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  - Type 28 3 1/2 Digit AC Multi-Function Meter - 200kHz - £250.00

- **General Radio**
  - Type 1842B 2 1/2 Digit DC Multi-Function Meter - 200kHz - £250.00

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- **Marconi**
  - Type 3500 B 3 1/2 Channel Logic Display - £300.00
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- **AEG**
  - Type 4560 2 1/2 Band & Component Tester - £250.00

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- **AEG**
  - Type 4560 2 1/2 Band & Component Tester - £250.00

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- **Yokogawa**
  - Type 5540A Frequency Counter - DC - 500kHz - £250.00

**SIGNAL SOURCES**

- **Heathkit**
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**SIGNAL GENERATORS**

- **Marconi**
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**OSCILLOSCOPES**

- **Fluke**
  - Type 54832 Oscilloscope - DC - 1000kHz - £250.00

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- **National**
  - Type 6012A Power Supply - DC - £250.00

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- **Marconi**
  - Type 3510B Recorder - £250.00

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  - Type 8801A Universal System - £250.00

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30pV, 100pV, 300pV, ... 300V
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30pV, 100pV ± 2% C/201 Kz.
LOG. RANGE
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Built: £99.95

Including VAT, post and packing, free course in computing, free mains adaptor.

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- BASIC language also handles full Boolean arithmetic, condition expressions, etc.
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Unique RAM

The ZX80's 1K-BYTE RAM is the equivalent of up to 4K BYTES in a conventional computer - typically storing 100 lines of BASIC.

No other personal computer offers this unique combination of high capability and low price.

The Sinclair teach-yourself BASIC manual

If the specifications of the Sinclair ZX80 mean little to you - don't worry. They're all explained in the specially-written 128 page book that comes with every ZX80. The book makes learning easy, exciting and enjoyable, and represents a complete course in BASIC programming - from first principles to complex programs.

Kit or built - it's up to you

In kit form, the ZX80 is pleasantly easy to assemble, using a fine-tipped soldering iron. And you may already have a suitable mains adaptor - 600mA at 9V DC nominal unregulated. If not, see the coupon.

Both kit and built versions come complete with all necessary leads to connect to your TV (colour or black and white) and cassette recorder. Plug in and you're ready to go. (Built versions come with mains adaptor.)

Massive add-on memory. Only £49.95.

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You can use it for those really long and complex programs - or as a personal database. (It will cost as little as half the price of competitive add-on memory for other computers.)

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We're also confident that it won't be long before you can buy cassette-based software using the full 16K-BYTE RAM. So keep an eye on the personal computer magazines - and brush up your chess perhaps!

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How to order

Demand for the ZX80 exceeds all other personal computers put together! So use the coupon to order today for the earliest possible delivery. All orders will be dispatched in strict rotation. We'll acknowledge each order by return, and tell you exactly when your ZX80 will be delivered. If you choose not to wait, you can cancel your order immediately, and your money will be refunded at once. Again of course, you may return your ZX80 as received within 14 days for a full refund. We want you to be satisfied beyond all doubt - and we have no doubt that you will be.

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<td>3mm diameter</td>
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<td>L32D</td>
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<td>Yellow</td>
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**FURTHER DETAILS**
a new look for the 80's

There's so much that's new about these phones...
Just detectable distortion levels

Attempts to arrive at a practical criterion for assessing audio equipment

by James Moir, F.I.E.E. James Moir & Associates

Are distortion levels of 0.1% really detectable when present in audio equipment as being reproduced? asks the author. Many tests are usually carried out in the belief that if a value is of the order of magnitude of 0.1% of greater value if information were available on the levels of distortion that are just detectable or just acceptable, he says. This article first examines the various signal characteristics that affect the detectability of distortion to the ear, then reviews attempts that have been made to determine 'just-detectable' distortion, including a new technique devised by the author. Finally the author gives some actual examples of what he considers to be 'just-detectable' distortion levels in various kinds of audio equipment.

Equipment suppliers generally provide a reasonable amount of information on the extent of the harmonic distortion produced by their amplifiers and tuners, though less frequently on loudspeakers and most other components. This distortion data is usually in the form of a quotation of the total harmonic distortion (t.h.d), the r.m.s. sum of the individual harmonic distortion components, that are responsible for the subjective judged distortion.

The 'just detectable' level is a function of so many variables that a precise specification, a single figure such as 0.1% or 1%, is unlikely to emerge from the discussion. Even in the simplest situation where the test signals are single-frequency tones it is impossible to specify a single figure without setting wide limits. An experienced observer will detect the addition of a second or third harmonic when this is less than 0.1%, but, given the opportunity to make repeat comparisons of the distorted and undistorted tone, he will lower the detection level by a factor of less than 0.01% distortion becomes indetectable. But the 'just detectable' level of distortion in sinusoidal tones is rarely of more than academic importance and need not be given further consideration.

However, the same problem exists when attempting to detect the presence of distortion in a musical programme, if the test facilities allow a smooth variation of the distortion content the 'just detectable' distortion (JDD) level continues to decrease by about 0.1% for every doubling of the peak signal amplitude. Thus if any figure is meaningful without providing full information on the test routine.

The specification of the 'just detectable' distortion in programme material is inherently more difficult, for the signal is continuously varying in amplitude and in consequence the instantaneous value of the distortion is also varying continuously.

Fig. 1 is a chart recording of the instantaneous levels during a nine minute period of 'Molly on the Shore' (Grainer) taken from an Enigma recording No. K: 53574. Between points 1 and 2 the level will be seen to vary by about 20dB but this is not an extreme example for records are capable of holding a volume range of at least 50 to 60dB and this range is commonly employed.

If we now look at some data on the variation of the distortion with signal output level of a typical amplifier and a domestic type of loudspeaker, we get the results illustrated by Fig. 2. If it is assumed that a maximum level of 95dB at 1 metre is the highest level that will be reproduced it is seen that detector content in the region of 3%. At a level below 95dB the distortion has fallen to less than 1%. The amplifier introduces much less distortion into the signal. If the sound level of 95dB is achieved by a power output of 10 watts (a rather audacious assumption) the distortion introduced is about 0.1% or less and it falls even lower at lower power outputs. Thus the distortion that is audible in the acoustic signal is practically all due to the loudspeaker and it varies over a range of about 30 to 1 when the acoustic signal output varies over a range of about 30 to 1. Thus in the audible distortion there is a predominance of pattern. The JDD level continues to decrease by about 0.1% for every doubling of the peak signal amplitude. Thus if any figure is meaningful without providing full information on the test routine.

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Using a system claimed to be flat between limits of 40Hz and 14kHz, Olson suggested that the introduction of 0.7% distortion was just detectable. For the bass frequency, he was the same for both even order distortion, and the odd order distortion, a conclusion that is supported by the variance with almost all the data obtained

A 3.5% total level was used as the basis for the frequency response and the average or F.M. amplitude (V.U. meter) may have the disadvantage of indicating the presence of intermodulation peaks that do not result in audible distortion. In many applications the use of a p.m. type meter may only result in a reduction in the signal to noise ratio, even for a passage that contains perhaps one peak having a duration of several seconds will sound 'dirtier' than a sinusoidal wave of a few milliseconds. The characteristic sound of peaks of the same amplitude, but each of short duration, even though the total duration of the peaks is the same for both passages.

However, there are other factors that are of significance. It is well established that distortions of the simple amplitude dependence type (harmonic distortion) are less obvious when the distortion level is not a function of the frequency or spectrum. The data quoted later suggests that the just detectable value of distortion in the frequency range of at least ten times the just detectable value at frequencies in the 1000Hz region. Thus the just detectable level is very much higher than that which would be expected to depend not only on the distribution in time of the peak amplitude, but also on the frequency band in which they occur. Characteristically the sustained peaks occur in the low frequency where the distortion introduced is least obvious. Indeed it has even been claimed that distortion introduced in the lower audio frequencies is 'rich' sound 'flat', a view that is unlikely to appeal to the hi-fi purist.

There are also many evidence that the intermodulation distortions that result from second order curvature are very much more disturbing subjectively than the distortion introduced by odd order curvature. All these considerations suggest that any simple single figure value that is quoted as an objective indication of the effective total distortion in a system is unlikely to agree with the subjective quality deterioration, for the annoyance aroused by the presence of the distortion that is not perceived but is still there, but it is not known how much the harmonic responsible for the major proportion of the subjective quality deterioration.

In summary the just detectable distortion level is:

1. The ratio of the peak-to-peak amplitudes of the signal during the effective listening interval.

2. The duration of each amplitude peak.

3. The frequency band in which the maximum distortion occurs. Distortion of at least 0.1% is tolerable for perhaps twenty milliseconds in the same listening period.

4. The order of the harmonics introduced by the various loudspeakers is

- The resultant quadratic intermodulation distortion components are less objectionable than those of the cubic intermodulation components.

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monic amplitude by r.m.s. sum. was a quotation of a just detectable value. He of distortion values to be expected in any another, an illustration of the wide spread systems for which the measured harmonic compared with the unweighted values obtained produced only the first order intermodulation company the intermodulation products if the presence of total distortion components of were made with calibration markings and these were recorded for each observer and averaged over about twenty determinations to obtain the quoted JDD value. Additional readings were taken at a distortion level in practice with limits in the range 0.8% to 1.3% but it should be remembered that weighting in this way prevents their values being directly com pared with the unweighted values obtained by other researchers.

Wigan (1961) made a very comprehensive investigation of the problem and came to the conclusion that the subjectively judged unpleasantness is a function of the time-rate-of-change of the departure of the signal from normal. As pointed out earlier in the discussion these conclusions are difficult to apply to a practical case where only the harmonic data are available. They do, however, confirm the earlier suggestions that there are likely to be wide limits on any suggestion of the just detectable value for the JDD.

More recently Fryer made a very thorough investigation of the problem using a distortion producing technique that introduced only the first order intermodulation distortion components into a clean signal. Skilled male listeners could detect the presence of total distortion components of about 2% to 4% in piano music and 4% to 5% in other types of programme. However his circuitry did not introduce the harmonic distortion that would inevitably accompany the intermodulation products if they were produced by curvature of the transfer characteristics of an amplifier or other circuit component. If the harmonic components had been included the r.m.s. sum would probably have been near the top end of the quoted JDD range of 4%, but, as with Shorter's weighted data, his JDD percentage cannot be directly compared with the data obtained by others.

Recently we took the opportunity of making a re-assessment using modern equipment. A 15in/master tape recording of a concert orchestral programme was used as a signal source, the amplifier output being fed to a pair of headphones chosen for their good frequency response and particularly low distortion. We were particularly interested in the audibility of cross-over distortion, a particularly annoying form of distortion. A simple addition to the bias circuitry in a good amplifier allowed the bias on the output stage to be smoothly varied by a single knob control from the under-biased to the over-biased condition, thus varying the amount of cross-over distortion over a wide range.

The amplifier output signal was monitored by an oscilloscope to show up any amplitude limiting and to reproduce the calibration waveforms. Bias on the output stages was adjusted until distortion on the programme material when subjectively judged was just detectable, each observer spending as much time as he wished in finding the point at which the distortion was 'just detectable'. The bias control knob carried calibration markings and these were recorded for each observer and averaged over about twenty determinations to obtain the quoted JDD value. Additional readings were taken at a distortion level well below the 'just detectable' to confirm that the residual distortion 0.13% in the equipment was unlikely to affect the results obtained.

This is a very sensitive technique for determining the 'just detectable distortion' for after a few comparisons the subject begins to recognise the particular form of distortion introduced into the music by the bias change. During subsequent comparisons the subject becomes increasingly sensitive to that particular distortion. After 10-15 minutes' experience his sensitivity to the distortion has probably increased by a factor of at least ten times.

As pointed out earlier in the discussion the actual distortion content in the reproduced music cannot be directly measured but can be approximately indicated. The peak-to-peak amplitude of the programme material at which the distortion was just detectable was marked on the oscilloscope face and a sine wave signal of the same peak-to-peak value substituted. This sine wave signal across the headphones was then analysed in the conventional manner using a Marconi Type TF2330 narrow band analyser, all components up to about the 20th being separately measured. Fig. 4 indicates the amplitude of all the harmonics that were present and also reveals the waveform of the sine wave signal having the same peak-to-peak amplitude as the programme signal. If the r.m.s. sum of the programme is taken in the conventional manner it is 1.2%, or if we multiply each harmonic by \( n^{2} \) then it is 15%. It is an interesting observation that when using simple 3 or 4-bit optical encoders has appeared over the years, but they have operating range, suitable for close hauled courses and so on in the very top units can introduce distortions that are below 1% (40dB down) at half their rated output power. Amplifiers in the very top class, but still below 0.001% class (60-80dB down).

Acockpit display of masthead windspeed and direction has become an essential for offshore racing yachts and is very useful for the cruising yachtsman. A number of commercial instruments are available, but they tend to be very expensive. The main requirements for such as instrument are as follows.

- the masthead unit must be small, light and weatherproof.
- the number of wires coming down the mast must be reasonably small.
- both speed and direction systems should work over a speed range of about 1 knot to 60 knot. At lower speeds, boat motion makes the indications unreliable, while at higher speeds it is only too evident what the wind is doing.
- the direction display should have a resolution of 1°, at least, that the wind is coming from.
- the system should operate from a 12V accumulator with a low current consumption.

To the best of the author's knowledge, no instrument suitable for amateur construction which meets all the above requirements has been described previously. A number of wind direction indicators using simple 3 or 4-bit optical encoders has appeared over the years, but they have inadequate resolution. A high-resolution direction indicator with a limited angular operating range, suitable for close hauled use, is described in Reference 1.

**Operating principle**

The most difficult problem in designing this type of instrument is the selection of the method of encoding the wind direction information. Commercial 360° rotation, low-friction potentiometers, choppers, resolvers and non-contacting digitizers can all be eliminated due to cost and availability problems.

The encoding technique adopted is one originally described by Tysoe. The principle of operation will be described with reference to Fig. 2. A cup anemometer and a wind vane, shown in Fig. 1, are mounted on a pair of softball shafts, which carry a pair of opaque discs with a small clearance between them. A fixed annular disc surrounds the small-diameter direction disc. These three discs are shown separated in Fig. 2, for clarity. A light source is located below the discrometer disc. The clock photocell, fitted above a hole in the fixed anodized, produces a pulse train as the circle of holes in the anemometer disc.

![Fig. 1. Complete masthead assembly.](image1)

**Fig. 1.** Complete masthead assembly. The encoding technique adopted is one originally described by Tysoe. The principle of operation will be described with reference to Fig. 2. A cup anemometer and a wind vane, shown in Fig. 1, are mounted on a pair of softball shafts, which carry a pair of opaque discs with a small clearance between them. A fixed annular disc surrounds the small-diameter direction disc. These three discs are shown separated in Fig. 2, for clarity. A light source is located below the discrometer disc. The clock photocell, fitted above a hole in the fixed anodized, produces a pulse train as the circle of holes in the anemometer disc.
(which are referred to as the clock track) sweep past, the frequency of this clock-pulse train giving the wind speed. Once per revolution of the anemometer disc, the reference hole past the reference photodetector and an output pulse results. Also once per revolution, at a point dependent on the angular position of the direction disc, the two coincidence holes pass each other and the coincidence photodetectors produce an output pulse. The number of clock pulses occurring between the reference and coincidence pulses gives the wind vane angle. In this simple form, the angular resolution is equal to the angle between successive clock-track holes. This resolution limit can be overcome by using a phase-lock-loop frequency multiplier to increase the clock frequency.

Mechanical design of masthead unit

This article is primarily concerned with the electronics of the system, but to assist potential constructors, some hints of the mechanical design will be included. A cross-section view of the prototype masthead unit is shown in Fig. 3 and photographs of the various components are re-produced in Figs. 4 and 5. The unit was constructed inside a piece of PVC tubing, the various discs being cut from glass-fibre printed-circuit board. The clock track has 36 holes 1.7mm diameter, equally spaced on a 40mm diameter circle, the clock photodetector window in the fixed annulus is 10mm diameter and all the other holes in the discs were about 1.7mm square. The light source consists of two tubular, linear-filament, automotive tail-light bulbs with the end contacts removed to fit them in the available space. Ball bearings are secured in the end fittings and the shafts fixed in the bearings with an adhesive such as ‘Loctite Bearing Mount’. The spacing between the discs (about 0.4mm) was set using temporary spacers between them while the adhesive on the shafts cured. This procedure avoids the need to accurately machine bearing-locating shoulders. Adjacent faces of the discs were painted matt black, while the rear faces of the discs and the rest of the interior was painted white.

The wind vane can be constructed from a variety of materials, the major requirement being that it should be of light weight and accurately balanced about its axis of rotation. A strong, well-balanced cup anemometer is difficult to make, so a commercial unit, manufactured by VDO and obtainable from chandlers was adapted. This anemometer, which had a mean cup radius of about 44mm, was found to give a clock calibration factor of 22.5 knots, since the system speed calibration is adjustable, any convenient commercial or home-made anemometer could be substituted.

Power supply

A 9V supply was selected for the instrument, since it can conveniently be derived from a 12 volt battery system. The circuit of a suitable regulator is shown in Figure 7.

Masthead circuit

To provide high-level, low-impedance signals to drive the long wires down the mast, the three photodetector outputs are amplified in the masthead transceiver unit. The necessary circuitry conveniently fits on a circular printed-circuit board which mounts on the direction end fitting, as shown in Fig. 5. The circuit of the masthead system is shown in Fig. 8. The two 12V bulbs in series are operated so far below their rating that they should have a very long life. It is desirable that the clock and coincidence amplifiers just swing to full output when the anemometer disc is rotated slowly and the direction disc is in.
These comparators are very tolerant of the incoming signals. The reference gramme material of the best quality in the transmission generally provides pro-reel-to-reel machines but the variation distortion spectra of a gramophone recording. The distortion content of cas-tion components are due to the odd order sign is changed it may be necessary to the position which gives the smallest...
**Prestel goes international**

Prestel, the public viewservice of British Telecommunications is to add new international facilities in its facilities in July this year. The decision to implement Prestel Internationally, as it is called, was made following the outcome of an international market trial which ran throughout 1980. The trial involved more than 300 business users in seven countries and had the co-operation of the telecommunications authorities and carriers concerned.

The international service is expected to follow the format found most successful in the trial – information for specific business sectors. These included, for example, the electronic publishting of statistics and commodity prices, plus a considerable use of 'closed user groups' in which organisations have exclusive use of certain parts of the information bank to meet their own needs. It will have a single database, which will be quite separate from the one used for Prestel in the UK. It will be supplied to United States, the United Kingdom and West Germany.

The three satellites which will be launched to support the international service are expected to be completed in 1982. London, and the third one will be launched from the United States.

**Data convention in Europe**

In the past few months a European convention on data exchange and protection has been drawn up and has been approved by the committee of ministers of the Council of Europe. At the time of writing it is due to be formally signed by the member states within the next few days. The creation aims to move obstacles to the free passage of data between the countries of Europe by encouraging them to treat each other's data protection measures in the same way. It specifies that each country must have this protection legislation in force before it can join the convention. When that legislation must be in place, and for a period of two years, each country must be registered and the authorities responsible must be notified by the other member states. The new convention will be doubly effective.

The EEC project is to create a single market for data exchange in which large European companies will have to pay for any information to be exchanged or transferred. The convention has been welcomed by a number of countries, including the United Kingdom and Germany, but there are concerns that the convention may be too lenient.

**Levy on blank video cassettes?**

At the first meeting of the British Videogram Association's Council of Management, Donald MacLean of Thorn-EMI was elected Chairman and Maurice O'Brien of CBS, Vice-Chairman. Peter Scaping will act as Secretary while the Association is becoming established.

Videogram producers are evidently experiencing roughly the same problems as those in the audio recording industry; the Association's Secretary, while the satellite is the first US domestic commercial satellite to operate at these frequencies. The aerial beams, which are defined in the Space Shuttle, are designed to deliver higher power to metropolitan regions in the United States.

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C.b. Green Paper
CBA’s response

In response to the invitation extended by the Home Office in the Green Paper-discussion document. The Campaign for Better Access to Information and Associated motorists has submitted a detailed reply with a letter dated December 1981. This is quite possible, to lose the 27MHz immediately, using the Advanced Raster Graphics System. One feels that the CBA has submitted a substantial interdepartmental document, which may, for that reason, not carry with it the influence it case deserves.

In a written answer on December 13, Mr. William Whitehall, the Home Secretary, said that he was "disposed to allocate frequencies to Open Channel Radio in the 850-930 MHz. This is in line with recommendations contained in the dissertation 'Open Channel', published in August.

On December 18, the Home Office was still engaged in correlating the 12,000-plus responses to the discussion document, it appears that Mr Whitehall has not felt compelled to pay excessive attention to the views expressed, which were, according to the Home Office department doing the correlating, greatly in favour of frequencies of over 930 MHz.

Jupiter probe

The Galileo satellite will transport an atmospheric probe to the Jupiter probe late as the decade as part of NASA’s planetary exploration programme. The carrier will receive scientific data from the probe on its descent through the Jovian atmosphere and then relay it to Marisat stations located some 100,000 miles behind Earth. The probe carrier spacecraft will be launched from the Vandenberg AFB in March 1984 and will transport the Galileo probe to Jupiter, where it will perform a flyby in 1994.

News in brief

The BBC was able to open its 22nd local radio station on December 7, and the number rises by over 12,000, with a telephone calls and two television channels reduce the data demand, the number of interdepartmental agreements and the number rises by over 12,000,000, with a telephone calls and two television channels were heavily over-subscribed, particularly in areas where the ground of its potential high gain antenna range. It also mentions the possible danger to health of such frequencies, particularly in hand-portable use.

The CBA is accused of "grudgingly overrating" the problems of interference to television and other users of the 27MHz band. The CBA claim that, in the ten countries covered, "nothing serious" has happened, and that there are still engaged in correlating the 12,000-plus responses to the discussion document.

One of astronomical objects. The coherent transponder will produce a coherent signal, which is then transmitted to the probe carrier spacecraft, which will then send back a copy of the received signal. The coherent transponder will use a frequency of 11 GHz, which is less congested than the 11 GHz band, which is more congested than the band.

The sponsors, Audio Trade, are able to announce this. The reason is simply that the Galileo program is a demonstration of the potential of the 11.780-computer system for use in telecommunications networks using data on a telephone network. Each computer can display image displays. The display system used the Advanced Raster Graphics System (ARGs) of Sigma Electronics, using electronic images consisting of a matrix of up to 512 x 512 picture elements. It can switch between the screen, plotter, and printer, allowing the user to control the system.

Cable and Satellite Communications, was launched on NASA’s 6 October. When it is placed in its permanent orbit, it will take up a position 42 degrees west of the equator.

During 1979, around 30 million telephone calls were made between the UK and USA, and the number is expected to increase by 30% by 1985. Each new set of communication satellites must have increased traffic capacity with one, and an IntelSat V has the capacity of an International System for:

- Telecommunication
- Data transmission
- Fax services
- Satellite television

All these services are not spun for stability, but due to the large number of satellites, the satellites are heavily over-subscribed. Further novel features include the use of the 14-19 GHz band, which is less congested than the 2-6 GHz band - also used in the 4-6 GHz band. The 14-19 GHz frequencies can be used for different purposes such as telecommunications equipment, with a refurbishing and calibration service. The display system used the Advanced Raster Graphics System (ARGs), of Sigma Electronics, using electronic images consisting of a matrix of up to 512 x 512 picture elements. It can switch between the screen, plotter, and printer, allowing the user to control the system.

Galileo Probe Carrier

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More satellite communications for shipping

A new global satellite communications system is being set up to meet the growing international telecommunications needs of the world’s shipping and offshore industries during the 1980s. Initiated by the International Maritime Satellite Organization (Inmarsat), the Inmarsat system will replace the current Marisat service with a new system of geostationary communications satellites, known as the Inmarsat system. The Inmarsat system will provide coverage of the Atlantic, Pacific and Indian oceans and will also act as a follow-up to the current Marisat system. Transition from Marisat to the new system is expected to be made in early 1982.

The decision by Inmarsat to involve contracts to three major suppliers - ESA, Inmarsat and Conmat - worth 180 million US dollars over the period 1982-84.

Radar simulators are needed to help train operators in control procedures. Marconi Radar simulators have already started work on the RAF recently, to design new and significant real-time system with the views expressed. The computer-generated models are designed to depict any type of aircraft or radar systems as well as geographical or meteorological factors. The equipment interfaces readily with all types of display and communication equipment. It can be set up either in the workshop or can be added to an operational radar system, when it may be used in conjunction with the operational radars of the system.

Electronic Brokers Ltd, who market second-hand scientific equipment, have added a further 20 receivers to their inventory, with a refurbishing and calibration service. Photosensitive epileptics are urged to ensure that the CBA have submitted a substantial interdepartmental document, which may, for that reason, not carry with it the influence it case deserves.

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Morse decoding

A machine-code program for decoding Morse transmissions on a home computer

by N. Kyriazis

Decoding Morse by means of a computer is a fairly simple matter and many programs have already been produced for home computers such as the TRS 80. This article describes such a program, which was written in machine code for the Z80-based Wireless World scientific computer.

The main advantages offered by this program are that it can be used to decode either machine or manually produced Morse signals and that it provides a certain amount of immunity to the effects of noise and interference associated with short-wave reception, which would normally cause unacceptable decoding errors.

To minimize the effects of poor sending and to encourage the use of a short-wave reception, the following features have been incorporated in the program:

- The ability to recognize and reject the effects of short-lived interference, such as that generated by ignition systems.
- The ability to recognize and reject short gaps in the transmission which may occur as a result of the type of interference described above. (These gaps may be severe in more advanced receivers which have effective noise limiters.)
- Generous tolerance for the definition of
- The provision of simple 'filtering' of characters, spaces, etc., to cater for the different "fists" of c.w.
- The program compares the time lengths of mark periods, i.e. periods of tone output from the receiver, and space periods, i.e. periods of no output, with a predetermined time unit. The tone mentioned here is, of course, the audio output from the receiver, which is converted into the receiver's code, usually around 750-1000 Hz. This audio output from the receiver must be converted to a logic-compatible signal, so that it can be fed into the computer via one of the five serial inputs. But I was used in this application, but any other bit may be used if required by modifying the program instruction following the IN instruction, details of which will be given later. The various elements of Morse characters are defined as follows:

- A dot has a duration of one unit of time.
- A dash has a duration of three units.
- Elements of the same character are spaced one unit apart.
- Characters are spaced three units apart.
- Words are spaced at least five units apart.

To make the program tolerant to sending errors (bad "fists") and to minimize the effects of interference, as mentioned earlier, the time unit values for the elements of the Morse characters are modified as follows:

- A dot becomes a mark period which is between one half and two units long.
- A dash becomes a mark period which is two or more units long.
- An inter-element space is from one half to one and a half units long.
- The space between characters is from one half to four units long.
- Words have a space between them of four units or more.

A maximum limit of eight units length is placed upon the dash by the program as will be described later. Mark or space periods less than one half unit long are regarded as the result of interference and are dealt with accordingly by the program.

It may seem initially that there is too much tolerance in the definition of these basic Morse elements; in fact, for example, a dash has a range of 4:1 in time duration. It has been found, however, that this method works well in practice and most hand-sent Morse is accurately decoded.

The program in machine code

The main program, as depicted in the flow-chart, uses two subroutines, one to test the input from the computer and the interface to determine whether a mark or a space is being inspected (in this case the interface gives a logic "0" when a tone is seen and a logic "1" when there is no tone) and another to display the decoded Morse character. More details of these subroutines will be given later in this description.

Referring again to the flow-chart, the program begins by clearing the MARK and SPACE counters to HEX 00, setting the UNIT to HEX 0C (corresponding to about 17 w.p.m.) and the CHAR to 01 (one space).

Next, the TEST INPUT subroutine is called and if the input is a mark, the MARK counter is incremented. If the mark value reaches eight units the program will wait until a space is detected and then return to the start and reset. Hence, mark periods are limited to eight units and if one tone to the calibrator of the receiver the program resets automatically as it sees a mark greater in length than eight units. If the mark does not reach eight units the MARK counter is incremented. The SPACE counter is then incremented but if the space does not reach one half unit in length, it is regarded as a break due to interference and its length is added to the mark period. If the space count does reach a length of half a unit then it is regarded as a valid space, so the program checks whether the mark is greater than two units and if so inserts a dash (logic "0") in the CHAR register. If the MARK is not greater than two units a dot (logic "1") is inserted.

The MARK register is now reset 00 and the program enters the SPACE count sequence at block D.

The SPACE counting sequence that starts at block C is almost identical to the

Program description

The program compares the time lengths of mark periods, i.e. periods of tone output from the receiver, and space periods, i.e. periods of no output, with a predetermined time unit. The tone mentioned here is, of course, the audio output from the receiver, which is converted into the receiver's code, usually around 750-1000 Hz. This audio output from the receiver must be converted to a logic-compatible signal, so that it can be fed into the computer via one of the five serial inputs. But I was used in this application, but any other bit may be used if required by modifying the program instruction following the IN instruction, details of which will be given later. The various elements of Morse characters are defined as follows:

- A dot has a duration of one unit of time.
- A dash has a duration of three units.
- Elements of the same character are spaced one unit apart.
- Characters are spaced three units apart.
- Words are spaced at least five units apart.

To make the program tolerant to sending errors (bad "fists") and to minimize the effects of interference, as mentioned earlier, the time unit values for the elements of the Morse characters are modified as follows:

- A dot becomes a mark period which is between one half and two units long.
- A dash becomes a mark period which is two or more units long.
- An inter-element space is from one half to one and a half units long.
- The space between characters is from one half to four units long.
- Words have a space between them of four units or more.

A maximum limit of eight units length is placed upon the dash by the program as will be described later. Mark or space periods less than one half unit long are regarded as the result of interference and are dealt with accordingly by the program.

It may seem initially that there is too much tolerance in the definition of these basic Morse elements; in fact, for example, a dash has a range of 4:1 in time duration. It has been found, however, that this method works well in practice and most hand-sent Morse is accurately decoded.

The program in machine code

The main program, as depicted in the flow-chart, uses two subroutines, one to test the input from the computer and the interface to determine whether a mark or a space is being inspected (in this case the interface gives a logic "0" when a tone is seen and a logic "1" when there is no tone) and another to display the decoded Morse character. More details of these subroutines will be given later in this description.

Referring again to the flow-chart, the program begins by clearing the MARK and SPACE counters to HEX 00, setting the UNIT to HEX 0C (corresponding to about 17 w.p.m.) and the CHAR to 01 (one space).

Next, the TEST INPUT subroutine is called and if the input is a mark, the MARK counter is incremented. If the mark value reaches eight units the program will wait until a space is detected and then return to the start and reset. Hence, mark periods are limited to eight units and if one tone to the calibrator of the receiver the program resets automatically as it sees a mark greater in length than eight units. If the mark does not reach eight units the MARK counter is incremented. The SPACE counter is then incremented but if the space does not reach one half unit in length, it is regarded as a break due to interference and its length is added to the mark period. If the space count does reach a length of half a unit then it is regarded as a valid space, so the program checks whether the mark is greater than two units and if so inserts a dash (logic "0") in the CHAR register. If the MARK is not greater than two units a dot (logic "1") is inserted.

The MARK register is now reset 00 and the program enters the SPACE count sequence at block D.

The SPACE counting sequence that starts at block C is almost identical to the
MARK sequence as far as the handling of short mark periods is concerned but when a valid mark is encountered, i.e. a mark of more than a half unit long, it checks whether the SPACE count is less than one and a half units. If less than one and a half units long, the space is regarded as an inter-element space. If the SPACE is added to the UNIT, the sum divided by two and the result entered in UNIT again. This results in an exponential of the UNIT towards the value representing the incoming SPACE. The receiver program can now adapt itself to the speed of the sender, provided it is not less than two thirds or greater than twice the present speed (about 17.5 W.P.M.). If the speed is greater than one and a half units then the space is regarded as a character space and the display subroutine is called. The SPACE register is incremented by a fixed number (HEX content of the table), the C register will contain a number equal to the number of elements being inserted in CHAR. A machine language listing is given in note a standard W.W. scientific compiler format starting at 0C16. The IN PUT routine is at 0C6 and the display routine at IC8 with the corresponding table at OC6 to 0000, the H.S.EQ. equivalent of MARK characters, and 0140 to 03B4, the ASCII equivalent of MARK characters. The instruction E6 02 at 0C0 is used to mask bit 1 of the input. This may be modified if another bit is used. If bit three in the instruction becomes E6 08. Note, however, that the byte at 0C05 may be changed to a value equal to three times the weight of the bit used, e.g. HEX 18 for bit t. The initial preset speed by which the receiver is to be altered by changing the byte at 0C05 or to a value equal to the unit of time of the desired speed in milliseconds, for example, for five, e.g. for 12 W.P.M. the unit of time is 1000 so 0C05 should be changed to HEX 14.

A simple receiver interface was made by the author using parts from an old "Pocket box" but for better results he recommends that a more effective circuit be built using ideally a p.p.l. tone switch such as the NE567 arranged to give a t.t.t. output with logic "0" given when the switch is open and a logic "1" when the tone is removed. A hand-key with a 1k1 resistor tied to the +5 supply can be used for testing.

Another subroutine which checks to see if the v.d.u. address point to the last eight points of a line, in which case if the character is the space the next two lines are cleared and the line called to avoid splitting words and to keep the display tidy. Next a search is made through the Morse table to find ASCII equivalent of the HEX code for the converted character which is then sent to the v.d.u., for display. If a HEX code outside the table is presented an asterisk will be printed. The Morse table contains the characters from A-Z, numbers from 0-9 and the following special characters: full stop, comma, question mark, semicolon, oblique (\), break (-), double-break (\), end of transmission (\), end of work (<), wait (?), end of paragraph. Japanese interference conditions. A machine language listing is given in note a standard W.W. scientific compiler format starting at 0C02. The IN GET routine is at 0C6 and the display routine at 0C8 with the corresponding table at 0C6 to 0000, the H.S.EQ. equivalent of MARK characters, and 0140 to 03B4, the ASCII equivalent of MARK characters. The instruction E6 02 at 0C02 is used to mask bit 1 of the input. This may be modified if another bit is used. If bit three in the instruction becomes E6 08. Note, however, that the byte at 0C05 may be changed to a value equal to three times the weight of the bit used, e.g. HEX 18 for bit t. The initial preset speed by which the receiver is to be altered by changing the byte at 0C05 or to a value equal to the unit of time of the desired speed in milliseconds, for example, for five, e.g. for 12 W.P.M. the unit of time is 1000 so 0C05 should be changed to HEX 14.

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European Electronic Component Distributors Directory 1981 is, of course, a rather small book. The repetitive nature of most of the English text is noticeable. The book contains 340 pages and is available at $12.50 from Mackay Publications Ltd, PO Box 28, Luton, England LU1 5DB.

Range of counters

Constructing a range of counters based on the versatile Intersil IC72126 i.e. from a set of modules and counter, two frequency measuring instruments, up to 200 MHz and a low frequency counter for 10 Hz-10 MHz.

"OPEN CHANNEL" FREQUENCY

The recent Green Paper called "Open Channel" (October 1980 issue, p.66), has been received with interest from all those concerned with radio communications, not least Philips Research Laboratories, Redhill, who have carried out field trials to assess the performance of a radio service at 900 MHz, and have made available to the public several frequencies in the 900 MHz frequency range. The experiments were designed to provide data on performance of a radio service at 900 MHz, and to allow the public to test equipment at 900 MHz.

If we set out to throw any light on the nature of the velocity of light, our clues must come from experiments and not from measurements. It is in the clocks that we shall look for the nature of the velocity of light in a clock and hence, and contrary to Einstein, light can be used as synchronising device. (Light is the electric pulse of course, but for better results he recommends that a more effective circuit be built using ideally a p.p.l. tone switch such as the NE567 arranged to give a t.t.t. output with logic "0" given when the switch is open and a logic "1" when the tone is removed. A hand-key with a 1k1 resistor tied to the +5 supply can be used for testing.

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Clear as a bell: "Save our public service broadcasters," as featured in the December 1980 issue of Radio Today. This piece, written by T. J. King, highlights the importance of public service broadcasting and criticizes the government for failing to make adequate funding available.

The author argues that public service broadcasting is crucial for maintaining a diverse and democratic media landscape, and that cuts to funding would result in a loss of important programming and services for viewers. He also criticizes the government's approach to funding, suggesting that it is not transparent or accountable and does not reflect the interests of the public.

While agreeing with the author in December's issue, "Save our public service broadcasting", I would like to make the following points:

1. The current funding model for public service broadcasting is not sustainable in the long term. It relies too heavily on advertising revenue, which is volatile and difficult to predict.
2. Public service broadcasting is essential for maintaining a diverse and democratic media landscape. It provides a platform for underrepresented voices and perspectives.
3. The government should commit to long-term, predictable funding for public service broadcasting, rather than relying on short-term or ad hoc solutions.

J. T. Senior
BBC

What has Wireless World come to? First you urge us to abandon our nuclear defences. Now (December issue) you tell us that the purpose of your magazine is to teach people from reality, to keep them quiet, uncertain, and critical - the same description could apply to one's view of the world.

Professor King is the BBA member with special interest in engineering.

Your comments in the December 1980 issue on commercial broadcasting are particularly apt, especially in view of the fact that there was a lot of demand or great enthusiasm, at the time, for its success. But has it really come up to expectations, as are the staff working for the broadcasting.

We, the Central London Medical Branch of the Association of Scientific, Technical and Managerial Staffs, would like to put forward the leading article "Microchips and megaloads" which can be a great deal more than just a page of television and radio. The purpose of this article is to make the reader aware that a new technology is available and that it would be wise to consider the results of their work in terms of moral and purely technical achievement.

Many people interested in electronics, young and old, amateur and mad respect Wireless World, considering it to be one of the few magazines which will take the importance of technical achievement. We wish that another magazine might consider the ultimate aim of salvation, and indeed required that an instruction card be displayed to enable any ship's crew to use it in an emergency.

It would not be necessary for Mr. Bowl's machine to cost over £10,000 for a motor astern. Observation in many ports shows that the great majority of the Furthermore, the large number of people interested in this magazine will be well served by the instruction cards and the ultimate aim of salvation, and indeed required that an instruction card be displayed to enable any ship's crew to use it in an emergency.

I fully agree with Mr. R. J. Hartnett ("An electronically small loudspeaker") October 1980) who drew attention to the inadequacy of the use of loud speakers on board. It is obvious that a loudspeaker of sufficient size must be used to produce a good sound when reproducing the original sound. I would like to make the point that it would be impossible for a speaker by giving a unit which is near enough in the same of the original sound. One cannot make it the theme of an 'entertainment' lecture.

Professor King is the BBA member with special interest in engineering.

What does your friend think about the sound reproduction on board? We have made a number of experiments in this line, and will vary from ship to ship.

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THE DEATH OF ELECTRIC CURRENT

I refer to the interesting article by Mr Irv Cart in your December 1980 issue. It is indeed refreshing to find Mr Cart having a sideways look at the apparently trivial matter of electric current.

If one rewrote the Maxwell equations using tensor notation in a four dimensional Riemannian Space, the effects predicted by Mr Cart becomes more obvious. If I had to have separate meanings, removing that most embarrassing of dualisms and the electromagnetic field (complicated in three dimensions) becomes a simple tensor field in four dimensions.

N. D. Lawns

Telecommunications Accessories Ltd
Thame

The author replies:

It's a pity that the obfuscation has to continue like this. I did not realize that my December 1980 article predicted any effects. What were they?

Irv Cart

LOGIC DIAGRAMS

While I applaud the aims of Tony Castron's article "Inntelial logic diagrams" in the November issue, I disagree with his use of a suffix L as the mnemonic for the 'active low' input. In the circuit above, it shows that the output is 'active low', whereas I believe the symbol should be in parentheses ( ).

Thus, the symbol in conventional logic as well as its logical function in the same for both normal and 'active low' inputs.

Conventional

Active low

AND

NAND

NAND

NOR

OR

NAND

NOR

Fig 1

The term NAND is generally understood to be a contraction of NOT AND, where the NOT corresponds to the literal "not" used in formal logic.

TV SETS FOR THE HARD OF HEARING

I was interested in the plight of your correspondent Mr Holloway (October letter), who had a problem finding a television set with a built-in hearing aid.

Mr Holloway was not specific as to whether he was looking for a monochrome or colour receiver but, in any case, many sets make use of power supplies which contain the chassis either as a whole, or as a dedicated bridge, to the mains.

Obviously direct connection of the chassis to a loudspeaker socket would be hazardous to a customer and some form of isolation is necessary. Since little power is involved, a small transformer would be suitable but this must have adequate insulation to safeguard the customer. BS 415: 1979 requires this isolation to be able to withstand over 2kV.

Such a transformer could prove to be a comparatively expensive component and a set designer must consider whether the extra cost on the receiver would still be acceptable to potential customers.

The above line of reasoning partly led to our decision to use a switch mode power supply to fully isolate most of the chassis on our current range of receivers (see part 4 of my recent series on articles on these chassis). This decision enabled us to provide a headphone socket as standard throughout the range; however, we do have some the only UK or European manufacturers provide this facility.

It seems rather a sad reflection on the dealers in Mr Holloway's area that they showed little or no interest in promoting British made sets with these features.

D. Williams

Deco Radio & Television Ltd

W. York ton

LEVY ON BLANK TAPES

As one of the relatively few holders of the Amateur Recording Licence, I find myself totally unable to support the proposed levy on blank tapes and those who have tried to find the case for a levy have been failures. So much must be alleged to be at stake that a levy of several pence must not be called for.

As technically informed people we should readily see that it would be imposed would be a gross injustice on a new generation of tape recorders using 15ips or even 10ips speeds and even with four mics to the deck. The fact is that most "pop" music, in which the money lies, is listened to on cheap transistor radiation or car radios and it is unwarranted, for this and many more reasons, a levy on blank tapes.

But is your correspondent Mr Simmons (December letter) right in his statement without qualification the proposition that manufacturers and their agents are entitled to a just reward for their labours? The money which is alleged to be lost by the use of tape recorders is that which once had to be spent on one a permanent record whatever it was an expensive record or tape? The very existence of the Monetary Commission indicates that the answer must be no. Therefore one needs to examine a little more carefully the matter of copyright, because that is the mechanism used for keeping the prices of records and pre-recorded tapes at a level far higher than the cost, rents, expenses, apart, justify.

Is it not an act of immoral musical divided into classical, where the composers are dead and their work is copyrighted, and the world of "pop" where composers now aim for the "jackpot." The composers of both type of music in theory to be content with a flat rate fee for their performances on the basis that it is just a job of work, but the pop suit classical music and manifests it in a manner that they do not "pop" musicians who are generally called "rockers" as well. In practice of course it may be difficult to distinguish between performers in the "pop" field even so it strikes me that the proposed levy is a Luddite-type action.

Two media, namely radio and records, were exploited vigorously and with the objective of making money. Radio, whatever the BBC may say, was the advertising medium and the objective was to make the music. Tape has performer and it is easy to record from radio, with the obvious result. Perhaps we should reflect that the BBC, in the guise of itself the tool of the record producers we would never have heard of and the source of wealth to the record producers.

Now we have the means of not being exploited by using a tape recorder, it is that freedom which is being attacked.

Looking back to the old days, e.g. those of the 78 r.p.m. record, it is noteworthy that we paid a modest fee to the BBC which provided music on a considerable scale almost entirely by composers like Holst, Elgar and Vaughan-Williams. What went wrong? It seems rather sad, you see the "pop" world do not accept that a healthy competition and a balancing of the supply and demand would solve these problems whilst still providing the features which are so important to present day music. It should be mentioned that the t.l.c. levy used in the probe are operating with pulse durations shorter than is recommended by manufacturers. Although two probes have been made without trouble in this respect, it may be necessary to experiment with several lecs. The total cost of the unit is about £10.

WIRELESS WORLD FEBRUARY 1981

T.I. logic probe

Performs static and dynamic tests on logic circuits, including 'glitch' detection

by A. J. Jameson, B.Sc.

The probe described is unusual in that it will detect and indicate the presence of 'glitches' that are normally caused by propagation delays in logic circuits. The probe, being also a dynamic testing, it also shows positive or negative coincidence in two pulse trains.

A logic probe is a useful aid to testing and fault-finding digital systems. The many commercial and amateur designs currently available provide information about the static and dynamic behaviour of circuits, but are limited in their ability to provide 'coincidence-detection' and cannot indicate the presence of 'glitches' in the waveform under investigation.

For example, in the simple case of Fig. 1, a 'standard' probe would indicate pulses at A and B, but the output C would remain high, leading to the conclusion that either the circuit is faulty or the pulses are not coincident. The next step in the exercise would probably require the use of a dual-beam oscilloscope to prove or not A and B are coincident. Even so, if the pulses are of different frequencies, the task of determining coincidence may be impossible using an oscilloscope. In addition, the use of an oscilloscope may be the highly portable, pocket-sized logic probe on the market.

Another example encountered all too often, despite careful design, is that of 'glitches' produced by static and dynamic race-hazards. In the example of Fig. 2, a negative-going 'glitch' is produced due to propagation delay through the JK flip-flop. This example is also shown in Fig. 3, where a similar situation has been produced using the circuit above.

The use of a logic probe on such a circuit would reveal no faults whatsoever. Even an oscilloscope with delayed-sweep facilities would probably show nothing since the pulse width is less than 1MHz. However, the presence of such a circuit within a system would exist to erratic operation and is quite often diagnosed as an 'elusive dry-joint'.

The logic analyser probe described, solves these problems whilst still providing the features of the probe described. It should be mentioned that the t.l.c. lecs used in the probe are operating with pulse durations shorter than is recommended by manufacturers. Although two probes have been made without trouble in this respect, it may be necessary to experiment with several lecs. The total cost of the unit is about £10.

WIRELESS WORLD FEBRUARY 1981

Circuit operation

Protection circuitry. The protection circuitry shown in Fig. 4 has been incorporated to prevent damage to the probe and the oscillator against incorrect supply voltages. In addition, D3 is illuminated when the supply voltage is correct, whereas, D3 is off when the voltage is incorrect.

Probe operation. Circuit A and B in Fig. 5 form 'window discriminators' with threshold voltages of 2V and 0.8V. These I.c.s are 9637 dual differential line receivers and, because of the input characteristics of the device, Vb and Ic are not needed to pull down the input to 1.5V when the probe is floating.

Fig. 1. An ordinary probe would not show whether a lack of output from the gate was due to the permanent failure of the gate, or the gate being faulty.

Fig. 2. Propagation delay between the input and output of the flip-flop produces a narrow pulse or glitch at C.

Fig. 3. Evidence of the glitch in Fig. 2 on a screen photograph.

Fig. 4. Protection circuitry avoids damage to the probe in the presence of incorrect supply voltages, and shows that the supply voltage is in the usable range.

Fig. 5. Current flow - with pull-up/base transistor.

Fig. 6. Probe output waveforms.
Thus the trailing edge of the pulse at the output of IC₅₆, whose duration is equal to the propagation delay through IC₅₆ (approximately 15ns). This pulse duration is extended by D₆₀, C₆₀ and R₆₀, which are discharged rapidly via D₆₀ and the output of IC₅₆ becomes high. D₆₀ is now reverse biased and C₆₀ is charged by the input circuitry of IC₅₆, until the high input-threshold level of IC₅₆ is reached, when the output of IC₅₆ returns to a low.

The duration of the monostable period has two additional lengths, determined by C₆₀ and C₅₆, which enable the glitch period to be determined approximately.

The propagation delay of IC₅₆ is compensated by a similar delay through IC₅₆. Thus, the trailing edge of the pulse at the CK input to IC₅₆ is time coincident with the positive edge of the pulse at the D input. These pulses are illustrated in Fig. 6, which shows that if the pulse produced by the monostable (output) is of shorter duration than the input pulse at A, then the Q output of IC₅₆ remains unchanged and therefore is not detected as a glitch. However, if the pulse from IC₅₆ is longer than that at A, then the D-type flip-flop (IC₅₆) toggles and the Q output goes high, registering a glitch. This latch is periodically reset by the unijunction oscillator.

Construction

As will be appreciated, pulses of less than 100ns duration are easily attenuated by stray capacitance and inductance. Therefore, all leads must be as short as possible.

By careful choice of components, it will be found that the two boards may be 'sandwiched' together, the centre sides are aligned, and the case is tightened and therefore can be fitted into a case of 100 x 50 x 25mm, as illustrated in Fig. 7.

Testing

If a high-frequency oscilloscope (of around 50MHz bandwidth) is available, the test circuit consists of a simple oscillator running at about 1MHz, driving a 74121 monostable with a variable pulse duration of 20-200ns. Using such an arrangement, it is a comparatively simple matter of checking the pulse lengths at which the glitch circuitry operates.

However, without a suitable oscilloscope, the only way of checking the monostable periods is to generate glitches of approximately known length, relying on the propagation delays of cascaded gates. It should be stressed that the timing periods need only be approximate and consequently, no great difficulty will be encountered.

The probes consist of a lm:m plug with a sewing needle soldered in place and also another needle, soldered to a short length of wire. The earth point should be connected by a short lead to the area under investigation to minimize pulse attenuation.

Literature received

Celestion have sent us a leaflet on the interferometric testing of loudspeaker cones, using the Doppler effect in a laser system. The leaflet also provides a complete history. It was accompanied by a spectacularly illustrated brochure and an incomprehensible poster.

Greenwood’s catalogue of electronic components, hardware, tools, etc., complete with prices, is now available from Greenwood Electronics Ltd, 447 Millbrook Road, Southampton SO1 0ER, price 50p.

A series of leaflets from Ferranti describe the F100-L, which is said to be the only 16-bit microprocessor to be designed, developed and made in Europe for commercial and military applications. The leaflets can be obtained from Ferranti Computer Systems Ltd, Computer Sales Dept., The Courtyard, 20 Denmark St., Wokingham, Berks. RG11 2BB.

A full catalogue of the enormous range of TAB books, which include publications on radio, antiques, aviation, d.i.y., car mechanics and many more subjects, is available from TAB Books Inc., Blue Ridge Summit, PA 17214, U.S.A.

Babani’s range of low-cost publications on radio and electronic topics are described in their new catalogue, which can be obtained from Renald Babani (Publishing) Ltd, The Grampians, Shepherds Bush Road, London W11 3NF.
Phase-comparator detectors

This type of detector also makes use of the varying phase relationship between two input signals, nominally in quadrature, such as the voltages across the primary and tuned secondary windings of a transformer but it does so in a manner quite different from that of the detectors described earlier. In Seeley-Foster and ratio detectors the two input signals are added to produce resultant voltages (the amplitude of which varies with the phase difference) which are applied to amplitude detectors, the combined output giving the required modulation-frequency signal.

In phase-comparator detectors the two input signals are limited so as to form rectangular pulses. Limiting may be carried out in separate stages preceding the phase comparator or in the phase comparator itself. The degree of overlap of these pulses varies with the phase difference between the two inputs and determines the output current of the comparator which is therefore a copy of the modulation waveform. The output of the comparator thus depends on the relative timing of the two sets of pulses and is independent of the amplitude of the input signals provided this is sufficient to give satisfactory limiting.

To summarise: in the detectors described in the first article, the amplitude of the primary and secondary voltages is the significant quantity whereas in the phase comparator it is the timing of these voltages which matters.

The general form of a phase-comparator detector is illustrated in the block diagram of Fig. 13(a).

Self-limiting phase-comparator detectors.

In an early form of phase-comparator detector the two input signals are applied to the two input grids of a special valve. Signals applied to such a grid next to the anode to suppress tetrode grid current. Finally therefore the valve behaves similarly and again there is a net output. The duration of these outputs depends, of course, on the extent of the overlap between the I.F. and quadrature inputs and varies with the phase difference between the two inputs. The output can be used as a.f. in f.m. receiver or for a.f.c. purposes.

Pulses are produced to stabilise the mean current through the detector and is one of the many auxiliary components included in its circuit to ensure that the performance is substantially unaffected by variations in ambient temperature or in supply voltage.

A number of i.c.s designed for use in f.m. receivers incorporate detectors with a circuit similar to that of Fig. 16 and they are often described as balanced, symmetrical, quadrature or product detectors.

Counter discriminator

This detector is employed in the i.c.s designed for use in the f.m. receiver to detect the presence of any carrier frequency component of the i.f. signal that is not associated with the modulation. The frequency of the output signal is such that it is convenient to use it as a discriminator in a variety of phasesensitive detectors. The circuit diagram of such a discriminator is shown in Fig. 17.

F.m. detectors—2

A survey and a system of classification

by S. W. Amos, B.Sc. M.I.E.E.
Battery-powered instruments

Chooosing and using dry batteries, with some suggestions for improving service life

by Ian Hickman

The use of batteries as the power source for small electronic instruments and equipment is often essential. The absence of a trailing mains lead (especially when there is no conven-
tient socket into which to plug it) and the freedom from earth loops and other hum problems often effects obvious disadvan-
tages. However, other considerations indicate batteries as the appropriate choice, the next choice to be made is between primary and secondary batteries, i.e., between throw-away and rechargeable types.

Rechargeable versus primary batteries

Rechargeable batteries offer considerable economies in running costs, though the initial cost is high. For example, direct-connection batteries can be made between certain layer-type batteries, e.g. PP3, PP9, and also certain single cells, e.g. AA, C, and D size primary cells, where mechanically inter-
changeable, rechargeable nickel/cadmium batteries and cells are available. This cost about ten to twenty times as much as the corresponding zinc/carbon (Leclanché) dry battery or cell, and as much or more again for a suitable charger. This double cost accounts for the continuing popularity of the common garden dry battery. Another point to bear in mind is that, contrary to popular belief, the em-

terprise of nickel/cadmium rechargeable batteries is no greater than (and in the case of multicell types often considerably less than) the corre-
sponding zinc/carbon cells, so that the use of Nickel/cadmium batteries is just as wise (and in the case of multicell types offer-
ning the same condition of exhaustion. However, note that if a nickel/cad-
mium "battery" is being assembled from individual cells they should all be in the same condition, ideally new, and in the same state of charge. Otherwise, one cell may become exhausted before the rest and thus be subject to damaging "reverse charging".

A really effective indicator on a battery-powered instrument may prevent this wastage of batteries. However, of the many types of "ov" indicator used, nearly all have proved of very little electronic use. The indicator manufac-
turer uses a rotary on/off switch, the part transparent skirt of the knob exposing fluorescent orange sectors when in the "on" position, and this is reasonably effective when the front panel is in bright light. Indicator lamps have also been used by usually with intermittent operation to save current. Examples are a blocking oscillator causing a neon lamp to flash, and a flasher circuit driving an i.e., unfortunately, the power that can be saved by flashing a lamp is very limited. The flashing rate cannot be much less than one per second or it may fail to catch one's attention. On the other hand, the eye integrates over about 100ms, so flashes much shorter than this must be much brighter to give the same visibil-
ity. Thus a saving of about ten to one in the running cost (ignoring any "housekeeping" cost introduced by the flasher circuit) is about the limit in practice.

The author must have raised as many batteries as most people by inadvertently leaving equipment switched on when not in use, and decided many years ago that the only effective remedy was to replace...
The on/off switch by an 'on' push-button. This switches the equipment on and initiates an interval at the end of which the instrument boots itself off. Clearly, it would be most annoying if just at the wrong moment — say when about to take a reading — the instrument or whatever switched itself off, so the push-button should also, whenever pushed, extend the operation of the instrument to the full period from that instant. One can thus push, if in doubt, by pressing the button again, 'just in case'.

The period for which the instrument should stick on, as well as on its use and the inclination of the designer. However, a very short period — a minute or less — would generally be rather pointless; provided one had one hand free one would go off with a straightforward 'on whilst pressed' button, which is also cheaper and simpler. For many purposes, ten or fifteen minutes is a full period, but clearly it is not critical unless the equipment is exceedingly current-hungry. After all, it is being left on overnight (or a week-end) that ruins batteries controlled by an ordinary switch, not the odd half hour or so.

In the late 1960s, when the first author used a ten-minute timer to save batteries, producing such a long delay economically was impractical or at best expensive. For many purposes, ten or fifteen minutes is a full period, but clearly it is not critical unless the equipment is exceedingly current-hungry. After all, it is being left on overnight (or a week-end) that ruins batteries controlled by an ordinary switch, not the odd half hour or so.

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Discharge period 12 hours/day

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Discharge period 1 hour/day

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Discharge period 0.5 hour/day

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Discharge period 0.1 hour/day

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Discharge period 0.05 hour/day

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Discharge period 0.01 hour/day

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Discharge period 0.005 hour/day

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Discharge period 0.001 hour/day

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Discharge period 0.0005 hour/day

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Discharge period 0.0001 hour/day

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Discharge period 0.0000000005 hour/day

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Programmable bandpass filter
This design simulates a resistor, \( R_{Cu} \), by switching a small capacitor, \( C_{Cu} \), at a clock rate \( f_{C} \) in the frequency range 500Hz to 500kHz. The size of the equivalent resistor is \( 1/c_{Cu} \), and a multivibrator circuit for simulating \( R_{Cu} \) is shown in Fig. 1. The s.p.s.t. analogue switch can be replaced by a dual switch, type TL 191 CN. Clock frequency is set by the RC networks to, say, 100Hz and this circuit replaces resistors \( R_{1} \) and \( R_{22} \) in Fig. 2. Centre frequency of the filter is \( 1.592 \times 10^{6} R_{P} = 1.595 \times 10^{6} C_{Cu} \) assuming \( R_{T1} = R_{T2} = 1/c_{Cu} \). Under this condition \( Q \) depends on \( R_{1} \), \( R_{2} \), \( R_{3} \), \( G_{Cu} \), \( A_{pp} \), for the pass band is \( 5.10^{4} R_{P} \), so \( R_{P} = 5.10^{4} A_{pp} \), and \( R_{T} = 5 \times 10^{4} (2-1/A_{pp}) \).

Fig. 3 shows an example of a four-pole Butterworth or Chebyshev band-pass filter where \( Q_{P} \) is 25, \( f_{C} \) is 1.5 kHz and \( A_{pp} \) is unity.

Computed values for Fig. 3:

- Butterworth Chebyshev
  - \( f_{C} = 1.01424 \)
  - \( f_{C2} = 0.98296 \)
  - \( Q_{1} = 35.56850 \)
  - \( Q_{2} = 35.56952 \)
  - \( C_{Cu} = 95 \times 10^{-6} \)
  - \( C_{Cu} = 93 \times 10^{-6} \)
  - \( R_{P} = 50 \times 10^{3} \)
  - \( R_{T1} = 40 \times 10^{3} \)
  - Operation of the band-pass is corrected by slight variation of the clock frequency \( f_{C} \).

Fig. 2

Improved audio-visual circuit
Where several locations or sub-systems are monitored, for example in an alarm system, it is common to have an audible alarm, which is activated if a noise point is triggered, and an array of visual indicators to show the particular location(s) involved. Because the audible alarm has a large number of inputs, this system can be costly in terms of wiring and connectors.

A simpler solution is to use the I.e.d.s as an OR gate, with the output as a current to ground which can be detected by a current mirror. Because the current can become reasonably high, \( T_{r} \) must be a medium-power type. Although this unbalances the current mirror, linearity is not important in this switching application. The final design used a p-n-p switch as an active pull-up. With this arrangement only one input connection is required for the audible alarm.

The mirror can also be used in an analogue mode for current to voltage conversion where the output represents the number of I.e.d.s turned on. The output can either cover all possible states, or \( T_{r} \) can saturate with, say, four or more I.e.d.s and operate an extra alarm when a pre-set number of faults require attention. Note that I.e.d.s and indicators can be used if a diode is connected across the base-emitter of \( T_{r} \), and \( T_{r} \) output is taken through a switchable monostable.

T. M. Forcer Southampton

Ringing-tone generator
A reasonable approximation to the standard telephone ringing tone can be achieved with two I.e.s and two transistors. A c.m.o.s. oscillator/divider generates both the tone and the gating signals so, in the quiescent state, only c.m.o.s. current and transistor leakage current is drawn. The output-stage values are appropriate for a \( V_{DD} \) of 10V and a low voltage supply of 4V. Resistor \( R_{P} \) gives a 1mA warble on the tone and can be omitted if this is not required.

T. Williams Tunbridge Wells

Wide-range p.p.m.

By using the exponential conduction characteristic of a silicon diode, a I.e.d. bar or needle display of audio level over a range of 40dB can be achieved.

The collector load of \( T_{r} \) is bootstrapped by \( T_{2} \) and \( C_{P} \) to produce a near constant-current drive to \( D_{1} \) and \( D_{2} \). The clamped signal is then amplified to drive a pentode transistor, and \( T_{3} \) maintains a constant current through the rectifier bias diode \( D_{1} \). Capacitors \( C_{1} \) and \( C_{2} \) determine the rectifier discharge time-constant, and \( R_{1} \) buffers the output. The I.e.d. driver, \( H_{D} \), supplies 15mA through the display diodes, and \( R_{2} \) limits the dissipation of \( C_{2} \) during large input signals.

To adjust the circuit, set \( R_{3} \) for maximum input, \( R_{4} \) to the mid-position and \( R_{5} \) to maximum resistance. Apply 12V and feed a 1kHz signal of at least +2dBm to the input. All of the I.e.d.s should turn on. Reduce the input to 0dBm and adjust \( R_{4} \) until I.e.d. 8 is just extinguished. Increase the input to +12dBm and adjust \( R_{5} \) until I.e.d. 10 is just on. Repeat the last two adjustments as necessary. Reduce the input to -30dBm and adjust \( R_{5} \) until I.e.d. is just on. Re-adjust \( R_{4} \) and \( R_{5} \) if necessary.

The calibration should now be within 1dB over the range 80Hz to 1kHz. The lower sensitivity limit can be extended by connecting a 33MHz resistor in series with \( D_{1} \). \( R_{3} \) can then be adjusted so that I.e.d. 1 turns on with an input of -55dBm, but the scale below I.e.d. 8 will need to be recalibrated.

The circuit is fairly sensitive to temperature variations, due to the characteristics of \( D_{1} \) and \( D_{2} \), but it is nevertheless useful

N. McLeod Hove E. Sussex
Gate tester

Fig. 1 tests quad dual-input type gates by comparing the logic operations of a reference i.e. with the device under test. Input signals are provided by a square-wave generator and divider.

Two alternative circuits are shown for testing 3-input and 4-input gates, using the same output arrangement.

K. Wright
Colchester
Essex

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If everything were perfect...

It is rarely necessary to have to boost the bass response of a top quality high fidelity system, (although the Quad 44 tilt control does enable subtle changes to be made to the overall balance of the programme), but there are a number of high quality loudspeakers on the market, which because of their Lilliputian dimensions, necessarily have attenuated low frequency response and the Quad 44 is fitted with a bass control which in the lift position provides optimum equalisation.

Considerations of domestic harmony frequently dictate loudspeaker placement that is less than ideal. The almost inevitable result is the excitation of the fundamental eigentones of the room and music reproduction with a characteristic and unpleasant honk.

The step side of the Quad 44 bass control switch eliminates this problem without rolling off the low frequency information, simply by putting a 5dB step in the frequency response, reproducing domestic bliss and a closer approach to the original sound!

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

The Acoustical Manufacturing Co. Ltd., Huntingdon, PE18 7DB. Telephone: (0480) 52561.

QUAD
for the closest approach to the original sound

QUAD is a registered trade mark.
Teledyne Semiconductor has introduced two evaluation kits for the new 7106/7107 3½ Digit Monolithic CMOS A/D Converters. The kits are simple to use and will measure AC and DC voltages, DVMs, resistance currents, temperatures and other physical dimensions.

The 7106 kit uses a liquid crystal display and is normally powered by a single 9V battery. It is portable, can be used inside or outside and will not fade in sunlight. The 7107 kit uses light emitting diode displays and requires an external power supply. It operates under normal indoor ambient light conditions. Both kits include parts for 200MV full scale. The kits use the I.C. internal reference, which at 100ppm is adequate for most applications. However, they can be modified to operate from an external reference where higher stability is required.

Each evaluation kit contains one I.C. (either 7106 or 7107), one display (either LCD or LED), a PCB, passive components, miscellaneous hardware and a detailed 6-page application note.

The comprehensive application note contains all assembly instructions.

**THE 7106 EVALUATION KIT COSTS £17.44 + VAT**

**THE 7107 EVALUATION KIT COSTS £14.31 + VAT**

---

**BUILD YOUR OWN HIGH ACCURACY 3½ DIGIT PANEL METER**

Interfacing microprocessor systems

The control of industrial plant and simulator circuits

by P. Jackson and S.O. Newstead

Several microprocessor systems are available, either in kit form or assembled, which can be adapted to control plant. These systems are usually modified desk-top computers with connections to additional memory devices.

Although many training establishments purchase such systems to teach programming, interfacing the microprocessor is not always tackled. This article outlines the design principles required for interface circuits and describes a simple boiler simulator suitable for microprocessor control.

Interfacing circuits for plant control should enable a microprocessor to read an 8-bit digital number, operate an a-to-d converter and read the output, switch external devices on and off independently, and output an 8-bit digital number. The first function is useful when several pieces of equipment are monitored. For example, when raising steam an oil-fired industrial boiler must have a flame, an induced draught fan and a forced draught fan in continuous operation. A sensor on each fan and a sensor on the flame whose outputs are converted to logic levels, can be read as the three l.s.b.s of an 8-bit number with the remaining bits connected to ground.

A subroutine which deals with this monitoring process can be written as follows,

SUBROUTINE NO. 1010

1000 RETURN

1010 READ 27,A

1020 IF A=7 GOTO 1000

1030 IF A=O PRINT "ALL SYSTEMS FAIL"

1040 IF A=1 PRINT "F.D. & FLAME FAIL"

1100 WRITE 30,1

1110 GOTO 600

The digital number is read into the microprocessor and stored in memory location A. The circuit which responds to instruction 1010 is discussed later. If the plant is operating correctly, the program leaves the subroutine. However, if there is a fault it is displayed on the v.d.u., instruction 1100 switches on an audible warning and the plant closes down. Instruction 600 is assumed to be the start of the closing down routine. A program stop can be included in this routine as follows,

650 IF A=7 GOTO 670

660 STOP

670

Therefore, a healthy system can be temporarily closed down, and a faulty system closed down permanently. The second function is useful whenever an analogue transducer is used. For example, pressure, temperature, acidity, rate of flow or position measuring devices. The program must be held until the a-to-d converter has completed its task. If the converter uses a counter and a comparator, the time for the converter to operate is proportional to the magnitude of the analogue signal. The status strobe from the converter is therefore...
used to hold the program.

The third function, switching external devices on and off, is the control of the plant by the processor. The final function, which gives an 8-bit digital number as an output on eight lines, can be used when variable control signals are needed. A programmable power supply in automatic test equipment could be controlled in this way.

When designing interface circuits, the signals available from the c.p.u. must be considered together with the system it is connected to and the plant to be controlled. Some of the pins on the c.p.u. are fully buffered and will drive 74LS logic, others are unbuffered and will drive c.m.o.s. As the interface circuits will probably contain a mixture of 74LS and 74 gates, control signals from the microprocessor must be buffered, and a c.m.o.s. 4050B provides six buffers at a reasonable cost. If the microprocessor contains a large memory, c.m.o.s. buffers may be needed between address, data and control busses and the interface devices which load them, but this is a matter of judgement.

Some microprocessor systems already contain ports, and the process to be described assumes that there exist but additional ports are needed. The ports which are added to the microprocessor, and through which the four functions listed previously are carried out, need to be addressed. Microprocessors have 8, 12 or more usually, 16 address lines which form the address bus. These are normally fully buffered to cope with the complete memory, 64K for 16 address lines. For port use, the eight least significant lines A0 to A7 are available together with the input/output read (IORD) and input/output write (IOW) control signals. The control signals are used when read and write instructions are reached in a programme.

Although machine code can be used to fetch data from a port or to output data to another port, because it is generally easier to work in a high-level language, the examples given here are in BASIC.

A system as purchased may contain some ports which use addresses 0 to 8, say. 7. Additional ports for plant control can therefore be numbered 8 to 255, using A0 to A7. To obtain extra ports use Fig. 1, or Fig. 2 for 32. C.m.o.s. buffers have been included but it may be possible to use 74LS154 devices and omit the buffers. To read an 8-digit number, connect the eight lines which carry the address to the inputs of the tristate buffer in Fig. 3. An instruction such as 30 READ 26, B will cause address lines A1, A3 and A4 to go high, and when the IOREQ pulse reaches the demultiplexer in Fig. 1, line 26 will go low. The other demultiplexer outputs remain high.

While the IOREQ pulse is present, the RD pulse is received by the tristate buffer in Fig. 3. This pulse, together with address 26, opens the buffer and connects the input signal to the data bus. During the RD pulse the buffer in the c.p.u. opens and closes to load the number on the data bus into a register. Several tristate buffers can be connected to the data bus and selected in turn by each address. If the input to one of these buffers is obtained from an a-to-d converter, three instructions may be used. The first instruction produces a pulse which sets the converter counter to zero and starts the count. At the same time, the c.p.u. is set to a Hold mode, which prevents it from advancing in the program until the wait signal is removed. The wait signal is held by the status signal from the a-to-d converter. The second instruction reads data into the c.p.u., and the third instruction resets the latch set by the first instruction. Typical instructions to read an analogue signal from address 20 and to store it in the memory at location Q are,

80 WRITE 19,1
90 READ 20,Q
100 WRITE 19,0 where 19 is the address of the latch which starts the converter. In this example, which uses the circuit in Fig. 4, the least significant data line is coupled with address line 19 to operate the latch in two ways. If this is not done, two address lines must be used, which makes the data quoted in the write instruction irrelevant. This method is advantageous when surplus address lines are available.

External devices may be switched by latches with the same addresses as shown in Fig. 4, or eight latches with the same address, connected to D0-D7, can output an 8-bit number. These can also be viewed as eight separate switchable lines. If read relays are driven by the 74 logic which makes up the interface system, it is possible to control many types of plant.

An oil-fired boiler simulator for microprocessor control

This simple model illustrates sequential switching of equipment, monitoring of the plant by reading a digital number and taking appropriate action, reading of an analogue number via an a-to-d converter and taking action based upon its value, use of a software delay after switching a device on and then verifying that the device is operating, reading pressure and temperature at predetermined intervals and, in the event of major failure within the plant, closing down and locking out the plant followed by a print out of the failures and an audible alarm.

The boiler simulator comprises an induced draught fan and forced draught fan. When the starters are switched on, these fans gradually run up to speed to the fan-running signal is subject to a delay. When the boiler is started, the fans must run for a while to purge the furnace before fuel is sprayed in.

A fuel pump, which must not be switched on unless the furnace has been purged, the fuel has been heated above the minimum temperature and the ignition has been switched on.

A flame detector. The flame must appear a short time after the fuel has been switched on; if it has not, the boiler must be shut down. The microprocessor can be programmed so that a flame failure stops the fuel pump, purges the furnace and attempts to ignite the boiler again.

A fuel heater. This is easily switched on, but a check can be made by measuring the fuel temperature, switching on the heater, introducing a software delay, measuring the fuel temperature again and checking that the temperature has risen.

The logic, is 74 series throughout, does not provide latches in the simulator because they are part of the output ports of the microprocessor system. A logic 1 applied to the fan start input of Fig. 5 switches the starter 1-Q from red to green. After a short delay the red i.e.d., which indicates that the fan has run up to speed, turns on and a logic 1 appears at the fan-running terminal. The delay must be allowed for by the software. This circuit can be used for both fans and for the fuel pump with a smaller capacitor to simulate the faster response. If the fan-failure switch is closed, the starter will operate but the fan will not run up to speed.

The a-to-d converter in Fig. 6 gives an output proportional to the fuel temperature. This output is between 00 and FF (0 and 255) and can be displayed in % without scaling. Once the oil is alight, the ignition can be switched off. If the fuel pump stops, however, the flame will go out. Flame failure and ignition failure can be manually introduced at any time as shown in Fig. 7 and the program should cater for these eventualities. The third instruction resets the latch set by the first instruction. Typical instructions to read an analogue signal from address 20 and to store it in the memory at location Q are.
Digital noise filter

Simple design suitable for electronic clocks

by P. A. F. Lam

Although LSI techniques and mass production have reduced the cost of digital clocks, the logic circuits are still susceptible to false triggering pulses from electrical noise and switching transients. A common solution to this problem is the addition of a carefully designed low-pass filter, but, in some applications, this does not always remove the problem. A more effective solution is the addition of a simple digital noise filter which can eliminate over 90% of all false trigger pulses.

A typical digital clock arrangement is shown in Fig. 1a and a modified circuit is illustrated in Fig. 1b. The filter is based on a non-retriggerable monostable, shown in Fig. 2, whose time constant must be smaller than the period of the incoming pulses in Fig. 3. In most clocks i.e., the time reference is derived from the mains frequency, therefore, \( T = \frac{1}{50} \) s and \( \tau < \frac{1}{50} \) s. Because the monostable is non-retriggerable, the clock is immune to noise which occurs during the \( T \) period in Fig. 4. If a false pulse appears in the \( T \) region, the monostable is triggered but the next correct trigger pulse occurs within the new \( T \) range and is rejected. Therefore, the reference frequency is not changed and the phase error only lasts for one pulse. Clock accuracy can only be affected if a continuous stream of noise pulses occur during the \( T \) region in a time \( T_n^2 T_m \) where \( n \) is \( \frac{T}{T_1} - 1 \).

A longer period for \( T \) gives a higher noise immunity coefficient but, usually, it cannot be longer than 95% of \( T \) due to the stability of the circuit. If this filter is to be used in a very noisy environment, the addition of an ordinary power-line filter will improve the performance. Application of this circuit is not limited to digital clocks because the design can be extended to any digital signal which has a periodic nature e.g., the synchronizing signal from a communication modem.

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Multiplex keying system for organs – 2

A practical solution to the wiring problem of multiple key contacts in pipe or electronic organs

by A. W. Critchley, Dipl.EI., M.I.E.R.E.

TDM system reduces drudgery and cost of building an organ, whether pipe, electronic or hybrid. It permits a wide range of organ features, many hitherto unobtainable on electronic organs, allowing closer simulation of pipe organs or fraction of the cost.

The principles can easily be adapted for microprocessor control at a much lower hardware cost and complexity.

As demultiplexers comprise not only a significant part of the electronics but also a source of complexity it obviously pays to use the extension principle, see part 1.

The various manual outputs come out of the pitch shift register at different times so they must be delayed to arrive at a common demultiplexer at the same time. So manual scan period delays are necessary when collecting the voice outputs for an extension organ, but not for the traditional one.

Mixture stops

These are normally found only on the large pipe organ and almost never on cinema organs. The principal reason is that they require two or more ranks of pipes for each stop. They have a peculiarity in that the notes sound louder and always toward the top of the range, no matter which keys are played, to add brilliance. To achieve this the individual ranks break to lower notes as they come in turn to the top of the keyboard. These breaks occur at different places in the scale of the manual.

To be strictly musical these stops should key generators which are independent from the rest of the organ (and have no tremulant on them either) as the pitches are supposed to be true harmonics of the keyed pitches. This is really a question for argument amongst purists but the reasoning is that the multiple notes sounded generate beat frequencies which should be the same as the fundamental or other low harmonics of the keyed notes. With common generators this does not happen due to the deliberate mis-tuning of the even-tempered scale and the resulting beats are off tune.

For most purposes this does not matter too much as a pipe organ is full of mismatched beats at the best of times (the chorus effect) due to the many independent pipes – especially so when mixtures are likely to be used. In an electronic organ of one generator rank it is a different story. Still, any mixture is better than no mixture and it is simplicity to provide one with this system. The method is shown in Fig. 9 which shows how to generate a four-rank mixture stop as found on a large organ. This one is based on the one found on the choir manual of St Albans cathedral organ.

The range of notes played is from 45 to 92. The maximum pitch required from the generators is 1½ octaves but the maximum pitch relative to a key is ½ octave (for notes 1 to 12). The pitch shift register thus has to extend for five octaves beyond unison pitch in order to accommodate this mixture stop.
Timing
The union pitch delay due to sub-octave coupling and 32ft pitch generation amounts to three octaves. With the five octaves required to generate up to 1/4 ft pitch for mixtures, eight octaves have to be added to the six for each keyboard scan to give clearance between keyboards. This results in a total of 14 octave pulses. It would be reasonable to settle for the good binary number of sixteen which then allows for a super-octave coupler (2ft pitch) if desired. A further keyboard scan period could be added to cater for other contact data such as stops, pistons, etc.

Sixteen octaves contains 192 pulses (keys). This is convenient as a suitable c.m.o.s. shift register contains 64 bits so that three packages would give the correct delay between manuals.

Demultiplexing
Conversion of the serial data back into parallel information to switch on and off the various pitches is performed in a demultiplexer consisting of a D-bistable per pitch and a decoder which sequentially clocks them. Fig. 10. The data inputs of all bistables are paralleled and each clock input receives one clock pulse per complete scan of the organ. The output data are therefore incremented in scan and faithfully follows the original keying.

There is unfortunately a practical problem with this arrangement in that the integrated circuits are packaged with separate data inputs and a common clock input. To overcome this, another shift register with taps at every stage is used to drive the data inputs sequentially whilst the clock input of the bistables receives a single clock pulse per scan. The clock input of the shift register is driven at the data pulse frequency. Fig. 11 shows the practical system.

The outputs of the bistables operate whatever form of keying circuit is to be used; a c.m.o.s. transmission gate is one possibility. A transistor interface would be used to drive a pipe organ magnet when the demultiplexer could be mounted on the pipe chest and thus save more wiring.

Automatic pedal
Pianists are sometimes called upon to amaze onlookers at an organ but are not able to perform adequately with their feet for the bass part of the music. Here is the answer.

The pedal department can be played from the lowest note only of whatever is being played on the manuals, usually the great mandal. Due to the scanning process, the first note obtained from the manual is also the one of lowest frequency. The simple circuit of Fig. 12 obtained this note and ignores the rest. The input data sets an R-S latch which can be set only once by the input data if enabled by the great gating pulse. The resulting pulse is thenshortened to obtain only the leading edge. This signal, together with a pulse occurring just before the great scanning period, reset a counter clocked at note rate. Its period is sufficient to place the output transition in the right place for the next note to be played in the pedal scan time – it must be less than one total scan. A D-bistable and or-gate reduce the long pulse from the counter to a one-note wide pulse at this time.

The output signal could be further gated to prevent the pedals from being operated by high notes on the manual. It could also "break back" the pedal notes to the lowest octave whichever keys were being played if a variable shift register were also included.

Automatic melody
With a small organ it would be useful to be able to solo and accompany on the same manual without the bother and expense of second-touch keys or splitting the keyboard. This can be done by extracting the last, or highest, note from the keyboard in use and using it to operate some other keyboard or voice. It is the reverse of the automatic pedal system.

A counter with a period at least equal to the delay between played note and the note to be played is clocked at the note rate. It is continually being reset by the input data from the manual so that the counter produces an output change at the correct instant to activate the note to be played as a solo. To prevent continuous action, the reset-pedal is fed with a pulse which disables the counter after the time required to produce the output. If no notes are played, the counter will not then give a false result. A D-bistable and and-gate convert the counter output back to a single note-wise pulse, Fig. 13.

For solos on the same manual with a different voice, a complication arises in that the clock pulses are to be reset just before that manual can operate. So to get the information from the demultiplexer requires that the counter have a delay to one total scan less one manual scan and the manual scan is made up with a shift register to render it coincident with the original note.

Percussive action
For bells, drones and similar percussive effects, each note has only a short duration even though the key may be held on. It also has to operate whether or not other keys are held down on the same manual. This is achieved by digitally shortening each note in the serial data stream for a particular demultiplexer. One such circuit will work for all the notes on that demultiplexer. Each note has its own decay system as required for the voice effect which is part of the demultiplexer. A suitable period for each note to operate is perhaps two scans of the organ (192 bits) and the delay is provided by a shift register.

An AND gate cancels out any pulses after the two scan periods. The shift register must be clocked at note rate but the total delay for the decays is in increments of the total scan time to effect cancellation in the gate. This gives a long shift register, Fig. 14.

One of these circuits can handle all the percussive requirements of the entire organ if the output is routed and gated by appropriate manual gating pulses. With

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Fig. 8. Voice collection system for extension organs (simplified).

Fig. 9. How to generate a four-rank mixture stop as found on a large organ (based on St Albans Cathedral choir manual).

Fig. 10. Serial to parallel data conversion is achieved by a D-type bistable per pitch and a decoder to sequentially clock them.

Fig. 11. Practical demultiplexer uses additional shift register to drive data inputs sequentially whilst the clock input of the bistables receives a single clock pulse per scan.

Fig. 12. Pedals can be played from the lowest note only of whatever is being played on the manuals.

Fig. 13. Solo and accompaniment can be obtained from the same manual by extracting the highest note in use.

Fig. 14. For percussive effects each note has to be shortened to two scans of the organ. Delay is provided by a shift register.
Further delays in increments of manual scan periods it can also provide pizzicato coupling between manuals. These delays already exist in the coupling system that all that is required is some logic.

Pizzicato coupling can also be used to momentarily key in noise or harmonics in electronic organs in order to simulate starting tones or chuff in flute and diapason pipes.

As the percussion output ceases if the notes are held down, it follows that a pulse will occur every time any note is changed even if the rest are still down. This is very useful; it means that untuned percussion is possible merely by gating out each manual or pedal scan in a simple percussion effect generator without the need for a demultiplexer. This is not possible on theatre organs where the key contacts were simply paralleled to operate the "trumpet".

Microprocessor control and other possibilities

The multiplexing system is an ideal application for a microprocessor. It could be implemented with a good deal less hardware than indicated, but at a great cost in programming. Basically, the organ can be considered to be a large programmable memory source which is continually being altered by the player. A sequential scan can be generated by the microprocessor in 8-bit format instead of 12 and the data stored in a holding store.

All stops, couplers, keys, switches and other controls can also be read into the store which then contains all the data available. The program then consists of manipulating the contents ex route to another output store according to the presence or absence of stops and couplers. For instance, to add an octave needs a microcensor to look for available notes and then add 12 to their addresses. The output store can be read out in serial form or the data can be transferred in 8-bit bytes directly to the keyboard.

The same hardware can cater for all types of organ and the specific details stored in programmable read-only memories.

Combination pistons can be included in the scanning process. The bigger organs have the facility of being able to couple them together in much the same way as the keys, e.g. to couple the great and pedal pistons. In any case it would further reduce the wiring.

Including a stickable delay in the de-multiplexer clock path, or in the data stream gives a method of synchronizing the wiring. In any case it would further reduce the memory source which is continually being altered by the player. As the percussion output ceases if the notes are held down, it follows that a pulse will occur every time any note is changed even if the rest are still down. This is very useful; it means that untuned percussion is possible merely by gating out each manual or pedal scan in a simple percussion effect generator without the need for a demultiplexer. This is not possible on theatre organs where the key contacts were simply paralleled to operate the "trumpet".

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Although Tellegen's theorem is a really basic network theorem, implying as it does a re-statement of the law of energy conservation in networks, it is not widely known to electronics engineers. This article first introduces the original formulation of the theorem in terms of energy and power, then discusses an immittance version of it, written for driven networks with storage elements, and finally gives some examples of its application to practical linear networks.

Tellegen's theorem is one of the most basic network theorems ever formulated, since it implies a re-statement of the law of energy conservation as applied to networks. It offers a highly useful method for analysis of electrical systems. In mathematical shorthand, the fundamental message of the theorem may simply be stated as $\Delta W = 0$, where $i$ is current, $v$ voltage, and $t$ time. The prerequisites for the use of the theorem are knowledge of the network topology, and Kirchhoff's laws. In some instances and special cases one need not even know the network topology so long as certain mathematical relations pertaining to the network are known. Typically, Kirchhoff's voltage-sum law and Tellegen's theorem together imply Kirchhoff's current-sum law, and the latter plus Tellegen's theorem imply Kirchhoff's voltage-sum law.

The very general nature of Tellegen's theorem is evident from the fact that it holds for any linear, time-invariant, steady-state network of any order and with any number of storage elements, whether time-variant or time-invariant. It holds for the periodic steady state as well as for transients, and for reciprocal as well as non-reciprocal networks. With reference to transients, we should not be surprised to find that among the many things that can be arbitrary bearing also the initial conditions. The excitation of the system can be almost anything, with one or more driving sources, in any mixture of coherent, incoherent, and random sources. The system can be driven in the steady state, periodic steady state, or transient state, with exponential and sine-wave drive common cases. In spite of all these remarkable features the theorem is not well known, or rather, it has remained quite unknown to the practical engineer up to the end of the 1970 decade. The reason for this is the stark simplicity of the theorem, its appearance of being self-evident. In numerous applications it is simply taken for granted.

In this short article we shall stay away from any and all proofs of Tellegen's theorem. The reader interested in such proofs may consult ref. 2, which proceeds to show how Tellegen's theorem may be used to derive or prove other theorems. Virtually, there is no end to the number of theorems derivable from Tellegen's theorem. The following quotation from ref. 2 is timely: "There is hardly a basic network theorem that cannot be proved by invoking Tellegen's theorem." A few typical cases are Heaviside's transient theorem, Van der Pol's transient theorem, the reciprocity theorem, and the reactance theorem. The last two are well known. Heaviside's transient theorem deals with energy supplied during transients in non-linear networks, and Van der Pol's transient theorem pertains to excess electric energy over magnetic energy in a CLR one-port, excited by direct voltage. Actually, when we are using Tellegen's theorem, we are inclined to automatically involve other theorems, and indeed we shall find this to be true in the following.

Tellegen's theorem implies that the energy entering the system equals that leaving it, some of the departing energy often being changed into other forms of energy. We may write a basic power relation for resistive networks in the simple form

$$P_i = P_{diode} + P_{out}$$

Here $P_i$ includes the power contributed by existing nonlinear sources, if any, of the network, whether time-variant or time-invariant. It holds for the periodic steady state as well as for transients, and for reciprocal as well as non-reciprocal networks. With reference to transients, we should not be surprised to find that among the many things that can be arbitrary bearing also the initial conditions. The excitation of the system can be almost anything, with one or more driving sources, in any mixture of coherent, incoherent, and random sources. The system can be driven in the steady state, periodic steady state, or transient state, with exponential and sine-wave drive common cases. In spite of all these remarkable features the theorem is not well known, or rather, it has remained quite unknown to the practical engineer up to the end of the 1970 decade. The reason for this is the stark simplicity of the theorem, its appearance of being self-evident. In numerous applications it is simply taken for granted.

Reducing to immittance

In his theorem formulation, Tellegen employs current-voltage products, thus dealing with power, readily extended to energy. Accordingly, he achieves an elegant treatment, independent of the precise form of the network, its number of meshes and nodes. In communications and electronics, however, many energized networks are inherently of single-mesh or single-node-pair form, or can with a reasonable amount of work be turned into one or the other of these two forms. Some interesting possibilities now evolve. If, as in given power relation such as equation (1), we divide out the common variable (current in a mesh, voltage in a node pair), one of Kirchhoff's laws results. If we carry out the same division a second time, an immittance (admittance or impedance) summation obtains, still governed by Tellegen's theorem. While our reduction from power to immittance scarcely requires a theorem of its own, such a theorem has nevertheless been published.

Written for driven networks with storage elements, the immittance theorem takes the general form

$$Z_i(t) = 0$$

Note that this form is restricted to single mesh and single node-pair networks. Like its parent theorem, the immittance theorem holds true whether the network is stable or brought to the point of instability. The summation always yields a zero with (2) providing an identity. This matter will be clarified in a following example. With reference to (2) it goes without saying that all sources must be converted to immittance by an application of the compensation theorem. Currents and voltages are automatically eliminated.

One important field of application for the original theorem as well as its immittance version is that of checking already obtained solutions to network problems. Such checking may involve considerable labour, however, particularly for algebraic solutions. On the other hand, since the Tellegen theorem solution may differ considerably from more common solutions, the immittance tool Tellegen has given us is highly useful for checking purposes.

As a first application example, consider the simple operational amplifier in Fig. 1, identified by the following formulas:

$$A_i = \frac{V_i}{E}$$

$$R_{out} = \frac{V_o}{I_{out}}$$

$$R_{in} = \frac{R_1}{R_0}$$

Here $A_i$ is the system amplification, $R_{out}$ the load resistance, and $a$ and $b$ initially constants. The voltage $V_i$ marks a dependent source. Let us dwell for a moment on the derivation of (4). Perhaps the most basic
The steps in using the immittance theorem are as follows. First, we apply the equivalent theorem to turn it into resistance, then sum up all resistance, writing
\[ Z = Z_L + \sum R_j = Z_L + \sum R_j. \]

The first term here represents a negative resistance. Eliminating all variables with the aid of the relations \( V_1 = (z - B) V_f \) and \( V_f = R_j \), and using \( V_f \) from (3), we quickly find the identity 0 = 0.

Knowing that Tellegen's theorem is in fact an extremely powerful mathematical tool, we can expect that the mathematical reasoning above would yield a relation which if the network instead had positive feedback. The switch from degeneration to regeneration is but a simplified sign of a change of the sign for \( b \). Specifically, then, we conclude that the identity is independent of the sign of \( b \). By this observation we quickly verify that this is the case. If we keep increasing the regeneration in a practical amplifier system, a point will be reached where we must accept non-linearity, and thus we have assumed a new transfer function approach. In theoretical work, however, we have the right to assume that the signal \( b \) is off point, the point of instability. We cannot proceed beyond this point without breaking theory. Generally, a network is equally valid after surges and oscillations have commenced. This observation is an important one.

Returning to our original example, we shall now claim that the previous result of an obtained identity holds true even when the system becomes unstable. As the only dependent sources in self-excitation, it maintains currents and voltages although there is no applied signal voltage here. We know, \( V_f = b V_f \), our summation takes the form
\[ \sum R_j + \sum R_j = \sum R_j \]
which directly gives \( h \). On the other hand, (8) is the direct result of the transfer function denominator \( R_{out} + R_j \) is set to zero equal. The point is that the transfer function is a formula but a formula for the port output impedance is known.

In passing, we shall make use of at least one other method for determination of the stability of a network under our definition, the popular Barkhausen criterion \( H = 1 \). In our example, the feedback transfer function is not zero, \( \sum R_j \) is set to zero equal. This with \( b = 0 \). We find that \( h = A = 1 \), so that the result of the termination of the theorem is known. The sign of the route to (8) of the route to the stability conditions, we must know the output impedance. Our equation may simply be to determine this impedance. We have already learned how to do this for some arbitrary transfer function which is known, but now let us instead assume that it is not. In (8), then is the only direct way of determining output impedance from a given network. We must find the ratio \( a = b \).

In the above examination of the network, we arrived at a summation that gave zero. The same result obtains if we instead work from the opposite end, using a theorem must be inserted \( t \) from (7) in its denominator.

Stability considerations

If our aim is to establish the stability conditions in general, without drawing from the network, the above discussion shows that the summing of power, or, in the case of constants, the summing of elements, does indeed provide the answer. In the many cases where the equivalent immittance is a formula similar to (3) and (4), with the network either unknown or known, Tellegen's theorem guides us, however, to a much more direct and time-saving procedure. We are already familiar with the differential equation of the network given, but by setting the denominator in transfer function to the given immittance, we find that in cases where the only available information is a port termination for the network in Fig. 1 is first to replace \( R_j \), then to use the compensation theorem. We find that indeed (4) is contained in (3), and in all cases of regeneration, the theorem given, a summation of all immittance all around the network attains self-excitation, it main­

vector. Thevenin's and Norton's theorems were the key to the procedure, Tele­

law power, following the theorem and electrical

References

4. "Output impedance theorem", Wireless Engi­


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10MHz oscilloscope

The Scopes 1401D is a 10MHz, dual-trace oscilloscope which supersedes the company's 401DB. The 10 x 4 moves digit and associated controls have been moved to the left of the front panel and the two input channels to the right. All the function switches are push


An op-amp with a gain bandwidth product of 1.5GHz and a slow rate of 1.8nV/√Hz is made by Analog Devices and distributed by Pascali Electronics Ltd. The applications include two high-impedance input amplifiers and wide band high-speed data converters. Unrivalled, the input offset voltage of the device is 1nV and the input voltage noise 26V/√Hz. The output current is based on a 2nV output swing in 200mA maximum and power dissipation is 600mW maximum. The 2010 is housed in a standard 14-pin dual-in-line package, costing £20.31 per unit and £13.53 in 100 unit quantities. Pascali Electronics Ltd, Dawsbury House, Green St, Sudbury-on-Thames, Middlesex TW16 6RA.

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An op-amp with a gain bandwidth product of 1.5GHz and a slow rate of 1.8nV/√Hz is made by Analog Devices and distributed by Pascali Electronics Ltd. The applications include two high-impedance input amplifiers and wide band high-speed data converters. Unrivalled, the input offset voltage of the device is 1nV and the input voltage noise 26V/√Hz. The output current is based on a 2nV output swing in 200mA maximum and power dissipation is 600mW maximum. The 2010 is housed in a standard 14-pin dual-in-line package, costing £20.31 per unit and £13.53 in 100 unit quantities. Pascali Electronics Ltd, Dawsbury House, Green St, Sudbury-on-Thames, Middlesex TW16 6RA.

V.m.o.s.f.e. transistors

Finfield TO-317 packaged v.m.o.s.f.e. transistors with a low-price have been developed by Siliconix. The VR1010 and VR1011 are capable of handling peak currents of up to 1A and have maximum blocking voltages of 100V and 30V respectively. Power dissipation is 1W in free air at 25°C. The devices feature a single-ended/differential input and will interface directly with t.t.l.

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This 16 x 1 bit fully static r.a.m. features 512 maximum address access and read cycle times and 960000 max. active power consumption. The KMS1400 16 x 1 i.d. package r.a.m., manufactured by Inmos, runs from a single 5V power supply and its i.o.s are all t.t.l. compatible. The 20 dice of the 8.16 x 1 d.i.l. package is a 'chip enable' with which the 16K r.a.m. can be addressed and will interface directly with the r.a.m. 16K r.a.m. is at present only available in small quantity samples but full availability is expected within the next three months. Inmos, Whitefriars, London, E.C.1.
Bourgeois ballistics

There has never been a better time for the d.i.y enthusiast. Employing trademen to come and poke about in your house or on your car gets more ridiculous by the day, and the results are very often little better than could be achieved by a trove of monkeys with a talent for social advancement. Run-off-the-mill joinery, bricklaying, plastering and painting need hold no terrors for the averagely detestable and even those of us with a full set of ten thumbs usually win through in the end. You can often obtain a lot of good stuff from our new stream-lined, dehumanized setting-room or a nicely finished set of drawers. A dear, dear thing.

There has always been a feeling of cosiness, for me, in all these d.i.y. magazines. The same old subjects appear every year: there's bound to be some stimulating overproofing the car. The wife keeps getting worried was the sheer malevolence of the car. I'm pretty sure that knowing my average weight every hundred yards, the main discovery what it is to be an unconsidered trifle; and, come to think of it, that is a bitter disappointment. The last office, Cycling, I can only suppose that your experience about how he should be functioning. I thought I'd have a go with a view to giving them at different times, no doubt trying to taste what you mean. Mind you, it's only free or charge)

No sale

Now we are heading so surely towards the cashiers, chicken society you would think commercial transactions would have become simplicity itself. It only seems to be a mere mechanical process of transferring a few digits out of one computer into another in a matter of microseconds. Not so, unfortunately. The old Adam (which includes his rib, I hasten to add) still holds sway in such tangible instants as distrust of the other fellow and his computer.

The other day, for example, we had a phone call from an engineer in a large public utility who was unsuccessfully trying to buy a bit of electronic parts from one of our mail-order advertisers. Could we help? Apparently the public utility wanted to place an order through its normal system, by which payment would be made after delivery of the goods. The mail-order firm, however, was not playing their chance, and we rejected the offer. They insisted on cash with order, or no sale. It seems at least three witty accountants in the public utility had a go at them at different times, so don't try to catch them off guard with a variety of silly voices; but no, they were adamant. Mind you, I can understand their reluctance. A friend who runs a small business tells me you can easily face ruin with a few of these large organizations as customers — they can take up a year to pay their bills.

Anyhow, the point is, we could offer the engineer was: why not pay the required sum himself, out of his own pocket, and then recover it later from his employer who surely must be honest enough to cough up? There was a sharp intake of breath at the other end of the telephone, followed by a long silence: "Oh, er ... I don't think our organization could cope with anything like that."

It's extraordinary that there can be such a stalemate between two parties who genuinely want to do business together. One is keen to buy, the other is willing to sell, but because each is a step (or two) removed from the real manufacturer, and method of transaction the result is no business. Mail-order transactions have become so refractory it's surely time we got in some of those intelligent machines to do the bookkeeping and contribution counting. This has been going on for about last month. Machina sapiens might be able to teach homo sapiens a thing or two about how he should be functioning.

Cycling hertz

Since the day some unprincipled lout at RAP Stafford stole my bike, I have not pedalled. (I was going to say I haven't set foot on one, but that didn't seem quite right.) With the move to Sutton, though, I thought I'd give a go with a view to giving myself a bit of exercise by riding to the office, since it's only three miles. So I did. One of my son's Moulton up a bit, it's costing me a fortune, filling all these bullet holes in every weekend.

"Yes, see what you mean. Mind you, it's all right for your three children highway-locity stuff, but you'll be in trouble with those blasted buzzsaw rockets."

"Well, I haven't got time for more than heavy-calibre machine-gun protection. I said I'd put the new lino tiles down at the hall today, and you know what she's like if I don't do things straight away. She's out this morning, down at the hand-grenade class."

Butter side down

Having just taken our library out of the orange plastic boxes it came from Dorset House, I've found an opportunity to observe Murphy's Law in inexorable velocit stuff, but you'll be in trouble with the Bourgeois 'Butter side down'. It's costing me a fortune, filling all these bullet holes in every weekend.

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<table>
<thead>
<tr>
<th>Model</th>
<th>Output Power</th>
<th>Frequency</th>
<th>Signal Noise</th>
<th>Price &amp; VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOS120</td>
<td>120W RMS</td>
<td>20Hz-20kHz</td>
<td>0.008%</td>
<td>£24.48</td>
</tr>
<tr>
<td>MOS200</td>
<td>200W RMS</td>
<td>20Hz-20kHz</td>
<td>0.008%</td>
<td>£32.48</td>
</tr>
<tr>
<td>MOS300</td>
<td>300W RMS</td>
<td>20Hz-20kHz</td>
<td>0.008%</td>
<td>£43.48</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Model</th>
<th>Output Power</th>
<th>Frequency</th>
<th>Signal Noise</th>
<th>Price &amp; VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>HYP100</td>
<td>100W RMS</td>
<td>20Hz-20kHz</td>
<td>0.008%</td>
<td>£20.48</td>
</tr>
<tr>
<td>HYP200</td>
<td>200W RMS</td>
<td>20Hz-20kHz</td>
<td>0.008%</td>
<td>£30.48</td>
</tr>
</tbody>
</table>

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BOX NUMBERS: £1 extra. Replies should be addressed to the Box Number in the advertisement, c/o Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.

PHONE: Eddie Farrell, BI-061 3050, Ext. 8154.

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Tremendous growth and success has created the need for even more first class staff for one of the world’s leaders in professional television broadcast equipment.

During 1981 some 60 to 70 jobs must be filled, most of which are available now and based at our European Headquarters at Brompton Stoke, plus several more in other parts of our marketing territory.

If you feel the thought of enjoying the success of world leadership then write in strict confidence to Barry White, Personnel Manager, Sony Broadcast, now! And please don’t forget the c.v.

Regional Sales Manager

Southern Europe

Reporting to the General Manager - Sales, the successful candidate will be required to take up a substantial assignment with an established company on the Eastern European market. The successful candidate, who will be expected to spend a substantial part of his time travelling in the territories, will have degree of initiative and self-motivation allowing him to build up and develop a substantial assignment in the region. The effective development of this region could lead to a major sales breakthrough.

Sales Manager – Africa

This is a challenging position for an experienced sales engineer or sales manager with a good knowledge of both the radio and television market. Knowledge of the African market or other overseas markets will be highly desirable. The successful candidate, who will be expected to travel extensively, will be required to build up and develop a substantial sale into the region. This type of position will be suited to a dynamic and suitably experienced candidate.

Sales Engineer

Within the sales division are several challenging opportunities for engineers who are experienced in video-camera and/or VTR’s to supplement our sales force. A number of vacancies exist in both TV and video equipment. Successful candidates are likely to be in the age range 25-30 and should be highly motivated and able to work on their own initiative. Experience in working or dealing with customers would be an advantage but the main requirement is a pleasant personality and ability to get along well with people. The basic salary will be above average and even better for those wishing to visit frequently to West Africa and the Middle East.

Senior Proposals Engineer

Reporting to the Sales Operations Manager. The successful applicant will have a technical background in television engineering preferably in the broadcast industry. He will be required to understand individual equipment as well as overall broadcast systems and will enjoy working with the minimum of supervision, often under pressure. The work will include the assessment of customer’s specifications and the preparation of the company’s response to both the technical and commercial conditions. A knowledge of foreign languages would be useful although not essential.

Assistant Product Managers and Product Engineers

We have openings for Assistant Product Managers and Product Engineers in each of our four regions: TV or Consumer, BROADCAST, TV or Consumer, and U/Matic VTRs. The Assistant Product Manager posts will ideally be graduate engineers with some years of experience in video equipment. Applicants for Assistant Product Engineer posts will probably be less experienced and will be offered both levels of experience to consider the right kind of experience in line with formal qualifications.

Successful candidates will be suitable for the position of Assistant Manager to provide technical product support both within Sony Broadcast and externally to customers.

Lecturer

The successful candidate would conduct theoretical and practical training courses on our major products. A background of working experience, if able to write circuit descriptions and produce training manuals with line block diagrams.

Appointments

Sony Broadcast Ltd.

City Hall House

Basing View, Basingstoke

Hampshire RG21 2LA

United Kingdom
Professional Careers in Electronics

All the others are measured by us...

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Name

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Years of experience 0-1 1-3 3-6 Over 6

Present salary £3500 £4500 £5500

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Return this coupon to John Prodir, Marconi Instruments Limited, FREEPOST, St. Albans, Herts AL4 0BR. Tel. St Albans 59292

WIRELESS WORLD FEBRUARY 1981

Appointments

Telecommunications Manager

KENANA SUGAR COMPANY LIMITED, in which the Sudan Government is a major shareholder, is developing Africa's largest sugar estate, including a sugar factory and refinery, on the White Nile some 200 miles south of Khartoum. The company has recently installed a VHF radio system (RCA) with over 300 mobile sets, 18 base stations and 10 channels. Other equipment includes UHF systems and HF with FSK for teleprinter communications. A contract for a microphone and multiplexdial telephone system (1,000 line exchange and 80 PABXs) will be let shortly. A Telecommunications Manager is required to control the Communications Division employing 40 people. He will be responsible for maintaining the service and equipment and will work closely with the company's consultants throughout the installation period.

An electrical/electronic engineering qualification at least to HNC level, management competence and a minimum of seven years' experience maintaining telecommunication/telephone equipment as specified are essential.

A highly competitive salary will be negotiated plus 15% end of contract gratuity, discretionary bonus and education allowances (where applicable). Four and one half years leave, passages paid, free air conditioned accommodation, services and medical attention. Sports and club facilities.

Please send relevant details - in confidence - to R. M. Cooper ref. ZH.60661. Further information will be sent.
RURAL OXON

Our client enjoys a reputation for innovative design in the field of Data Communications and has recently become the U.K. distributor for an International world leader in modems. With many excellent graduates in "the pipeline" an exciting expansion programme has been planned for the 1980's, starting with a move into a modern custom-built factory. To accelerate the development of these new products, opportunities now exist for ambitious electronics engineers to supplement the present management team and make an effective contribution towards the continued success of this dynamic young Company.

PRE-PRODUCTION ENGINEER

Aged 25-40 with an Electronics degree you will need to demonstrate a high level of practical expertise in new product development.

This key position requires a person with the ability to put theoretical ideas into practical, economical production and involves a great deal of liaison with management at all levels.

Design or user know-how of modems, line drivers and data communications would be a distinct advantage although additional in-house training will be given to the successful candidate.

For the successful applicants the rewards will be high, not only in the attractive package and relocation expenses but also in the opportunities that exist for personal career development in a rapidly expanding company which is geared to extensive, controlled growth in a buoyant market.

Applicants, Male or Female, should telephone Ken Hoare on 020 846 0021 or write to:

Gresham Executive Appointments, 3rd Floor, New Church Chambers, 87a New Street, Birmingham.

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Data Communications Engineers

£8,000

We are looking for experienced Data Communications Engineers to work in their R&D department in Oxford. The role would suit an engineer with experience in digital telecoms in a R&D role. The position would suit someone with experience in liaison and project management.

Newly appointed to a leading electronics company. The post will be linked to their R&D department, initially working on an advanced digital protocol. This will involve the design, development and testing aspects of the protocol, and the successful candidate will need to have experience in these areas. They will work closely with the design team and the project manager, and will be responsible for ensuring that the project is completed within the set time and budget.

The role will be based in Oxford and would suit an engineer looking for a new challenge in a leading company.

If you are interested in this role, please contact us for further details.

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Digital and analogue skills for new equipment development and some research work. For further details and application forms from the Personnel Officer, Design & Development, E. M. Walton & Co. Ltd., Milton, Montacute, (Bath) BA1 5ET. Telephone 0823 2635.

RURAL OXON

TECHNICAL SUPPORT ENGINEER

This new position will ideally suit an experienced engineer used to acting as a technical co-ordinator between the customer and the company. The successful candidate will act as a link to all sales and will carry out a troubleshooting role with the end-user.

This diverse role calls for an engineer co-ordinating the field service function, providing technical support for service manuals for company products, in-house and end-user technical troubleshooting as well as a back up to the marketing function. Hence appreciation of user problems in the data communications-computer data link field would be a great asset.

We are looking for a Broadband or Plessey technical resource.

If you are interested in this role, please contact us for further details.

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SMALL BATCH PRODUCTION WIRING ASSEMBLY TO SAMPLE OR DRAWINGS. Complete standard and component units to assembly drawings. Contact M. S. Electricals, 52 Western Road, New Eltham, SE9 1SS. Tel: 01-850 8750.

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For cash or exchange, any 12 volt, 24 volt, or 3 volt radio equipment. Contact The Life Electric, 103 Uscombe Rd, Berks. Tel: 01-877 9778.

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STORAGE SPACE SPARE one shelf in electronics equipment storage area. Only available for cash or exchange.

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5mv/div 15MHz @ £185 + VAT

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- CH1, CH2: 5mv/div \( \rightarrow \) 20/div in 12 (1-3-5-7)
- BANDWIDTH: 10MHz (DT-410), 12MHz (DT-411)
- TIME BASE: 0.25ms/div – 150ms in 1 step
- X5 Multiple in / 15
- X5 FACTOR, metro X = CH1, CH2

- TRIGGER: Level Control, 1 Slope, Bright Line AUTO
- NORMAL, TV Triggering CH1, C42 0.3 ms, EXT Trigger 100ms
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- Cat output grade compensation
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- SIZE: H:215mm W:183mm D:228mm Weight 4.5 kg

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