>
<td>20</td>
<td></td>
<td>40 on page 20 — location of the first byte to be printed.</td>
</tr>
<tr>
<td>0040</td>
<td></td>
<td>LDSX</td>
<td>Load acc. A with block</td>
</tr>
<tr>
<td>0044</td>
<td>n</td>
<td>STAA</td>
<td>Copy acc. A (n) into memory</td>
</tr>
<tr>
<td>0047</td>
<td></td>
<td>STAA</td>
<td>location 10 on page 20 to be used as a counter</td>
</tr>
<tr>
<td>0068</td>
<td>27</td>
<td>BEQ</td>
<td>Branch to M2, if n = 0 — forward 11</td>
</tr>
<tr>
<td>0069</td>
<td>0B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>006A</td>
<td>A8</td>
<td>LDSX</td>
<td>Load acc. B next byte to be printed</td>
</tr>
<tr>
<td>006C</td>
<td>B7</td>
<td>STAA</td>
<td>PRINT — printer address 1000</td>
</tr>
<tr>
<td>006D</td>
<td>10</td>
<td>DEC</td>
<td>Decrement byte count (held)</td>
</tr>
<tr>
<td>006E</td>
<td>00</td>
<td></td>
<td>in memory location 2010</td>
</tr>
<tr>
<td>006F</td>
<td>08</td>
<td>INX</td>
<td>Point to next byte</td>
</tr>
<tr>
<td>0107</td>
<td>7A</td>
<td>DEC</td>
<td>Decrement byte count (held)</td>
</tr>
<tr>
<td>0112</td>
<td>20</td>
<td>BRA</td>
<td>Branch to M1 — back 13</td>
</tr>
<tr>
<td>0113</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0114</td>
<td>F3</td>
<td>WA1</td>
<td>Stop</td>
</tr>
<tr>
<td>0202</td>
<td>15</td>
<td>M2:</td>
<td></td>
</tr>
<tr>
<td>030E</td>
<td>3E</td>
<td>WA1</td>
<td>Stop</td>
</tr>
</tbody>
</table>

Fig. 10. Block diagram of the PRINT problem.

Table 2: Hex listing of the PRINT problem when implemented using the wait/go mode and the Intel 8080.

<table>
<thead>
<tr>
<th>Hex address</th>
<th>Hex listing</th>
<th>Mnemonics</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>21</td>
<td>LX1</td>
<td>Set memory pointer to line</td>
</tr>
<tr>
<td>0100</td>
<td>40</td>
<td></td>
<td>40 on page 20 — location of the first byte to be printed</td>
</tr>
<tr>
<td>0202</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0306</td>
<td>0E</td>
<td>MV1 C</td>
<td>Load register C with block length (n)</td>
</tr>
<tr>
<td>0405</td>
<td>C</td>
<td>INRC</td>
<td>Increment C-sets flags</td>
</tr>
<tr>
<td>0502</td>
<td>0D</td>
<td>DCRC</td>
<td>Decrement C</td>
</tr>
<tr>
<td>0607</td>
<td>CA</td>
<td>JZ</td>
<td>Jump to L1, if n = 0 — set the zero flag is set</td>
</tr>
<tr>
<td>0808</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0909</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0A0A</td>
<td>7E</td>
<td>MOV A, M</td>
<td>Move into A next byte to be printed</td>
</tr>
<tr>
<td>0B0B</td>
<td>D3</td>
<td>OUT</td>
<td>PRINT</td>
</tr>
<tr>
<td>0C0C</td>
<td>06</td>
<td>INX H</td>
<td>Point to next byte in the block</td>
</tr>
<tr>
<td>0D0D</td>
<td>23</td>
<td>JMP</td>
<td>Go to L2</td>
</tr>
<tr>
<td>0E0E</td>
<td>C3</td>
<td>C4</td>
<td></td>
</tr>
<tr>
<td>0F0F</td>
<td>06</td>
<td>C4</td>
<td></td>
</tr>
<tr>
<td>100A</td>
<td>10</td>
<td>C4</td>
<td></td>
</tr>
<tr>
<td>110B</td>
<td>76</td>
<td>HLT</td>
<td>Stop</td>
</tr>
<tr>
<td>1202</td>
<td>15</td>
<td>M2:</td>
<td></td>
</tr>
<tr>
<td>130E</td>
<td>3E</td>
<td>WA1</td>
<td>Stop</td>
</tr>
</tbody>
</table>

Fig. 12. Programming chart of the PRINT problem using the M6800.

Fig. 14. Programming model for the PRINT problem using the Intel 8080.

References


Demetrius Zissos is Professor of Computer Science and Adjunct Professor of Electrical Engineering at the University of Calgary, Canada. Educated in Britain, he has been associated with industry on both sides of the Atlantic for the past twenty years. He has written five books and numerous articles, including a series (with Brian Holdsworth) on logic design in Wireless World. He is currently writing two further books, one on logic design and the other on distributed systems.
The earth-less vertical

In one of his series of classic papers on transmitting antennas, Dr. George Brown of RCA (Proc IRE, June 1937) analysed the efficiency of monopole radiators in terms of their use with 'simple' verticals and horizontal arrays at moderate height. The concept of the earth-plane, however, has many advantages of cost and convenience since it requires no tower, no rotating mechanisms, and is a permanent structure and so presumably falls outside the scope of local authority planning, while at the same time offering plenty of scope for further investigation and development.

Amateurs and c.b. operators, particularly in recent years, amateurs using verticals on 7MHz and below have been persuaded that an extensive earthing system or "mast" is a vital essential. Since such an earthing system cannot be fitted into the average garden, the h.f. general is generally accepted as not providing the sort of performance at long distances of which it should be theoretically capable.

Recently, Leslie Moxon, G6XKN, who has been building a considerable number of verticals for many years and has been trying out many different earth methods, has come to the conclusion that he can achieve the same performance using an earth based for over 75 to 90 per cent. More and more, in recent years, amateurs using verticals on 7MHz and below have been persuaded that an extensive earthing system or "mast" is a vital essential. Since such an earthing system cannot be fitted into the average garden, the h.f. general is generally accepted as not providing the sort of performance at long distances of which it should be theoretically capable.

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amplifier, one which adds no extra noise to the thermal noise of the source, the noise factor is unity, and the noise figure zero. Usually there is not a great deal of value in reducing the noise figure much below 3dB. A noise figure of 5dB is equivalent to saying that the amplifier and source are contributing an equal amount of noise to the wanted signal. Even if the amplifier noise could be reduced to 0.1 of the source noise, the total system noise is now about 0.7 of the BD condition. However it must be remembered that an amplifier with a noise figure of 0.5dB at 1kHz with source resistance of 5kΩ will have a higher figure at low frequencies and at source resistances away from the optimum.

The normal procedure is to design the amplifier for a minimum noise figure at the desired source resistance. The optimum collector current for the transistor depends on the driving source resistance $R_s$ and the direct current gain $β$.

Optimum collector current

For example, determine the optimum current for a 2N4403 transistor with a source resistance of 400 ohms. Initially $β$ can be taken as 200.

\[
I_C = \frac{(100)^3}{40kΩ} = 0.88mA.
\]

As shown in Table 1 a $β$ of 200 at 0.88mA is possible. If the formula had given a much lower optimum collector current, say 50mA, then the $β$ would have to be reduced to about 100 and the optimum collector current recalculated. This procedure is repeated if necessary until the $β$ is believable for the calculated collector current.

The procedure is not too critical because of the wide variations in $β$ between one transistor and the next and because the optimum collector current is proportional to the square root of $β$.

The minimum noise factor $F$ at the optimum collector current can be calculated from the source resistance $R_s$, the collector current gain $β$, and the intrinsic base spreading resistance $r_{bb0}$.

\[
F = 1 + \frac{1}{\beta} \left( \frac{r_{bb0}}{2RF} \right) \quad \text{if} \quad 2RF > 204 \text{ or 46dB.}
\]

Table 2 shows results on two amplifiers giving within 1dB of the calculated value. The input resistance was 27kΩ. As

<table>
<thead>
<tr>
<th>Transistor</th>
<th>$β$</th>
<th>$r_{bb0}$ (Ω)</th>
<th>$RF$ (Ω)</th>
<th>NF</th>
</tr>
</thead>
<tbody>
<tr>
<td>2N930</td>
<td>150</td>
<td>51</td>
<td>1,198</td>
<td>0.79</td>
</tr>
<tr>
<td>2N4124</td>
<td>150</td>
<td>51</td>
<td>1,028</td>
<td>0.61</td>
</tr>
<tr>
<td>BC109</td>
<td>250</td>
<td>65</td>
<td>4,130</td>
<td>0.53</td>
</tr>
<tr>
<td>2N3707</td>
<td>220</td>
<td>61.8</td>
<td>2,101</td>
<td>0.42</td>
</tr>
<tr>
<td>2N4403</td>
<td>100</td>
<td>41.7</td>
<td>5,108</td>
<td>0.46</td>
</tr>
<tr>
<td>2N4125</td>
<td>100</td>
<td>41.7</td>
<td>5,108</td>
<td>0.46</td>
</tr>
<tr>
<td>2N9684</td>
<td>280</td>
<td>67.7</td>
<td>1,085</td>
<td>0.38</td>
</tr>
<tr>
<td>2N4250</td>
<td>280</td>
<td>67.7</td>
<td>1,085</td>
<td>0.35</td>
</tr>
</tbody>
</table>

The practical open-loop gain for this type of circuit is

\[
RF = \frac{320 \times 470}{108^2} = 16,400 \text{ times 83dB.}
\]

A practical measurement of this circuit gave an open-loop gain of 84dB, which is perhaps more realistic.

Unlike the first circuit, where the gain was well defined by the collector current, the gain of this circuit depends on the $β$ of the second transistor. Overall negative feedback is therefore essential to accurately define the closed-loop gain. In Fig. 5 the closed-loop gain is 60dB and the frequency response is 3dB down at 81Hz and 45kHz.

The closed-loop gain is defined as

\[
G = \frac{1}{1+R_s/R_1}.
\]

Resistor $R_1$ is required so that the closed-loop gain can be defined by overall negative feedback. It also provides series local feedback for $R_s$ and reduces the open-loop gain by about 7dB. However the open-loop gain of 80dB which was measured is adequate to provide a reasonable amount of feedback at low frequencies even though the equalization curve demands a 20dB gain boost (below 50Hz) above the mid-band gain. The value of $R_1$ cannot be made too low as this will force a reduction in the feedback impedance, reducing the available output voltage swing at high frequencies where the equalization curve falls at 6dB per octave.

Although negative feedback does not alter the amplifier’s noise figure, $R_1$ is effectively in series with the source and can contribute a component of thermal noise, the effect of which depends on the source resistance. It should be made much smaller than the source resistance. Noise factor with $R_1$ is

\[
F = \frac{F_1}{F_2} \cdot \frac{R_1}{R_2}.
\]

In the example

\[
F = 1.107 \times 470 = 1.185 \text{ times 6000}
\]

thus $NF = 10 \log 1.185 = 0.74dB$.

Although this appears to be a significant degradation the resultant noise figure is still less than the 5dB level considered to be a reasonable value. It does indicate why an approach like Fig. 2 is valuable for critical applications, because the gain can be closely determined by the circuit parameters without using emitter degradations.

Further reading

Low-noise Electronic Design, by C. D. Metcalf and W. F. Wiese, 1973, gives many practical examples which are fully specified in terms of gain, bandwidth, and noise for up to four different values of passive components.
Magnetic recording review

2 - Performance of modern cassette tapes

by J. Moir, F.I.E.E., James Moir and Associates

Mr Moir continues his survey of magnetic recording technology and materials with an examination of modern cassette tapes. A brief look as possible future developments concludes the article.

Equalization

The limited frequency response of the early ferric coated tapes led to the extensive use of electronic equalization, a shaping of the frequency response of the record and replay amplifiers to improve both the frequency response and the signal to noise ratio. The correction required to achieve a flat overall record/replay response was divided between the record and replay systems in a way that eliminated the need for variable equalization in the user's equipment. Standard replay calibration tapes were produced, having a closely specified response curve, and the recording engineer, having equalized his replay equipment to ensure that these standard tapes played with a flat frequency response, was required to vary the equalization of his recording system to ensure that equal response was achieved until the overall record/replay system response gave the same flat overall response.

However, the performance of tape coatings and our knowledge of record and replay head design has so far improved that the equalization originally specified is not only unnecessary but actually degrades the performance of many of the recent types of tape.

The equalization to be applied to the system was specified indirectly as the relation between the signal voltage at the input of the recording head and the resultant surface induction (now the short-circuit flux) on the tape. It was defined as the combination of two curves, one being the response of an RC circuit with a time constant of 1590 microseconds, defining the low-frequency performance, and a second RC circuit with a time constant of 120 microseconds defining the performance at frequencies above about 800Hz. The combined frequency response can be read from Table 1: Standard time constants

Table 1: Standard time constants

<table>
<thead>
<tr>
<th>Speed</th>
<th>Time Constant</th>
</tr>
</thead>
<tbody>
<tr>
<td>76.2 cm/s (20in/sec)</td>
<td>35</td>
</tr>
<tr>
<td>38.1 cm/s (15in/sec)</td>
<td>70</td>
</tr>
<tr>
<td>19.05 cm/s (7 1/2in/sec)</td>
<td>100</td>
</tr>
<tr>
<td>9.53 cm/s (3 1/4in/sec)</td>
<td>200</td>
</tr>
<tr>
<td>4.76 cm/s (1 1/2in/sec)</td>
<td>1200</td>
</tr>
</tbody>
</table>

Fig. 9, showing the appropriate curves. The low-frequency signal is boosted and the high-frequency signal attenuated in the recording process to minimize distortion arising from the limited signal handling capacity of magnetic tape at high frequencies. Table 1 provides data on the agreed correction curves for all the current standard tape speeds.

To obtain a flat overall record/replay response, the replay chain must have the inverse response, but to achieve this some additional high-frequency equalization must be included to compensate for the high-frequency losses in the replay head.

The standard replay calibration tapes are recorded with a carefully controlled surface short-circuit flux/frequency relation that follows the specified recording curve. When these tapes are replayed, a flat replay system frequency response can be obtained in the replay system. The standard replay calibration tapes are recorded with a carefully controlled surface short-circuit flux/frequency relation that follows the specified recording curve. When these tapes are replayed, a flat replay system frequency response can be obtained in the replay system.

Current tapes

At this point it appears appropriate to change from outlining simple theory to looking at some examples of current practice in tape production. About 100 samples of current cassette tapes from 25 suppliers were examined, using a Nakamichi 582 discrete-head machine, which is a good modern machine, with facilities for bias and equalization adjustment, and which is capable of handling metal tapes without saturating the recording head.

The bias settings were chosen using the Nakamichi facilities for equalizing the signal output at frequencies of 406Hz and 15kHz and with the equalization set to 120µs for the ferric and 70µs for the ferrichrome, chromium dioxide and metal tapes. The bias settings are quoted in dB with respect to the appropriate DIN reference, but since there are as yet no metal reference tapes, the bias setting employed for these tests are quoted with reference to the Nakamichi metal tape.

The data for all the examples of each type of tape coating are averaged and these are the values in Table 2. The limits given in the Frequency ‘Response’ column should only be taken as being generally indicative of the results, the complete curves being used for every more detailed comparison.

The advantage possessed by the metal-tape recording medium of saturation value at high frequencies is not immediately obvious from the data in the Table, but, being masked by the reduction of the high-frequency pre-emphasis from 120µs to 70µs, it is against the bias the metal-tape tape accepts a reduction in the high-frequency attenuation of the standard recording amplifier and this in turn necessitates a reduction in the replay bias-amplifier high-frequency boost, with a corresponding improvement in the overall signal/noise ratio.

The frequency response curves are provided for each type of tape in Fig. 10. Five separate bias levels are needed to enable optimum performance from every type of tape. However, the person who buys and special ‘offer’ tapes is unlikely to be interested in paying for a wide range of bias adjustment on his machine, so three levels of bias adjustment are probably adequate for the majority. Few of the cheap machines provide bias adjustment on the bias performance of the simple ferric tape.

The penalty for buying ‘special offer’ and ‘advertising-postal circular’ types of tape is illustrated by the frequency response of Fig. 11. This is measured frequency response of a tape widely advertised under the name of, but having no connexion with, a very well known company. Not all such budget tapes are equally bad, however, and some of the very cheap ferric tapes may well be perfectly satisfactory in a machine bought for a youngster. At an intermediate price level, many own-name tapes from Boots and other well known multiple stores are excellent value for money.

The ferrichrome, two-layer tapes produced an unexpected response curve with a step of about 4dB at frequencies in the region of 2kHz, presumably due to the presence of an extra coating type of tape between the chromium dioxide and ferric layers. This step would appear to require a special equalization curve to achieve the optimum performance. With the bias optimized as described for each type of tape, the metal tapes are seen to have the highest m.o.l. at 40kHz, the highest saturation level at 10kHz, the lowest noise level and currently the highest price, but note the qualification about optimizing the bias. A less well appreciated limitation to the use of metal tapes and even some of the CrO₂ tape is the inability of many machines to fully modulate the tape at high frequencies, head design and circuit limitations being the apparent cause.

The performance of metal tapes used in machines incapable of providing the optimum bias is generally much worse than that of magnetic discontinuity at inferior ferric/chromium-tape.

Some comment about the material employed for the tape base is probably interesting. The original tapes were all precoated, but in recent years tensile-poly

Table 2: Typical performance characteristics of cassette tapes

<table>
<thead>
<tr>
<th>Tape Type</th>
<th>Bias level</th>
<th>32kHz MOL</th>
<th>Sensit. (CCIR)</th>
<th>1kHz Sat.</th>
<th>Noise (CCIR)</th>
<th>Print through</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferric tape</td>
<td>+0.29</td>
<td>0.84</td>
<td>78.4</td>
<td>-7.25</td>
<td>56.6</td>
<td>0.34</td>
</tr>
<tr>
<td>Ferric tape</td>
<td>+1.31</td>
<td>5.14</td>
<td>1.07</td>
<td>-6.34</td>
<td>54.7</td>
<td>0.34</td>
</tr>
<tr>
<td>Ferric tape</td>
<td>+3.13</td>
<td>7.3</td>
<td>0.7</td>
<td>-6.38</td>
<td>54.7</td>
<td>0.35</td>
</tr>
<tr>
<td>Ferric tape</td>
<td>+5.62</td>
<td>9.07</td>
<td>0.97</td>
<td>-6.38</td>
<td>54.7</td>
<td>0.35</td>
</tr>
<tr>
<td>Ferric tape</td>
<td>+6.33</td>
<td>5.09</td>
<td>0.67</td>
<td>-6.12</td>
<td>54.3</td>
<td>0.34</td>
</tr>
<tr>
<td>Metal tape</td>
<td>+11.4</td>
<td>6.82</td>
<td>0.6</td>
<td>-3.56</td>
<td>54.8</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Notes:

1. CrO₂ sensitivity quoted with respect to DIN CrO₂ sensitivity on optimum bias setting (+6dB).
2. FeC sensitivity quoted with respect to DIN Fe sensitivity.
3. Metal sensitivity quoted with respect to Nakamichi metal tape.
4. @ Equalization problem on Nakamichi with FeC tapes.
5. All tapes were played without Dolby reduction of otherwise stated.
6. From an initial inspection of the Table it would appear that the high-frequency saturation level of metal tapes is little better than that of good quality ferric tapes. However, the tests carried out on the metal tapes were with 70µs equalization whilst those in the ferric tapes were done using 120µs equalization. In absolute terms, the performance of the metal tape in this respect is at least still better than the ferric tapes but, because the manufacturers have chosen to use a different equalization arrangement, the benefits of improved high-frequency saturation are not realized by the user. As far as the average user is concerned, the main advantage of using a metal tape would be an improvement of 4dB in background noise level.

www.americanradiohistory.com
Dividing by fractions
continued from page 61

.. a control unit would consist of a variable control and a programmer selector switch.
In practice, correctly designed tone controls can make a significant contribution.

.. a constant sound level, replay from a gramophone record produces distortion which increases very rapidly at high frequencies, doubling in fact for every major third increase in pitch.

There comes a point when the contribution of this distortion is increasing at a greater rate than the

If everything were perfect...

musical content and this is what decides the optimum setting of the comprehensive Quad filter system, an essential integral part of every Quad pre-amplifier.

The rate of attenuation can be set anywhere between 0 and 25dB per octave starting at one of three frequencies 5k, 7k, or 10kHz and an appropriate setting can be found for each record to provide more of the music and less of the distortion.

To learn all about the Quad 44 write or telephone for a leaflet.

The Acoustical Manufacturing Co. Ltd.,
Huntingdon PE16 7DB.
Telephone: (0480) 52561.

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Surface acoustic wave devices

2 – More on bandpass filters, delay lines and oscillators

by R. J. Murray and P. D. White
Philips Research Laboratories

This second part gives fuller information on the specification, operation and performance trade-offs of bandpass filters, delay lines and oscillators.

Bandpass filters

There are two types of s.a.w. bandpass filters. The first is the transversal filter, which consists of two or more interdigital transducers (see "principles") and is a travelling wave structure. These filters are wideband, with bandwidths of 0.2% to 100% of centre frequency. Centre frequencies in the range 10MHz–500MHz are readily achievable with a projected upper limit in excess of 1.5GHz. Design procedures are similar to those used for digital filters. The second type of bandpass filter is the resonator kind, which consists of one or more i.d.t.s in a cavity formed by two surface wave reflectors. This structure supports a standing wave. Bandwidths of 0.01% to 1% of centre frequency are feasible, with centre frequencies currently in the range 50–500MHz and ultimately greater than 1.5GHz. Design procedures are similar to those of conventional LC filters.

Transversal filters. Fig. 7 (a) shows a s.a.w. transversal bandpass filter, which consists of two i.d.t.s on a piezoelectric substrate. An electrical signal is fed into one transducer, converted to a surface acoustic wave, reconverted to electrical energy at the other i.d.t. and emerges as a filtered signal. An alternative structure is shown in Fig. 7 (b) which incorporates in the s.a.w. propagation path a multistrip coupler. Design procedures are similar to those of conventional LC filters.

Delay lines

The filter amplitude response A(f) is given by:

\[ A(f) = H_1(f) \cdot H_2(f) \]  

and the phase \( \phi(f) \) by:

\[ \phi(f) = -2\pi f t \tan^{-1} \left( \frac{\Im \{H_1(f) \cdot H_2(f)\}}{\Re \{H_1(f) \cdot H_2(f)\}} \right) \]

where \( H_1(f) \) and \( H_2(f) \) are total insertion loss of the filter.

In general, spurious signals will arrive at the output transducer with a different time delay from that of the main signal. These cause ripples in the amplitude, phase and group delay response of the filter.

This optimum is achieved by designing the filter so that the group delay is constant and is equal to the required value. For a delay line of length \( L \), the group delay is given by:

\[ T = \frac{L}{v \cdot s_{\text{min}}} \]

where \( s_{\text{min}} \) is the minimum centre-to-centre separation of the i.d.t.s, \( v \) is the s.a.w. velocity and \( T \) denotes complex conjugate.

Multistrip coupler

Fig. 7. (a) S.a.w. transversal filter geometry; (b) s.a.w. transversal filter incorporating multi-strip coupler to suppress unwanted bulk waves.
group delay responses of the filter. These spurious signals can cause quite large deviations from the ideal response and appropriate steps are usually taken to minimize their effect.

The most serious unwanted response is usually the triple transit signal which is illustrated in Fig. 8. This is caused by successive reflections from the output and input transducers before detection. If the main signal delay is $\tau$, then the triple transit signal is delayed by $3\tau$. If two or more of these elements are connected together, a compound resonator is formed.

The equivalent circuit of a two-port resonator is shown in Fig. 13(b). The capacitor $C_2$ is defined by the coupling transducer and is given by:

$$C_2 = \frac{N_2}{N_1}$$

where $N_1$ is the length of the input/output I.D.ts and $N_2$ is the length of the coupling I.D.t.

Normal coupled resonator behaviour is observed as $N_2$ is changed, as illustrated in Fig. 14. By appropriate choice of structure, including in some cases inductive tuning, various standard filter types may be realised (Butterworth, Chebyshev, etc.). In general, any number of resonators may be coupled together to form a multistage filter. A third-order filter is shown in Fig. 15.

S.A.W. resonator filters are low loss narrowband filters and are temperature stable if a quartz substrate is used. In the frequency range of application (50-1500 MHz) there are very few suitable alternative filters. However, since the resonator allows narrowband filtering to be implemented at frequencies at which it has previously not been feasible, this has many implications in the design of modern systems where the filters may be included at the front end of communication systems and in the high frequency section.

Design procedure for S.A.W. resonator filters is similar to those for LC filters and the filters are minimum phase. Unlike transversal filters, the phase response achieved for a given amplitude response is uniquely defined.

Further details of delay lines

S.A.W. delay lines consist of two I.D.ts suitably placed on a piezo-electric substrate. If each I.D.t. is geometrically symmetric or antisymmetric (about its geometric centre) then the delay line frequency response is band-pass with a linear phase characteristic. Identical uniform transducers are usually used and the amplitude response is, therefore, $\sin a/2$ (see section on "Principles"). Alternatively, with a suitable asymmetric design of the I.D.t. the delay line can be made to be dispersive (I.e. the delay varying as a controlled function of frequency).

Linear phase delay lines can be made with bandwidths of up to 100% of centre frequency over the frequency range of 10 MHz - 1.5 GHz. Delays ranging from 400 nanoseconds to 30 milliseconds or more can be achieved. Relative delays of less than 10 nanoseconds and phase deviations of less than 0.1% may also be achieved. The delay of such a S.A.W. resonator can be used in essentially the same oscillator circuits as conventional wide bandwidth resonators, or two port resonators can be used in an amplifier feedback loop. Resonator oscillators can only provide very narrowband linear frequency modulation but can provide better noise performance. Both types of oscillator work at fundamental frequencies in the range 10 MHz-1.5 GHz without additional multiplying circuitry. The devices are considerably smaller, cheaper and lighter than conventional oscillator techniques.
Delay line oscillators. Fig. 17 is a schematic representation of a delay line oscillator. The delay line consists of two d.t.s separated by a distance L, with a delay of L/ν corresponding to a phase shift at a frequency of ν0, where

$$\nu_0 = \frac{2\pi f}{c}$$

where ν0 is the electrical phase shift around the loop and f is the frequency. It is written at a level which has only been seriously studied for around twenty years. It is published in 1976, which thoroughly describes a multiple frequencies using one reference oscillator. The output signal can be taken at any point in the delay line. This technique is illustrated in Fig. 18.

Resonator oscillators. S.a.w. resonators (see earlier section) operate at high Q components operating at frequencies of 50MHz and above. It is possible to use these devices as oscillator control elements to provide stable sources at fundamental frequencies in the range 50MHz to 1.5GHz.

A resonator may be used in an oscillator as either a one-port or two-port device. If the two-port configuration is used, then the circuit becomes similar to that used for delay line oscillators, i.e. an amplifier and a resonator device in a feedback loop. The advantage of a resonator over a delay line oscillator is that the resonator need only provide 4 to 5dB of gain since the resonator has a lower insertion loss than the delay line. For a one-port configuration, there is less potential for insertion frequency modulation.

If the resonator is used as a separate device then the circuit would be similar to that used for bulk wave crystal oscillators (e.g. Colpitts oscillator) and because of the higher frequency (at u.f.) the construction could be based on a cavity or resonator stabilized oscillator. A single crystal can be used in some cases, giving a very compact oscillator.

Multipath distortion

Many broadcasting authorities have introduced, or are planning to introduce, vertical or circular polarized transmission to help reception on vertical aerials in areas of domestic reception problems. However, there is some correlation between polarisation and an increase in degradation caused by receiving the signal from more than one source. Research in Japan and Germany has helped to analyse the problem.

A recent survey article—"How serious is multipath distortion?"—drawed attention to the lack of recognition in the UK that multipath propagation is probably the most serious cause of the degradation of quality of v.h.f./m stereo broadcasts reproduced in the home through good quality equipment, even when reasonably careful regard has been paid to aerial installation.

The article stressed that over 25 years after the start of regular v.h.f./m broadcasting in the UK (May 2, 1955) and about 15 years after the gradual introduction of pilot-tone stereo, there was still widespread lack of knowledge about the extent, and methods of mitigating multipath effects, induced to some degree by the reluctance of broadcasters, long concerned with the problem of吸引更多 listeners to use v.h.f./m rather than fm/m, to draw attention, except in the technical simplistic terms, to this problem.

Since that article was written, several developments have taken place which have serious consideration by those interested in high-quality reproduction of broadcast sound.

(1) While the original article drew attention to the work carried out by NHK in Japan, the information then available was limited to a short English-text summary. Full details of this valuable investigation have now been published by Mitsuo Ohara in IEEE Transactions on Broadcast (Ref. 2). This paper makes it clear that multipath distortion is "far greater" on stereo than on mono transmissions and also stresses the need for stereo separation (although the early investigations in the US and UK between 1940-1960 were of course concerned with mono). Additionally it shows that multipath can be the cause of serious crosstalk into the broadcast programme of information carried on additional sub-carriers, including the SCA (sub-channel) system commonly used in the USA and, by implication, the ultrasonic tone signalling systems used in the UK, and the experimental 'programme labelling' systems, etc.

(2) Investigations carried out in the Cologne area of West Germany, including 212 test sites carried out by three specially equipped vehicles, and reported in EBU Review (Technical Part) (Ref 3) indicate that the addition of a vertical component to an horizontally polarized transmissions, that is any form of mixed polarization, significantly increases rather than decreases the extent of multipath distortion, even for listeners with good, outdoor horizontal polarized aerials. This report emphasizes that from both the economic and purely technical points of view, the adoption of circular polarization in West Germany would be undesirable. This report has been published shortly after the BBC announced its intention (Ref 4) of adding a vertical component to its national v.h.f./m networks of Radio 1-4 (with Wrotham to be modified in 1981), on the grounds that "provision for listeners using car radios, although the German investigators question even this assumption.

(3) The vulnerability of digital systems (including text) to short as long term echo was noted in the earlier article. Since then it has become clear that British Telecom are experiencing more domestic transmission problems than they anticipated in the planning of high-speed digital networks (140 Mbit/s etc) even on strictly line of sight microwave links. The Post Office Research Department (Ref 5) notes that "Analogous I.M. link systems are relatively tolerant of the signal distortions produced by a narrowband interference, whereas an increase in intermodulation noise... in digital systems, the signal carriers arriving at alternate paths introduce multipath interference... errors in the phase of the recovered carrier... result in a more severe degradation in system performance". To overcome multipath problems without increasing the amount of distortion of monophonic or stereophonic broadcasting.

It is now clear that even well-planned,
microwave links can suffer from multipath effects caused by such things as reception on a v.h.f./f.m. sound broadcasting channel, or reception of double sidebands on a television channel. The IEEE B5 committee (Radio and Communications) is planning a Colloquium on Multipath Problems in May 1981. Although current thinking tends, for a variety of reasons, to favour digital systems there is the hope that with the gradual fall-off in the use of analogue systems it is preferable to the 'going-go' characteristics of digital.

Proling is a portable, multi-channel data acquisition and transmission system, with dual microprocessors controlling all over control operational functions. It is described in detail in their catalogue, contained in a colour brochure, which can be obtained from the company at Monitor House, Station Road, Huntingdon, Cambridgeshire PE17 1AR. 

Hence we refer to the Japanese work and the 50% of digital signals which are transmitted in the absence of any terrestrial link.
Amplitude sensing and control

by Peter Williams, Ph.D. Paisley College of Technology

There are two reasons for controlling the amplitude of a sinusoidal generator. The obvious one is where that amplitude affects the behaviour of some associated circuit or where its value is involved in consequent calculations. Less obviously any increase in amplitude changes the waveform because the output transistors are non-linear over the range of the active devices. The harmonics resulting are returned to the input which produces intermodulation due to the non-linearities producing new components at the fundamental frequency. These are equivalent to a phase-shift in the fundamental and have the same effect in shifting the frequency of oscillation as would any other perturbation. The amplitude control mechanism is essentially a negative feedback system in which some property of the output amplitude is sensed, used to modify the feedback, and hence to set the amplitude to a desired level. The first two networks contain elements whose resistance is temperature- and hence dissipation-sensitive. Their time constant is made long compared with the oscillation frequency. Amplitude is sensed at a point at which the heating effect (r.m.s. dependent) brings the element to a level at which the oscillation is self-sustaining.

The r.m.s. methods involve elements that consume power and have of necessity a slow response. When to these factors the relatively high cost and possible temperature dependence are added, alternative solutions become increasingly attractive. Conditions for sustained oscillation at constant amplitude is that the loop gain be identically unity. When a non-linear network is included in the feedback loop then the loop gain can exceed the critical value at low amplitude ensuring that oscillation build up. As amplitude increases the signal forces the non-linear elements into regions of their characteristics where the loop gain fails to less than unity. The amplitude stabilises such that the mean value of the loop gain is at the critical value. Stabilising action is instantaneous in that there are no time-constants involved other than stray. Disadvantage of the method is that it achieves its effect by deliberately distorting the feedback signal, though the remainder of the circuit may attenuate the harmonics as they pass through the frequency dependent network. The most common technique places a symmetrical pair of diodes (or series connected back-to-back zener diodes) so as to increase the feedback at higher amplitudes. A field-effect transistor having a low dynamic impedance at low voltages and then going into current limit would have the same effect placed in the other limb.

A third method combines some of the advantages of the previous two. It uses only electronic devices, consumes very little power and can introduce negative feedback. It has the disadvantage that a deliberate time constant has to be introduced into the sensing action, though this time constant can be suit the value (a property not shared by thermistors of lamps whose thermal time constants must be long compared with the period of the lowest desired oscillation frequency). The output is peak-referenced and the direct voltage is applied to the gate of a field-effect transistor. The on-resistance of the drain-source path is varied and can form part of a potential divider feedback loop. As shown the positive peaks generate a positive voltage that reverses the p-channel F.E.T. The value of $V_{DS}$ increases and with it the feedback. Because the F.E.T.'s characteristic is non-linear it cannot be used directly with very small voltage swings – preferably $V_{DS}$ > 10 where $V_{DS}$ is the pinch-off voltage. With additional direct feedback across the F.E.T. as shown it is found that the linearity is markedly improved. The resistance across the capacitor is a compromise between speed of response and distortion; increased ripple worsens the second end is by attempting to improve the first.

The methods above have the amplitude sensing mechanism in the passive network, the assumption being that the amplifier is perfectly linear. It is equally feasible to incorporate the non-linearities in the forward path i.e. in the amplifier. The disadvantage is that the harmonics are then fully present at the output, the filtering due to the R.C. network only being effective in reducing the distortion present at the input. In such cases the distortion is minimized by arranging the loop-gain for small signals to be only slightly greater than that required to sustain oscillation. This reduces the non-linearity required, though the output no longer is a compromise between speed of response and distortion; increased ripple worsens the second end is by attempting to improve the first.

The above examples demand high-Q passive networks as the distortion introduced via the non-linearities of the sensing mechanisms need not be large. These methods are thus acceptable for simple R.C. oscillators even though the attenuation of harmonics offered by these networks is relatively small. With LC oscillators or certain R.C. oscillators based on high-Q active filters the constraint is relaxed. If a high-Q band-pass circuit is driven by a square wave whose fundamental frequency is the filter centre frequency, then the harmonics are so reduced that an almost pure sine-wave results. It is difficult to maintain the drive frequency at the filter centre frequency since each harmonics offers an equal and usual tolerance. If instead the square wave is passed through a squaring circuit then its input is a square-wave of the appropriate frequency and constant amplitude. Provided the filter gain at the centre-frequency is constant the constant the amplitude square wave ensures an equally stable sinusoidal output. The square wave can be obtained either by a simple diode limiter or with greater accuracy using a comparator and precision clipping. Amplitude feedback with diodes in the forward path of an amplifier are also found.

Amplitude sensing and control

by Peter Williams, Ph.D. Paisley College of Technology

**THEORY**

- Networks are used as an amplitude-controlled negative feedback. At low amplitudes the steady state condition is $|2R|$ for the thermistor or $|2R|$ for the lamp, hence feedback $<1/3$ and for standard Wien type oscillators the amplitude increases. Conversely at high amplitudes the feedback $>1/3$ and amplitude decreases, stabilizing at the steady state level where the negative feedback just balances the positive feedback.

- These methods are mostly used where only approximate amplitude limiting is required, though they are instantaneous in their action while using little power. The non-linearity makes analysis difficult.

- The f.e.t. drain current is $\frac{1}{2}(V_{GS}-V_{TP})V_{OS}$ for $V_{GS}=0$, $V_{TP}$, i.e., conductance $\frac{1}{2}(V_{GS}-V_{TP})V_{OS}$, and is a linear function of the gate-source voltage. Hence varying the gate-source bias varies the conductance and hence the feedback.

**EXAMPLES**

1. A thermistor has a maximum permitted dissipation of 3mW and sets the output of a Wien oscillator to 1V r.m.s. Choose a suitable value of resistor to complete the bridge.

   $$\frac{1}{2} \cdot \frac{1.5^3}{3^2} \cdot \frac{3}{4.5} \cdot 10^{-3} \text{ A.m.s.}$$

   Series resistor $R = \frac{1}{3} \cdot 10^{10} = 3.3 \Omega$.

   A suitable resistor might be 100Ω, to keep the thermistor well below its maximum dissipation.

2. At what output voltage does diode conduction commence in the simple diode amplitude control circuit?

   Diode voltage at which current flow commences $= 0.5V$. Diode voltage is 2/3 of peak output.

   Output voltage $= \frac{2}{3} \cdot 0.5V$.

   R.m.s. output voltage $= \frac{2}{3} \cdot 10^{3} \cdot 0.5V = 10^{7} \text{ r.m.s.}$.

   In practice higher values are required since this level corresponds to only slight conduction, barely modifying the amplitude response and requiring critical resistor adjustments.

3. The peak sensing circuit has $R = 1\Omega$. If the frequency of oscillation is 1kHz, and the ripple across the capacitor is not to exceed 2% peak-peak, choose the corresponding capacitance.

   For small ripple, then as in simple rectifier theory linear discharge is a reasonable assumption

   $\frac{\Delta V}{V} = \frac{1}{T} \cdot \frac{1}{C} \cdot \frac{V_{os}}{V}$

   $\Delta V = 1 \cdot \frac{1}{C} \cdot \frac{V_{os}}{V}$

   $V_{os} = 10^7 \cdot \frac{V}{C}$.  

   For $C = 10^{-3} \cdot 10^9$.

4. The ringing resonant circuit uses a filter with $Q = 10$ a centre-frequency gain of 20 and an approximate square-wave of 1.2V peak-peak. Determine the % 3rd harmonic at the filter output.

   For square-wave of amplitude 1.2V peak-peak, the fundamental and 3rd harmonic amplitudes are

   $V_0 = 0.6$ and $V_3 = 0.6$.

   $\%$ 3rd harmonic = $\frac{V_3}{V_0} \cdot 100 = 12.5%$.

   Hence there is a second harmonic term in the output which expressed as a percentage of the fundamental term is proportional to the amplitude of the latter. Similarly higher-order terms result in the following transfer function, determining the effect of each harmonic in the output indicating the absence of the nth order term in the transfer function. Symmetrical transfer functions are preferred in the even-odd harmonic terms thereby cancelled so that the lowest harmonic is the third harmonic.
Cassette deck
Parts subject to wear have been kept to a minimum by eliminating belt drives, pulleys, friction clutches and mechanical brakes in a cassette recorder, designed by Revon, called the B70. These parts are avoided by using four direct-drive motors, two Hall controlled magnetic direct-drive motors with inductive tacho generators for the capstans and two optical tacho-controlled tape-hold motors. Separate P.L.L. circuits with a common, crystal-based reference are used to control the capstan motor speeds. Damped sub-plates engage the Sendust/ferrite heads and lock the cassette in position, and the whole drive mechanism is co-ordinated by a microprocessor to afford maximum protection to the tape. A four-digit display doubles as time-clock/counter and tape-position indicator, and has provisions for electronic set, scan and recall of values for both functions. Bar-type I.D. indicators display the peak recording level. This recorder is designed for professional use and switching to equalization, changeover, bias, the monitoring and Dubbing in stereo to avoid noise. F.W.O. Busch Ltd, 49 Theobald St, Borehamwood, Herts.

Data conversion kit
A data conversion evaluation kit for engineers wishing to assess analog-to-digital and digital-to-analog converters for a particular application is offered by Goldin. The kit, designed by Ferranti, costs £28 and comprises two 16-bit-a-to-ds, 8-bit d-to-a, two 8-bit a-to-ds and two 8-bit d-to-a-to-ds with all the relevant data in folder form. The latter devices require only a comparator and a gate and clock signal to change their operation from a-d to a-to-d. Goldin, 37 Loverock Rd, Reading, Berks RG3 lED.

Fibre-optic interfaces
A pair of small fibre-optic interfaces called HHIC-1 can be used to transmit digital data optically over distances in excess of 10m and at data rates of up to 15Mbps/sec. These modules, one a transmitter and one a receiver, are manufactured by Litchfield and measure 30×20×17mm without the fibre-optic connector. The transmitter module operates on a 5V supply, but the receiver can be operated on 4.5 to 12V, to give a t.t.l., d.t.l. or c.m.o.s.-compatible output. Connection is by four wire-wrap pins in d.d.l. formation on the base of each module. Fibre-optic cable can also be supplied by this company to provide a complete data transmission system with a bit error rate of better than 1 in 10^9. Litchfield Fibre Optic Communications, 129 Lindsey St, Epping, Essex CM16 6RE.

Computer interfacing a-to-d
Analog input data from sensors is processed to provide digital I/O data, for use with any computer or terminal which has a 20mA or RS-232 port, by the μMAG-4000 measurement and control system from Analog Devices. This system consists of a single 241×30mm board which provides sensor-conditioning, analogue multiplexing, analogue-to-digital conversion, digital I/O, serial communications and a p.c.b. Up to four of these boards, each of which accepts 4, 8 or 12 analogue inputs, can be used together to provide 48 channels! expansion boards can be used to allow up to 164 channels. A variety of using and non-isolating signal-conditioning modules which plug directly into the p.c.b.s are available for voltage and current sensing and for direct connection to thermocouples, r.l.ds (resistance temperature detectors), strain gauges, etc. For control functions, eight t.t.l-compatible outputs and eight t.t.l. or optically isolated inputs are provided on each board. Conditioned signals are processed by a low-drift, programmable-gain amplifier and 13-bit, integrating a-to-d convertor. An 8050 processor with 6K t.o.m. and 1K t.r.m. are used to monitor the computer and control interface units and store the converted input data. The data updating rate can be either 15 or 30 channels per second. A full duplex interface with t.t.l., t.r.m. receiver and transmitter is available in both serial and parallel versions at the serial i/v port over distances of up to 10000m from the host computer, using 20mA loops (for base rates under 600). Band rates of up to 9600 are quoted for the parallel interface with 300V d.c. The two ASCII-based protocols are compatible with assembly and high-level languages. Analog Devices Ltd, Central Avenue, Evesham, Worcestershire WR1 3GN.

15in oscilloscope
Various faceplates and colors are available for the 15in c.r.t. of the 1530 data oscilloscope from Robelex Electronics Ltd. This oscilloscope, with its small spot size and high writing speed, can be used in a number of applications, including computer-based analysers, radars, sonars and most processing systems, including a.f.s., d.c.s and m.o.s.-compatible output. Connection is by four wire-wrap pins in d.d.l. formation on the base of each module. Fibre-optic cable can also be supplied by this company to provide a complete data transmission system with a bit error rate of better than 1 in 10^9. Litchfield Fibre Optic Communications, 129 Lindsey St, Epping, Essex CM16 6RE.

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L.e.d. arrays
L.e.d. arrays with five or six elements and rectangular faces are manufactured by Improkes Ltd for use as level meter frontends, readout panel indicators or simple graphic displays. Each element, measuring 4.5×3.5 mm, is basicaly a 50mA peak forward current and 2V maximum forward operating voltage, so the arrays can be driven by t.t.l. outputs without buffering. Three one-colour versions, red, yellow or green, and one version with four green elements, are available. Luminous intensity varies from 0.2 and 1.7mcd, depending on the colour selected. These l.e.d.s are also available in the single form. IBR Electronics Ltd, 9600, 106 West St, Borehamwood, Herts.

Zero insertion force sockets
Under conditions where occasional field replacement of l.c. is unavoidable the Econo Zip from BFI Electronics can be used. These zero insertion-force connectors are a series of plug-in clips which are designed for production rather than test applications and the usual locking lever is replaced by a screw head. Otherwise, the design is similar to other such devices on the market but the cost per unit has been kept low. Six versions are available to take 16, 24, 26, 40, 48 or 64 pin l.c.s. and are gold-plated to 100um thickness. BFI Electronics Ltd, 51a Alden Road, West Molesey, Surrey.

Magnet machining
Permanent magnets from stock or supplied by the customer can be machined by Magnet Developments Ltd. Their factory, they say, is equipped with eleven and spot-welding machines, geared to machine and cut permanent magnets accurately for prototype or short production runs. The variety of magnets stocked by the company include sintered and bonded rare-earth types, unisised and ferrite types and cast-alnico. A design advisory service also is available to customers. Magnet Developments Ltd, Unit 7, Hardwick Trading Estate, Swindon, Wilt SW2 6QJ.
Cycling still hertz

My heart-rending experience with the bike (Feb. issue) did not go unnoticed. Keith Matthews, of the Wessex District Cyclists' Touring Association, writes to tell me to be so silly-livered and to have another go (although he is much too polite to put it in those words). It's really too bad — something to do with not being "bike-fit" and not having anything better to ride than a Moulton. Well, quite right to agree with him about not being in shape for this sort of thing, but my, they thought Moultons were nice little bikes. Maybe that's the trouble: I ought to have one of those snobbery controls — a saddle like an emaciated razor blade and handlebars bent down to somewhere near the front hub.

I am considerably encouraged, however, by Mr. Matthews' assertion that most car drivers will give way to a bike (I am informed that I cannot be a cyclist until I graduate — maybe by riding the three miles without my feet touching the ground or being provoked to actual violence) because they realise that if they hit you, you will probably bleed all over the paintwork, which means a visit to the car wash, a matter of some inconvenience and expense.

The real point of his letter was not, however, all the above, but was contained in the last sentence. He assures me that I shall take up my cycling career again after its disastrous start, and will want to try the bike computer thing all started with in the February issue. When I do, he says, I shall discover that it is unreliable above 30 m.p.h. (I am 4°, it is true) — inadequate, I suppose, the gulf that separates visions from real cyclists. Thirty miles an hour, Mr. Matthews, I had in mind a rather more sedate progress than that. They would appeal to people who would suffocate, and die at speeds over 20 m.p.h., and for all I know, they could be right. No, as long as I go fast enough to avoid the danger of falling off sideways, I reckon that's enough for anyone. I have no ambition to be a yellow jersey to go with the platter and banners that would be the certain result of my travelling at 30 m.p.h.

Thing-un-a-jig

I frabjous day! Callio! Callio! The dual snubbershless Schottky! I do beg your pardon — I was so overcome by the arrival of a bit of paper announcing a freebie of a bike that I felt a little outgrowing of the old mantelpiece was permissible. But all right — I'll stop now, or Ed. will vorpal square writers to say they're intended as rectifiers, or some such earthbound fare.

It didn't need much thought to see that a dual snubbershless Schottky is not a device you can tie down to anything too specific. It needs a little re-in to be allowed to breathe and develop in an atmosphere of its own, so there is going to be a lot more of this Ed.

You have no idea how frustrating this job can be sometimes. I was only going to say that a d.a.s. could be the very thing for one of those electronic games, maybe. Hunting the Snark, each player being armed with a potted-comforted voipal blade. Every time a v.b. went 'snickers-blade. Every time a v.b. went 'snickers—

I've been watching the domestic television programmes of microseconds, and a few seconds — in fact, I don't even think they give much thought to the public's needs and wishes, or any of the public's needs and wishes: in so many words, they happen to think that their electronic think is quite good enough when printed in a newspaper, but, as I am sure you know, just like that, by a television person — well, it's enough to curdle the milk.

Isn't it lovely, though? Anyone whose imagination is untouched by a chance to use a dual snubbershless Schottky must be the luckiest, I should think. Not just one, mark you, but a dual package of the famous little beasts. Now that they're here, and not before time, if you ask me, we've got to find something really beamish to do with them, before some dorky (by which I mean in square) writers in to say they're intended as rectifiers, or some such earthbound fare.

I don't even think much to see that a dual snubbershless Schottky is not a device you can tie down to anything too specific. It needs a little re-in to be allowed to breathe and develop in an atmosphere of its own, so there is going to be a lot more of this Ed.

Well, it's only a thought. You can't give a device a name like dual snubbershless Schottky and expect people to use it for anything too serious.

Spoilt by choice

I've been watching the domestic television recording scene for some time now (video). It seems to be called, for some reason, with the kind of feelings I would expect from a Man to have experienced when confronted by an army of arrow heads down at the stonemonger's. All he had to choose from was a couple of dozen plans, ordinary arrowheads for the shot towing scene and here was this cathode offering him umpteen models to fit different shafts sizes: all equally well designed, chipped, mind you, but totally incompatible.

Masters were fairly evenly tallied, of course, and for such an act of thoughtlessness, Neanderthal was quite likely to split the stonemonger down the middle and use his skin for trousers, appeal to his better nature notwithstanding. Headstrong, they were, in those times, and direct to the point of rudeness.

There has had its effect on Homo sapiens and I'm not sure that a bit more directness wouldn't be a bad thing, particularly dealing with all these clever people who keep on inventing video tape recorders and video disc players that do more or less the same job but are just different enough to prevent you from using the software from one machine on another. I don't for a moment think that they are deliberately contemplative of the public's needs and wishes: in fact, I don't even think they give much thought to what the needs and wishes, apart from the need to 'create' a market and persuade people to buy their wares. If they happen to think that their electronic arrow shaft should be 10 m. in diameter, they'll go ahead and make millions of arrows lost in the fact that someone else is making them 2 m. in diameter, and has been for years.

It's no good at all saying that it's up to the buyer to make his mind up: how many people need to simply want to rent the television Shakespeare canon or transfer Nationalise to a more convenient time in a position to make a difficult technical choice between the different v.c.r.s? And how many will be able to decide on which is the better of the three methods of reading a video disc, or realise that you can't play Philips discs on a JVC player, while all the time considering the claim of several firms to have the best disc library?

Quiet, please. It's breakfast time

When I was a bit younger, I used to have a finely manicured moustache in those times, and a few years' work in putting in a new blade in the razor, or a serious lapse in concentration resulting in the razor getting itself lost in the bathtub could have havoc. Many's the time I've been ejected from the house without a second cup of coffee.

I've relaxed a bit, now. For one thing, I don't have to drive to my wife's school any more. She gave up teaching and, for another, I've learned more sense. The move to Sutton has helped, too. Now I take my mornings very gently, luxuriating over a leisurely bath, savouring a proper breakfast and invariably having a second cup of coffee.

Even so, taking all this gracious living into account and making due allowance for the need to keep abreast of world affairs, I can see no possibility of television getting a look in at that time in the morning. There are many things we want from life, but television with my crispy bacon and scrambled eggs in not one of them. As far as I am concerned, thanks, but no thanks, particularly there are to be any of those indelibly vivid commercials for orange juice, or Soupaklakes, or whatever. And what that 'little slice of life' business amounts to is quite enough when printed in a newspaper, but, as I am sure you know, just like that, by a television person — well, it's enough to curdle the milk.

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The image contains a classified advertisement page from a magazine, with various items for sale, details about electronics and hardware, and contact information. The text is dense and contains technical terms, prices, and contact details. The page includes sections such as "NEW 1981 MODERN ELECTRONIC CIRCUITS REFERENCE MANUAL," "1981 RADIO AMATEUR HANDBOOK," and "THE SCIENTIFIC WIRE COMPANY." The format is typical of classified ad sections in technical magazines, likely aimed at radio enthusiasts and electronics professionals.
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For further information on either Mikro 1000 system, please contact:

Unit A2, Longford Avenue, Kilwinning Ind. Est., Kilwinning, Ayrshire, KA22 8NP.
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