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Front cover
A robotic arm is put through its paces before taking its place in one of Britain's industrial research establishments. The hand, with almost as many joints as a human hand, and claimed to be just as versatile, is capable of gripping up to 5 kg (11 lb). Southampton University has been researching robotic hands for more than 15 years, producing a number for medical uses. Some of these are not only natural in appearance but also have a sense of 'touch'. This particular arm, which has separate controls for the shoulder, forearm, elbow and hand, has been designed for use with dangerous materials in special industrial environments. All the movements are made by a series of powerful miniature electric motors. Ten microcomputers are hooked up between the arm and joystick, effectively forming the 'brain'. It is said to be capable of moving in a 180 degree arc in one second and to have a repeatable accuracy of ±0.1 mm.
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In Britain, as in most western countries, we have strict legal requirements to ensure that mains-operated equipment is safe as regards electric shock and fire caused by undue rises in temperature. The relevant laws and regulations apply equally to proprietary and home constructed equipment and installations.

Also, in Britain we have one of the safest domestic electricity supplies in the world. Yet, an average of 40 people die each year in this country from electricity-related accidents, while a further 2,000 need hospital treatment. Although these figures compare well with those of most other countries, they are not good.

It is probably because of the high degree of inherent safety and the relevant legal requirements that most of us take safety for granted and are no longer (at least consciously) aware of the risks of injury or death from electric shock or fire caused by electrical faults. Invariably, such faults are man-made.

To increase people's awareness, the Department of Trade and Industry and the Electrical Installation Equipment Manufacturers' Association (EIEMA) have recently launched an Electrical Safety Awareness Campaign. One of the aims of this campaign is to persuade people to use Residual Current Devices (RCDs) to reduce the risk of injury or death.

Basically, an RCD is capable of detecting an electric current that flows anywhere other than the circuit intended for it, and switches it off rapidly so that it can prevent electrocution or an undue rise in temperature.

The Wiring Regulations of the Institution of Electrical Engineers already require the use of RCDs within an installation where hazards are recognizably greater than normal, such as electrical equipment used outdoors.

Since an RCD provides protection that supplements the basic measures and offers a degree of safety against the inevitable wear and tear or any misuse, abuse or degradation of the inbuilt safety of electrical installations and equipment, it is to be hoped that people will start making far greater use of it, particularly, but not only, with electrical musical instruments. An RCD Information Bureau has been established that may be contacted by telephoning the operator and asking for 'Freephone RCD Devices.'
A remarkably simple solution is offered to a problem almost any constructor of a test card or callsign generator, logomat, graphics card, or any other video equipment must have been faced with at some time: phase synchronicity between clock pulses in the system and the chrominance subcarrier.

A PLL circuit is described that enables deriving the TV line and field frequency, and a number of other useful signals, from the chrominance frequency, 4.433 MHz. A mystery unravelled!

by J. C. Stekelenburg PE1FYZ

In video equipment, the beneficial effects of phase-locking the central clock oscillator to the chrominance subcarrier are mainly the elimination of annoying digital interference and colour cross-patterning. The improvement can be noticed in the well-known colour bar test chart, in which colour transitions become sharply defined rather than blurred with bands of spurious lines and randomly moving coloured spots while longer lines are moving slowly and diagonally or horizontally across the screen.

In professional video systems and studios, complex equipment is available to ensure that all TV synchronization signals have a fixed phase relationship with the chrominance frequency, as set forth in the relevant CCIR specifications.

This article demonstrates how some thinking on the technical background of the PAL (Phase Alternation Line) and NTSC (National Television System Committee) TV systems, and a comparison between these in respect of possible interference, leads up to simple computer-assisted arithmetic and, finally, the design of a circuit that achieves the above objective of providing chrominance-locked, standard clock frequencies for digital video generators.

Choice of the chrominance subcarrier frequency

The PAL TV system is based on double-sideband modulation of the picture colour information onto a subcarrier of 4.433 MHz. This system is basically similar to that used for NTSC TV. The Y (luminance) signal is obtained by adding the three primary colours, red (R), green (G) and blue (B), in proportion, as

\[ Y = 0.3R + 0.59G + 0.11B \]

The degree of luminance of each individual pixel determines its brilliance, black corresponding to minimum, and white to maximum luminance. For a monochrome TV set, the luminance signal is sufficient for producing a picture. A colour receiver, however, needs the three primary colours for mixing to give each pixel on the screen the correct colour. The colour receiver finds two modulated signals, R-Y and B-Y adjacent to the 4.433 MHz subcarrier. From these, the R, G and B signals are obtained by means of a number of
simple operations involving subtraction and addition. The R-Y and B-Y signals are quadrature-modulated on the 4.433 MHz carrier, so that the instantaneous phase provides a measure for the colour of a pixel, and the amplitude for the colour saturation. Since the colour subcarrier is found within the luminance band (0...5 MHz), its sidebands will become visible as a pattern of thin lines. In the NTSC TV system, this undesirable effect is minimized by using a colour subcarrier frequency that is an odd multiple of the line frequency. This gives rise to a dot pattern which is far less conspicuous and annoying than the line pattern that would be formed in the PAL picture (see Fig. 1).

In the PAL system, the phase of the modulated R-Y signal is inverted for every line in the picture. This causes two sidebands adjacent to the 4.433 MHz subcarrier, at an offset corresponding to half the line frequency. When the subcarrier frequency is chosen such that it is an odd-subharmonic multiple of half the line frequency, B-Y information will result in a dot pattern, and R-Y information in a line pattern. To avoid this, the chrominance subcarrier frequency is an odd multiple of the line frequency divided by four (quarter-offset). Time-averaging of the remaining interference on a raster-by-raster basis is further achieved by adding 25 Hz (raster frequency) to the colour subcarrier, so that cross-interference between luminance and chrominance is least noticed. Summarizing the above, the optimum frequency of the chrominance subcarrier, \( f_{osc} \), becomes:

\[
\begin{align*}
  f_{osc} &= \frac{(15,625/4) \times 1135 + 25}{4,433,618.75} \\
  &= 4,433,618.75 \text{ Hz}
\end{align*}
\]

Table 1.

<table>
<thead>
<tr>
<th>x</th>
<th>divisor d</th>
<th>divisor e</th>
<th>real output frequency [Hz]</th>
<th>deviation from 15,625 MHz [Hz]</th>
<th>phase comparator frequency [Hz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>9</td>
<td>3,998,256.975</td>
<td>38.059098</td>
<td>442,381,875</td>
</tr>
<tr>
<td>2</td>
<td>31</td>
<td>28</td>
<td>4,001,565.871</td>
<td>17.808089</td>
<td>431,919,959.7</td>
</tr>
<tr>
<td>3</td>
<td>41</td>
<td>37</td>
<td>4,001,070.579</td>
<td>4.191901</td>
<td>108,137,042.7</td>
</tr>
<tr>
<td>4</td>
<td>91</td>
<td>83</td>
<td>3,998,950.245</td>
<td>-0.409464</td>
<td>48,191,508.15</td>
</tr>
<tr>
<td>5</td>
<td>317</td>
<td>286</td>
<td>4,000,047.2</td>
<td>0.084376</td>
<td>13,986,179.02</td>
</tr>
<tr>
<td>6</td>
<td>409</td>
<td>369</td>
<td>4,000,131.004</td>
<td>0.0507978</td>
<td>10,840,143.64</td>
</tr>
<tr>
<td>7</td>
<td>501</td>
<td>452</td>
<td>3,999,981.367</td>
<td>-0.037217</td>
<td>8,849,538.423</td>
</tr>
<tr>
<td>8</td>
<td>910</td>
<td>821</td>
<td>4,000,011.092</td>
<td>-0.0042657</td>
<td>4,872,108.516</td>
</tr>
<tr>
<td>9</td>
<td>227</td>
<td>204</td>
<td>3,998,998.993</td>
<td>-0.0039341</td>
<td>1,910,219.194</td>
</tr>
<tr>
<td>10</td>
<td>316</td>
<td>281</td>
<td>3,999,999.999</td>
<td>0.0001254</td>
<td>1,070,663.789</td>
</tr>
<tr>
<td>11</td>
<td>899</td>
<td>829</td>
<td>4,000,000.032</td>
<td>0.0001254</td>
<td>482,334,528</td>
</tr>
</tbody>
</table>

Table 2. Denominators 910 for d and 821 for e were found to yield a reasonable approximation of the target frequency whilst giving a practicable operating frequency for the phase comparator in the PLL to be designed. Also, these denominators allow relatively simple divider circuits to be used. The final deviation from 4,000,000 MHz is virtually negligible at +1.092 Hz.

Wanted: two denominators

Many digital video circuits have a central clock oscillator that runs at a multiple of 1 MHz. This is so arranged because the line frequency is then readily obtained with the aid of binary counters/dividers. For instance, when a clock of 4 MHz is available, 15,625 Hz is obtained by division by 256 (= 2). The question here is: how can we relate 4,433,618.75 Hz to 4,000,000 Hz? The answer can be provided by a computer, programmed to find two integer denominators: one \( d \), for the chrominance frequency, and another, \( e \), for the clock frequency. In other words, if the chrominance frequency is divided by \( d \), and the result of this division is multiplied by \( e \), 4,000,000 MHz should be obtained.

The BASIC computer program listed in Table 1 gave the results summarized in Table 2. Denominators 910 for \( d \) and 821 for \( e \) were found to yield a reasonable approximation of the target frequency whilst giving a practicable operating frequency for the phase comparator in the PLL to be designed. Also, these denominators allow relatively simple divider circuits to be used. The final deviation from 4,000,000 MHz is virtually negligible at +1.092 Hz.

Practical circuit

The above considerations lead up to the block diagram of Fig. 2. It is seen that 4 MHz is divided by multiples of 2 to obtain commonly used frequencies in digital video circuits. The chrominance frequency is multiplied by 2 to give 8.86 MHz, which is frequently required as a clock signal for IC-based colour generators.
Figure 3 shows the circuit diagram of the chrominance-locked clock generator, which is essentially a discrete phase-locked loop designed around commonly available parts.

The 4.433 MHz crystal oscillator is set up around gate N5, whose output signal is fed to buffer N6 and counter IC3. This, together with bistable FF1, divides the chrominance frequency by 910 to give 4.8721085 kHz. IC3 counts 909 periods of the clock signal, while FF1 delays 1 period (approx. 226 ns) during the resetting of the counter, giving the required divisor and allowing sufficient time for IC3 to reset all internal bistables.

The 4 MHz L-C oscillator is a varicap-controlled Colpitts type set up around Ti, with T2 and Schmitt-trigger gate N4 acting as a buffer to obtain a digital compatible output signal. Division by 810 in IC4 is achieved in a manner similar to that in IC3-FF1 as discussed.

The clock generator is essentially a discrete phase-locked loop. Construction and setting up

The circuit is fairly uncritical in respect of construction, and is simple to build on a small piece of Veroboard. Connections in the 4 MHz and 4.43 MHz oscillators should be as short as possible though, and due attention should be paid to decoupling of the positive supply line.

The only component that requires further discussion here is L1. In the prototype, good results were obtained with a Neosid Type 7A0 inductor assembly. The required inductance of about 22 µH was achieved by winding 60 turns of 0.2 mm dia. enamelled copper wire onto the former. Do not use ready-made 4.433 MHz inductors with a built-in parallel capacitor, since this is often too large to ensure the relatively high L-C ratio required in this application. The 4.43 MHz crystal was a type salvaged from a colour TV chassis.

After building the circuit, it is recommended to commence testing the 4 MHz oscillator by temporarily breaking the PLL control loop. Disconnect R4 from pin 4 of N3. This enables checking the operation of the 4 MHz oscillator with the aid of an external tuning voltage obtained from the wiper of a po...
tentiometer connected between +12 V and ground. To begin with, adjust L1 so that oscillation is achieved around 4 MHz. Check that the oscillator can be tuned with the potentiometer. The output of N1 should supply CMOS-compatible clock pulses. It is essential that these pulses have the full CMOS swing of about 12 Vp-p when the oscillator is tuned around 4 MHz. Do not add too much capacitance to the parallel tuned circuit when its resonance frequency is found to be too high: instead, ensure more inductance by increasing the number of turns on L1.

Next, adjust trimmer capacitor C2 to give 4.43362 MHz at the buffered output. Measure the frequency at pin 2 of N2 — this should be 4.8721085 kHz. Similarly, measure the frequency at pin 1 of N3 to check the operation of IC-FF2. Tune the oscillator to obtain about 4.8 kHz here.

When these tests check out, it is time to close the loop by removing the potentiometer, and connecting R4 to the output of N3. Connect the frequency meter to the 4 MHz output. Some readjustment of L1 may be required to get the PLL to lock.

The oscilloscope photographs of Fig. 4 may be used as guidance if difficulties are encountered in the setting up. The upper two traces show the 4.8 kHz signals at the inputs of the phase comparator, i.e., pins 1 and 2 of N2 (or N4), the lower trace the phase comparator output (pin 4 of N3). Although the latter signal is different in the photographs, the PLL was locked in both conditions, with only L1 set differently within the hold range of the oscillator. It is clearly seen that the phase comparator is essentially an exclusive NOR function: the output goes low only when the two input signals are different.

The operation of the PLL can be checked by carefully adjusting L1 while monitoring the phase comparator output with an oscilloscope. It will be found that the PLL loses lock when the pulses become significantly narrower than those in the lower trace of Fig. 4b. When the PLL is locked, L1 can be adjusted over a small span while the output frequency remains stable at 4.000002 MHz (7-digit resolution).

Finally, switch the power to the circuit on and off a few times to verify that the PLL starts and locks properly. All drift on the 4 MHz output is, of course, caused by drift of the quartz crystal frequency. It is, therefore, recommended to make the final adjustment of C2 and L1 after a warming-up period of about 10 minutes.

Multiplier for TEA1002

The circuit described is used by the author as part of a digital test chart and call-sign generator for amateur tele-

vision. The system incorporates a TEA1002 colour generator chip (Ref. 9) which requires an input signal of 8.86 MHz. The circuit of Fig. 5 multiplies the buffered crystal oscillator output of the chrominance oscillator by two to obtain this frequency. The multiplier is essentially a double-phase rectifier with a parallel-resonant L-C output filter. Suggested diode types are AA119 or OA95 (in any case, germanium types should be used). L2 and L3 are wound as 30 and 20 turns respectively of 0.2 mm dia. enamelled copper wire, with a centre tap. It is also possible to use ready-made inductors provided they are known to have a centre tap and the correct inductance (use a grid-dipper to check the in-circuit resonance frequency). Both L2 and L3 are simply peaked for maximum amplitude of the 8.86 MHz output signal.

Reference:

For further reading:
MICROPROCESSOR-CONTROLLED RADIO SYNTHESIZER — 1

The addition of a microprocessor-controlled synthesizer to a continuously-tuned receiver greatly improves tuning accuracy and provides several additional facilities that have become available in recent years.

The versatile synthesizer described has a 6-digit LCD or LED display and a 16-position keyboard which allows direct frequency entry, channel or frequency increment or decrement, as well as the storing and recalling of 30 frequencies. The MW, SW and FM band are covered each with a choice of IF offsets.

by P. Topping

Most recently designed quality radios employ synthesized local oscillators controlled by a microprocessor. These complex designs should not discourage the advanced home constructor, however, as components are currently available which enable similar facilities to be either incorporated in individual designs, or added to existing radios.

Synthesis of the local oscillator (LO) in a superheterodyne receiver provides many advantages over the more traditional mechanical tuning. The main benefits are improved tuning accuracy, stability and the possibility to store often used frequencies. Accuracy and stability result from the fact that the local oscillator is phase-locked to a reference crystal oscillator. Before synthesizers became available, crystals were used to obtain a good degree of accuracy. This has the disadvantage of requiring a separate crystal for each frequency. Using a phase-locked loop (PLL) synthesizer, similar performance can be achieved at an unlimited number of frequencies from only one crystal. Accurate, drift-free tuning is particularly important for stand-by use of a receiver when nobody is on hand to provide fine tuning.

A synthesizer can be incorporated into almost any receiver simply by replacing the tuning capacitor with a variable capacitance diode (varicap) as shown in Fig. 1. The voltage biasing this varicap is supplied by the synthesizer, which thus takes over the RF tuning. A simpler solution is to retain the RF function of the existing tuning control as a preselector to avoid tracking problems in multiband designs. The current trend is to eliminate front-end tuning altogether, and employ only a wideband filter between the RF input and the first mixer.

Synthesizer MC145157

The Type MC145157 CMOS synthesizer from Motorola is one of a series offering a variety of options including serial or parallel interfacing, and single or dual modulus prescaling. In the synthesizer described here, only single modulus

MULTIBAND RF SYNTHESIZER

Features:

- Coverage of MW, SW and VHF FM bands.
- Variable step size in accordance with station spacing.
- CMOS design allows battery back-up while minimizing power consumption and RF interference.
- 11 switch-selected bands with a variety of IF offsets, including nought.
- Power-down mode for display and processor.
- Easy to operate keyboard.
- RIT (receiver incremental tuning) control provided.
- Choice of three 6-digit displays: 7-segment LED, static LCD or multiplexed LCD.
- Memory function for up to 30 often-used frequencies.
- Last used frequency automatically recalled at receiver power-on.
- Simple to incorporate in almost any general-purpose receiver.
- Direct synthesis up to 16 MHz without prescalers.
- Prescalers for up to 60 MHz and up to 150 MHz.
- IF offset can be customized to individual requirement.

Fig. 1. A local-oscillator synthesizer can easily replace mechanical tuning to provide crystal-controlled accuracy and many other improvements in performance and convenience.
The MC145157 synthesizer includes two 14-bit shift registers, one each for the reference divider (top) and the variable (LO) divider. Their loading is controlled by the value of a trailing 15th bit. The outputs of these dividers are compared in respect of phase to control the frequency of the local oscillator. The equation below shows the relationship between the various frequencies, where $P$ is the LO prescaler, $N$ is the reference divider ratio, and $Q$ is the LO divider ratio. The received frequency can be changed by altering the LO divide ratio. The microprocessor takes care of the decimal to binary conversion, IF offset, and the other required arithmetic.

$$f_{LO} = f_{RF} + f_{IF} = P(f_{xto}/1V)Q$$

The practical application of the MC145157 is shown in the circuit diagram of Fig. 3. The output signal of the synthesizer’s 10 MHz crystal oscillator is divided down by 10,000 to obtain the reference frequency at which the phase comparator operates. A compromise is required when deciding on this frequency. Filter design is relaxed by choosing a high reference frequency, but the disadvantage is that the minimum step size of the synthesizer is determined by the reference frequency, as the smallest change which can be made results from a change of 1 on the LO divide ratio (see the above equation). A reference of 1 kHz is a reasonable compromise for most broadcast receivers. The MC145157 is specified to operate up to 20 MHz, so prescaling is required on FM (VHF) and SW. Shortwave band divide-by-5 prescaling is used, and for FM divide-by-10. This increases the minimum step size to 10 kHz on FM, which is ideal for this band, and to 5 kHz on SW, which is suitable for most broadcast receivers but too large for some shortwave applications. Fortunately, however, this can be alleviated by the use of an RIT (receiver incremental tuning) control, formed by external potentiometer $P$. The low-IF (455, 468 and 470 kHz) SW bands do not use prescal-
RIT control is not required, pins 1 and 2 should have a 47 pF capacitor and a 30 pF trimmer to ground respectively, the trimmer being adjusted to provide a reference of 1 kHz. If a frequency meter is not available, this adjustment can easily be made by tuning into a strong broadcast of known frequency, and adjusting for optimum reception and symmetric off-channel response.

An important part of any phase-locked loop is the loop (low-pass) filter. The active filter has the advantage of increasing the available voltage swing beyond the supply rail (5 V) of the synthesizer chip. The supply voltage on the active filter has the advantage of increasing the tuning voltage decreases the reverse voltage on it increases the frequency of the local oscillator. In some oscillator designs, however, the fixed side may be taken to the supply rail, so that increasing the tuning voltage decreases the frequency. With the filter design shown, the choice can be made simply by interchanging the connections to pins 15 and 16 on the MC145157. Resistors R7...R11 incl. may need to be adjusted empirically to stabilize the loop and eliminate any trace of the reference frequency from the output of the radio (remember that LO phase noise is demodulated together with the wanted signal).

Microprocessor and keyboard

The next module in the synthesizer is the microprocessor circuit — see Fig. 4. The microprocessor used is the CMOS Type MC146805E2 from Motorola, which offers powerful bit manipulation instructions, useful for this type of application. It also has a stand-by (power-down) mode in which the clock is stopped. This

**Fig. 4. Circuit diagram of the microprocessor-based controller and the keyboard.**
has the double advantage of saving power in battery applications, and eliminating interference problems with the radio. When a key is pressed, the microprocessor 'wakes', performs the required function, and then goes back into the stand-by mode.

The MC146805E2 has a multiplexed bus for data and low-order addresses. This arrangement saves pins but requires an external address latch, IC4, to interface with the system EPROM, IC5. This is a CMOS Type 27C64 so that the whole system consumes only a few milliwatts when active, and a few microwatts in stand-by. Although the control program in the EPROM could have been accommodated in a 27C16 (2K x 8) with room to spare, an 8 Kbyte EPROM was chosen because this is currently less expensive and generally better obtainable; the 2716, and its CMOS version, 27C16, is now rapidly becoming obsolete.

After performing the initialization routine at power-on, or following a reset, the microprocessor is programmed to switch lines PA4...PA7 of port A to output, and PA0...PA3 to input. The output lines are set logic low before the CPU is software-switched to the power-down state. Any subsequent action on one of the keys S1...S6 incl. drives the processor's interrupt request (IRQ) line logic low, ending the power-down state. Instructions in the EPROM cause the CPU to start scanning the keyboard with the aid of outputs PA4...PA7 and inputs PA0...PA3, to determine which key was pressed, execute the appropriate command or load the pressed number on the keyboard, write serial data to the synthesizer via PB0, PB1, and PB2, and update the display read-out via PB3, PA7, PB0-PB2, or PB1-PB3-PA7 (the port lines used depend on the display type — this will be discussed later).

The EPROM-resident control program is located in address range 1800H to 1FFFFH. This is the top of the CPU's address space (it can address 8 Kbyte of memory), and includes the reset and interrupt vectors. These vectors reside between 1FF6H and 1FFFFH with the program itself starting at 1800H. The MC146805E2 microprocessor has a 112-byte on-chip RAM area in page zero. The CPU bus is demultiplexed by octal latches IC4 using the address strobe (AS) pulse.

The 5 V supply to the controller should not be switched off if the station memories are to survive. The supply does not need to be regulated, and four 1.5 V zine-carbon or Ni-Cd batteries will do. With the static LCD on, the current drawn in stand-by is about 50 μA, without it, less than 1 μA. Eight 100 kΩ pull-down resistors on the multiplexed bus lines of the CPU are used for ensuring minimum stand-by power dissipation.

When the display is switched on, it will show random data, but will be written to when any key is pressed (use of the execute key restores the display to its previous data), or automatically by the reset circuit shown in Fig. 3.

Using the keyboard

The 16-key keypad performs the following functions:

**0-9** These keys are used for both direct frequency entry and recalling (for storing) the ten frequencies available in each band.

**UP** Increment by one channel (5 kHz SW; 9 kHz MW; 50 kHz FM) or 1 kHz (10 kHz on FM, not applicable to 10.7 MHz SW).

**DOWN** Decrement by one channel (5 kHz SW; 9 kHz MW; 50 kHz FM) or 1 kHz (10 kHz on FM, not applicable to 10.7 MHz SW).

**STORE** Next key (0-9) stores current frequency at that key (indicated by a decimal point on the left-most digit).

**CLEAR** Clear display (direct frequency entry). Also toggles between channel steps and 1 kHz steps (indicated by a decimal point on the second digit from the right).

**MODE** Change between frequency and station mode.

**EXECUTE** Go to frequency, but stay in current mode.

The leftmost digit in the display indicates which mode is current:

- Display blank: direct frequency entry mode;
- Number: last station stored or recalled — station mode;
- Small square (LC display) or a single lit horizontal centre segment (LED display) — station mode.
which was in use when it was switched on to retune the frequency.

Can be used when the receiver is newly entered. The store facility also works in the frequency mode - new frequencies can be selected with only the key required after each new frequency has been written into or recalled from memory.

A choice of two modes permits the minimum number of keystrokes regardless of method of use. In the station mode, previously memorized stations can be recalled by pressing only the required key — there is no recall key. Storing a frequency requires two key actions, viz. STORE (indicated by a decimal point on the left-most digit) followed by the memory number.

If direct frequency entry is required, MODE is pressed followed by the frequency. There is now a choice: press MODE again to jump to the new frequency, and return to the station mode. Alternatively, press EXECUTE to jump to the selected frequency but stay in the frequency mode — new frequencies can then be selected with only the EXECUTE key required after each new frequency entered. The store facility also works in the frequency mode.

If it is desired to change back from frequency mode to station mode without retuning the radio, press STORE, then MODE, and to display current frequency press EXECUTE. In station mode, EXECUTE updates the synthesizer and the display with the current frequency. This can be used when the receiver is newly switched on to retune the frequency which was in use when it was switched off, even if that frequency was not stored. Returning to the circuit diagram of Fig. 3, it is seen that this is achieved by Ti resetting the microprocessor when the radio is switched on — when the 10 V supply rises, Ti momentarily pulls the CPU's reset input low.

**Bands and IF offsets**

Port B lines PB4...PB7 incl. are used for providing band selection information to the CPU. These lines can be tied to the appropriate logic level if only one band is required (one band can constitute all the bands which use the same oscillator, but select frequency range by switching inductors). If, however, more than one oscillator has to be tuned, or the step size has to be changed (e.g. between MW and SW), the port lines can be set to the appropriate logic level by means of a set of switches (as shown in Table 1).

**Table 1**

<table>
<thead>
<tr>
<th>Band</th>
<th>PB7 (S18)</th>
<th>PB6 (S19)</th>
<th>PB5 (S20)</th>
<th>PB4 (S21)</th>
<th>IF offset (kHz)</th>
<th>Step (kHz)</th>
<th>Memory</th>
<th>Use</th>
<th>Prescaler</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>455</td>
<td>5/1</td>
<td>1</td>
<td>SW</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>468</td>
<td>5/1</td>
<td>1</td>
<td>SW</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>470</td>
<td>5/1</td>
<td>1</td>
<td>SW</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>10,700</td>
<td>5</td>
<td>1</td>
<td>SW</td>
<td>+5</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>-10,700</td>
<td>50/10</td>
<td>2</td>
<td>FM</td>
<td>+10</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>50/10</td>
<td>2</td>
<td>FM</td>
<td>+10</td>
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<tr>
<td>6</td>
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<td>1</td>
<td>1</td>
<td>0</td>
<td>-70</td>
<td>50/10</td>
<td>2</td>
<td>FM</td>
<td>+10</td>
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<tr>
<td>8</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>455</td>
<td>9/1</td>
<td>3</td>
<td>MW</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>468</td>
<td>9/1</td>
<td>3</td>
<td>MW</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>470</td>
<td>9/1</td>
<td>3</td>
<td>MW</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>10,700</td>
<td>5</td>
<td>3</td>
<td>SW</td>
<td>+5</td>
</tr>
</tbody>
</table>
the remaining 6 Kbyte in the EPROM (080011-1FFFH).

Table 2. Hexadecimal dump of the EPROM contents. EPROM address range .043011 to 0070:

<table>
<thead>
<tr>
<th>Address</th>
<th>Value</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>00A0:</td>
<td>00B0:</td>
</tr>
<tr>
<td>00C0:</td>
<td>00D0:</td>
</tr>
<tr>
<td>00E0:</td>
<td>00F0:</td>
</tr>
<tr>
<td>0100:</td>
<td>0110:</td>
</tr>
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<td>01C0:</td>
<td>01D0:</td>
</tr>
<tr>
<td>01D0:</td>
<td>01E0:</td>
</tr>
</tbody>
</table>

Table 2. Hexadecimal dump of the EPROM contents. EPROM address range 043011 to 0070:

<table>
<thead>
<tr>
<th>Address</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0030:</td>
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<tr>
<td>0030:</td>
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</tr>
<tr>
<td>00A0:</td>
<td>00B0:</td>
</tr>
<tr>
<td>00C0:</td>
<td>00D0:</td>
</tr>
<tr>
<td>00E0:</td>
<td>00F0:</td>
</tr>
<tr>
<td>0100:</td>
<td>0110:</td>
</tr>
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<tr>
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</tr>
<tr>
<td>01B0:</td>
<td>01C0:</td>
</tr>
<tr>
<td>01C0:</td>
<td>01D0:</td>
</tr>
<tr>
<td>01D0:</td>
<td>01E0:</td>
</tr>
</tbody>
</table>

It is seen that bit combination 0112 in PB6, PB5 and PB4 will select 10.7 MHz IF shortwave regardless of the state of the line PB7, so two banks (1 and 3) of memory giving a total of 20 stations can be used, provided that the second bank is not being used for medium wave. A front-panel button connected to PB7 is required to utilize this feature. This will also work for the low IF shortwave options in which the raising of PB7 selects medium wave with the same IF offset. The IF offsets can be modified in EPROM if required. They are in 8-bit unpacked BCD format, starting at memory address 1E05H with negative offsets appearing in 10-complement form. IF offsets are in tens of kHz, all others in kHz. For medium wave, starting at band 8, the same series of offsets is used again starting at band 0's 455 kHz. Only the first three are meaningful for medium wave, and at band 11 the software automatically repeats a selection of band 3 as described above. Beyond this there are no useful bands except, perhaps, band 13 which, like band 5, has a zero IF offset.

The software does not include any restrictions on the frequencies which can be used in each band. This maximizes the versatility of the synthesizer. For example, the shortwave bands can be used for MW in the USA where the
Select your display
The display indicates the current frequency and memory number, and assists with the entry of commands and new frequencies. The user is offered a choice of three types of 6-digit display for the synthesizer:
1. LED display; this has the advantage of probably being the least expensive thanks to the use of common 7-segment LED displays. The disadvantage of this circuit is its relatively high current consumption.
2. Static liquid crystal display.
3. Multiplexed liquid crystal display.

All three displays are driven with only two or three lines from the processor board to simplify wiring, and they work without any change in the software. It is, of course, possible to omit the display altogether, or use two displays simultaneously.

The multiplexed LCD is definitely the most elegant of the three options available, since it enables building a compact display unit with only one driver chip and few connections between this and the LCD. Unfortunately, however, the display required in this application proved very difficult to obtain, and it was, therefore, decided not to support this option with a printed-circuit board. The circuit diagram will, however, be discussed below.

LED display
The circuit diagram is given in Fig. 5. In line with the rest of the design, the LED display driver is also based on low-power CMOS LSIs chips from Motorola, in this case two Type MC14499 display decoder/drivers set up in a multiplexed circuit with four and two common-cathode 7-segment LED displays. The anode resistors, R3...R6 incl. and R7...R8 incl. should be dimensioned to give the required compromise between brightness and power consumption. ICs and ICs share their clock and latch enable (LE) lines with the synthesizer (IC), and receive their data from the shift register (S/R) output, pin 12.

As the current consumption of the LED display unit is of the order of 100 mA using 270 Ω anode resistors, the module cannot be left on with the microprocessor in battery-backed up applications, but should be switched off with the receiver. As the data to the drivers is supplied by the MC145157, the display should not be switched off while the MC145157 is still powered, unless the data line (SR) from this is also disconnected by opening S2.

Static LC display
6-digit static displays are currently available with standard pin-outs from a number of manufacturers, with only minor differences in the use of colons and other signs, which are not used here. Figure 6 shows the circuit diagram of the static LC display unit set up around drivers Type MC144115P. The suggested display from Philips Components (formerly Mullard/Videlec) gives good contrast while requiring very little power — the total current consumption of this display module is about 50 µA. Non-used segments in the display are tied to the backplane.

Multiplexed LCD display
The software can control a display unit composed of a 6-digit multiplexed LCD and a single driver chip as shown in Fig. 7. The benefits of a multi-plane display are immediately apparent from a comparison of the number lines between the controller and the display in this circuit diagram and that of Fig. 6. The controller, a Type MC145000, is fed serially with 48 bits corresponding to 6 digits of 8 segments, including the decimal point. It formats this data into the four backplane and 12 front-plane waveforms required to drive the LCD. Preset P2 is used for setting the contrast. To avoid interference with the radio owing to multiplexing pulses, the complete display module should be fitted in a metal enclosure.

Part 2 of this article will deal with the prescalers and the construction of the synthesizer.

COMPONENT NEWS

Mullard no more
After 68 years in the forefront of Britain’s electronics industry, ‘Mullard’ has ceased to exist, at least the name. The company, acquired in 1927 by the Dutch Philips Group, is now trading under the name ‘Philips Components’. The new name has also been adopted by Philips’s world-wide component operation, formerly known as ‘Elcoma’.

Optical shaft encoder
An optical shaft encoder, made by Sharp, is now available from Greenweld at a very competitive price. Producing two phase-shifted outputs and a sync pulse once every revolution, it is ideal for use in robotics applications or, in fact, anywhere where the position and speed of a rotating shaft need to be known.

The encoder costs £8.50 incl. VAT and is supplied with comprehensive data sheet. See p. 10 for Greenweld’s address.
What better occasion to present an ultra-simple 80 m receiver than this month's issue devoted to amateur radio and TV? An ideal project for the holidays, this CW/RTTY/SSB receiver is inexpensive, yet has good sensitivity and selectivity. You will have it ready in no time, and it only requires headphones, a set of batteries and a long-wire aerial to bring in the 80 metres band, popular among hams around the world for its reliable propagation characteristics.

The tuning range of the receiver discussed here is about 3.5 to 4.0 MHz, a section of which is assigned to licensed radio amateurs. In most areas in the world, the 80 m amateur band extends from 3.5 MHz to 3.8 MHz. Predominant modulation methods are single-sideband (SSB), continuous wave (CW) and FSK RTTY (Radioteletype based on frequency shift keying, using an SSB transmitter). The 80 m band has some interesting properties as regards propagation. Daytime range is usually of the order of a few hundred kilometres, while in the evening and at night field-strength increases, and stations up to 2,000 kilometres away can be heard. Occasionally, American stations are received in Europe in the early hours of the morning.

**Direct-conversion receiver**

The operating principle of the direct-conversion (or homodyne) receiver is simple: the received signal is mixed with that of a local oscillator to give a beat note, which is at once the AF output (see Fig. 1). In a direct-conversion receiver, the degree of selectivity is determined almost exclusively by the AF low-pass filter. The present design uses an active mixer which doubles as a linear detector, obviating the need for a prestage and providing the necessary high audio amplification thanks to a special feedback circuit. The practical circuit of the receiver is shown in Fig. 2. The circuit looks relatively complex at first, but is basically not very different from the block diagram. The aerial signal is fed via coupling capacitor \( C_1 \), to a parallel tuned circuit, \( L_1-C_2-C_3-D_1 \). This band-pass filter can be tuned by applying a direct voltage to variable capacitance diode (varicap) \( D_1 \). Coupling capacitor \( C_5 \) feeds signals passed by the filter to operational transconductance amplifier (OTA) \( I_1 \), a Type CA3080. An OTA differs from an operational amplifier in supplying an output current rather than an output voltage. In the present application, amplification of the CA3080 is controlled by the feedback circuit and the voltage on pin 5, which is provided by the local oscillator, to achieve the desired mixing effect. The feedback network is composed of \( C_8, C_9, C_{11}, T_1, R_5, R_6 \) and \( C_6 \). It is a relatively complex circuit because it functions as a current-to-voltage converter in conjunction with FET \( T_1 \), and at the same time as a low-pass filter whose roll-off frequency is determined mainly by the capacitance across \( R_6 \), i.e., \( C_u \) (100 nF; CW/RTTY) or \( C_u + C_{12} \) (570 nF; phone). The oscillator set up around \( T_2 \) is a varactor-tuned Clapp type with polystyrene capacitors to ensure optimal propagation conditions.
turns of 0.2 mm dia. enamelled copper and identical. They are composed of 20
inductors \( L_1 \) and \( L_2 \) are home-made multiturn presets \( P_t \) and \( P_3 \) later.

Holes to ensure access to the spindles of necessary, bending the screens.

corners to aid in positioning and, if the overlay. Use soldering pins at the
locations are shown in dashed lines on the
screens onto the component side - the soldering 15 mm high tin plate or brass
able it to function as a ground plane. This board is left largely unetched to en-
shown in Fig. 3. The component side of the double-sided printed circuit board
structed on the double-sided, but not

The direct-conversion receiver is readily
seen that \( P_t \) and \( P_3 \) set the upper frequency increases with the voltage on the
tuning range. Since the capacitance of a
trimmer is obtained from multiturn
voltage for the oscillator and the input
capacitors form part of a potential divider, and enable
accurate setting of the receiver's
Form part of a potential divider, and enable

Construction

The direct-conversion receiver is con-
structed on the double-sided, but not
through-plated, printed circuit board shown in Fig. 3. The component side of
this board is left largely unetched to enable it to function as a ground plane.

Commence the construction with soldering 15 mm high tin plate or brass
screens onto the component side - the locations are shown in dashed lines on
the overlay. Use soldering pins at the corners to aid in positioning and, if necessary, bending the screens. Drill holes to ensure access to the spindles of multturn presets \( P_t \) and \( P_3 \) later.

Inductors \( L_1 \) and \( L_2 \) are home-made and identical. They are composed of 20 turns of 0.2 mm dia. enamelled copper wire wound on the plastic former of a Type 7A1S inductor assembly from Neosid. Remove the three pins on one side of the base, and use the remaining two pins for connecting the winding. Scratch off the enamel coating with a pen-knife, pre-tin the wire end, remove solder flux by scratching again, and then wind the wire end two times around the pin. Tighten the winding and move it up towards the base to prevent a short-circuit with the ground plane. Solder fast to prevent the base melting and the pin being dislocated. Now close-wind 20 turns of the wire upwards on to the former, right up to the rim. Adjustment of the inductor is facilitated when the grounded ('cold') end of the inductor is near the rim on the former. Secure the winding with a few drops of glue or wax, and check continuity at the pins. Carefully mount the inductor on the board, and solder the pins at the track side. Fit the ferrite cup, and insert the core. Finally, mount the screening can, and solder the tabs to ground at both sides of the PCB.

The mounting of the remaining components on the board is a matter of routine. One terminal of the following components is soldered to ground at both sides of the PCB: \( R_t, R_5, R_6, C_2, C_3, C_4, C_5, C_{16}, C_{19}, C_{20}, D_1, D_2, P_t \) and \( S_i \). The two rotor terminals of foil trimmer \( C_s \), and the two ground pins (supply and AF output), are soldered likewise. In the case of the trimmer, take care not to damage the PTFE material by overheating it with the iron.

Unfortunately, there is a small error on the ready-made PCB for this project: facing the flat side of varicap \( D_1 \) (BB212), the right-hand side terminal of the device should not be inserted in the hole provided. Instead, it is soldered direct to the ground surface. PCBs supplied through our Readers Services are accompanied by a note advising of this design error.

Capacitor \( C_{16} \) is preferably an MKT type. When this is not available, a low-leakage electrolytic type may be used instead. The photograph of Fig. 4 shows a prototype of the receiver. Note that a number of ceramic capacitors are fitted in positions that should have polystyrene (Siemens: styroflex!) capacitor material. Unfortunately, these were not available when the photograph was taken. The previously mentioned grounded terminal of \( D_1 \) is clearly visible to the left of the device. It is essential that the receiver is fitted in a metal enclosure. Figure 5 shows a suggested front-panel layout.

Setting up

The following items are required for set-

<table>
<thead>
<tr>
<th>Parts list</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistors (± 5%):</td>
</tr>
<tr>
<td>( R_1, R_2 = 20K )</td>
</tr>
<tr>
<td>( R_3, R_4 = 15K )</td>
</tr>
<tr>
<td>( R_5, R_6 = 100K )</td>
</tr>
<tr>
<td>( R_7 = 27K )</td>
</tr>
<tr>
<td>( R_8 = 10K )</td>
</tr>
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<td>( R_{10, R_11} = 4K7 )</td>
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<td>( R_{12} = 4K7 )</td>
</tr>
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<td>( P_1 = 10K ) multiturn preset</td>
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<tr>
<td>( P_2 = 10K ) linear multiturn potentiometer</td>
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<td>( P_3 = 10K ) multiturn preset</td>
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<td>( P_4 = 100K ) logarithmic potentiometer</td>
</tr>
<tr>
<td>( C_1 = 10p ) trimmer</td>
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<td>( C_2 = 330p )</td>
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<td>( C_3 = 470p )</td>
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<tr>
<td>( C_4 = 40p ) trimmer</td>
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<td>( C_8 = 390p )</td>
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<td>( C_9 = 330p )</td>
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<td>( C_{11} = 47n )</td>
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<td>( C_{12} = 470p )</td>
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<td>( C_{13} = 220p )</td>
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<td>( C_{14} = 1u5 MKT )</td>
</tr>
<tr>
<td>( C_{15} = 270p^* )</td>
</tr>
<tr>
<td>( C_{16} = 1n5^* )</td>
</tr>
</tbody>
</table>

polystyrene (Siemens: styroflex!) capacitor 8% (available from Cricklewood Electronics).

Inductors:

\( L_1, L_2 = \) Neosid assembly 7A1S; winding details are given in the text. Neosid part no. 06955500. Neosid Limited ● Icknield Way West ● LETCHWORTH SG6 4AS. Telephone: (0462) 481000. Telex: 826405. Fax: (0462) 481008 (contact Mr. E. Adcott). Neosid
inductor assemblies are also available from C-I Electronics P.O. Box 22089 ● 6360 AB Nuth ● The Netherlands.

Semicapacitors:

\( D_1, D_2 = BB212 \) (Cirkit stock no. 12.02455) \( T_1 = BF256 \) \( T_{2, 3} = BF494 \) \( I_{C1} = CA3080 \) \( I_{C2} = CA3090 \) \( I_{C3} = CA3080 \) \( I_{C4} = CA3080 \)

Miscellaneous:

\( S_1 = \) miniature SPST switch.

Test Type 886034X (see Readers Services page).
Tuning up the receiver: a nylon trimming tool, a multimeter and a frequency meter (or a good-quality 80 m receiver). Temporarily power the completed receiver from a regulated 12 V supply. Connect the AF output to an amplifier. Turn P2 to the centre of its travel, and measure the voltage at the wiper. Adjust P1 and P3 to obtain 4 V. Connect the frequency meter to the emitter of T2, and use the nylon trimming tool to adjust the core in L2 until the oscillator produces 3.65 MHz. Turn P2 fully counter-clockwise, and check that the oscillator frequency decreases. Exchange the wires to the outer connections of the potentiometer if the frequency increases.

Adjust P3 until the frequency meter reads 3.4 MHz. Turn P2 fully clockwise, and adjust P1 for an oscillator frequency of 3.9 MHz. Turn P2 to the centre of its travel, and check that the oscillator frequency is about 3.4 MHz. If necessary, re-do the adjustments of P1 and P3 until P2 covers the full tuning range of 3.4 MHz to 3.9 MHz.

As a matter of course, the function of the frequency meter can be taken over by a calibrated 80 m receiver, which should have no difficulty picking up stray radiation from T2. The oscillator frequency can then be read from the dial of the auxiliary receiver.

Connect the aerial to the input of the direct conversion receiver. Tune to a weak transmission at the lower band edge (3.4 MHz), and peak C4 for optimum reception. Then tune to a station at about 3.9 MHz and similarly adjust the core in L1. Repeat the adjustment of C4 and L1 to optimize sensitivity across the band.

Prototype of the receiver board.

Power supply: beware of adaptors

The receiver is preferably fed from a well-regulated 12 V supply, or a set of batteries that gives the same voltage. In many cases, however, it will be convenient to power the receiver from an available 12 VDC mains adaptor. When this is used, it is likely to cause hum in the receiver, a problem which can often be solved by fitting an additional smoothing capacitor of 470 or 1000 µF across the adaptor's output terminals. If hum persists, it is probably caused by capacitive coupling of the receiver and the mains. When the rectifier diodes in the adaptor are reverse-biased, they behave as capacitors. This is not normally a problem, but the oscillator signal, via the supply wires, can thus find a path to these diodes, which cause amplitude modulation of 50 (60) Hz (single-phase rectifier) or 100 (120) Hz (double-phase rectifier). This modulated signal is radiated by the mains wires, and is picked up again by the receiver. In this, the oscillator frequency equals the received frequency, so that hum is produced as the AF output signal.

The supply connections of the receiver should be decoupled by fitting chokes between the terminals of the 12 VDC input socket and the relevant soldering pins on the board. Both socket terminals are decoupled to ground with a 100 nF capacitor. The L-C networks prevent the oscillator signal being superimposed onto the supply lines. If hum still persists, try winding the supply wires through a ferrite ring core, or around a ferrite rod. A final tip is to solder a 100 nF capacitor across each rectifier in the mains adapter.
NEW LITERATURE

CIRCUITS, SIGNALS & DEVICES
by Michael Julian
ISBN 0 582 99467 5
515 pages - 238 x 164 mm
Price £14.95 (soft cover)
Circuits, Signals & Devices is a textbook intended for first- and second-year undergraduates and diploma students in electrical and electronic engineering. It will also be of value to students studying systems and electronics in other engineering and scientific disciplines.

The mathematical content is broadly consistent with the intended readership. The text is written for readers meeting a topic for the first time. To meet the needs of an evolving technology, the book examines not only the more traditional areas of circuits and devices, but also covers important aspects of signal analysis which are often omitted from introductory books.

Consistent with its title, the book is divided into three sections. The first, Circuits, starts with basic principles and progresses through circuit analysis and techniques to time and frequency responses.

The second section, Signals, commences with Fourier Series and proceeds through modulation techniques to noise in transmission systems.

Although the first two sections deal with the subject matter in a clear and direct manner, the third section, Devices, is, for me at least, the most fascinating part of the book. It gives a wealth of information on all kinds of semiconductor devices—from materials and bipolar transistors to microprocessor systems.

The book is well illustrated and indexed. Each chapter ends with a useful selection of exercises, answers to which are given at the end of the book.

A clear, useful textbook that will no doubt find its way to many a college or university library and also to students' own bookshelves. The very reasonable price is an additional bonus.

Longman Scientific & Technical
Longman House
Burnt Mill
HARLOW CM20 2JE

CIRCUITS, SIGNALS & DEVICES
by R.C.V. Macario
ISBN 1 85181 182 6
194 pages - 225 x 155 mm
Price £9.95 (soft cover)
This lavishly illustrated book, written by one of the UK's authorities in the field of mobile radio telephones, provides a clear guide to this topical subject. Dr Macario deals with the subject in a manner that will enable the reader to get to grips with the technical, social, and legislative aspects of mobile radio telephones in an enjoyable way.

The technology is described and placed in an historical context, enabling the reader to appreciate the sources of technical innovation and understand the steps that have led to the present revolution in communications. The geographical aspects of both transmission and reception are covered and the limitations of the available spectrum discussed. The various technologies available for radio telephone usage are explained and future possible developments described.

The regulation and licensing of the radio spectrum are covered and an appendix outlines the present allocation of frequencies.

The text is confined to UK allocations, activities, and developments in mobile radio, unless a common European policy becomes applicable (as, for instance, in cellular radio).

This book is in no way meant to be a textbook, manual, or system guide. Its primary intention is to be a text that can be read easily, say on a train, or late at night, to give added awareness to the remarkable engineering achievements of mobile radio. It should please many of the tens of thousands of radio mobile users who want to know a little more about their equipment and its background.

Glentop Press Ltd
Bath Place
BARNET EN5 5XE

VIDEO TECHNIQUES
by Gordon White, CGIA, CEng,
MIERE
ISBN 0-434-92290 0
496 pages - 220 x 145 mm
Price £30 (hardback)
This second edition of Video Techniques, which provides a comprehensive treatment of the many aspects of video for the engineer or technician working in television or associated industries, has been updated throughout and enlarged.

Amply illustrated (235 diagrams and 100 half-tones), Video Techniques does not describe circuitry or individual pieces of equipment, unless it is to illustrate a principle, as these change rapidly. Rather, it describes the principles of television and shows how the equipment is designed and functions in the complete system and, with present technology, its capability and limitations. These principles generally remain the same irrespective of the model, which usually involves only modifications to the performance or operation.

Contrary to so many other books on video, it does not ignore different transmission systems, such as SECAM, and NTSC. It is right up to date with descriptions of the MAC system, direct broadcast satellite (DBS), and high-definition television (HDTV).

Other contents include standards converters, CCD cameras and television, camera tubes, broadcast video recorders, ENG cameras and recorders, domestic recorders and cameras, video tape, video discs, interactive video, conference television, fibre optics, television receivers and displays including FST, broadcast monitors, teletext, large screen projection, world standards, digital techniques, and graphics and digital effects generators.

A book that nobody involved in whatever aspect of video engineering, production, or management can afford to be without.

Heinemann Professional Publishing
22 Bedford Square
LONDON WC1B 3JH

BRITISH STANDARDS
BS 5310:Part 3A
BS 6840:Part 12:1987
IEC 608-2-27:1987
BS 5428:Part 5:Section 5.3

BS 5310: Part 3A
This additional Part of BS5310, Specification for hand crimping tools for contacts of electrical connectors, gives details of requirements for such equipment, incorporating a system of multiple indentors for use with removable male and female contacts complying with BS 9521, electrical connectors complying with BS9210, and components that meet these standards.

BS 5070:Parts 1 & 2
This standard, Engineering diagram drawing practice, has been revised and published in a fresh format. It complements BS 308: Engineering drawing office practice, which last year celebrated its diamond jubilee amid considerable professional acclaim.

BS 5783
This revised standard, Code of practice for handling of electronic sensitive devices, has now been published. It describes practices which, if adopted, will reduce the risk of inadvertent damage to the components. It provides revised definitions and workshop layout drawings and includes revised recommendations.
BS 9530
This is a new standard giving a Specification for cable fitting accessories of latest developments, standards, software, products Available free from Hitachi New Media Products, Hitachi House Station Road, HAYES UB4 3DR. Telephone 01-848 8787.

BS 6513:Part 5: 1987
BS 6513:Part 6: 1987
These parts of the multipart standard for Wideband cabled distribution systems cover (Part 5) Recommendations for one-way and interactive data services, and (Part 6) Specification for safety requirements.

CECC 52000
This generic specification for the test and measurement procedures of Mercury wetted change-over reed contact units mechanically biased has been formally approved by the CENELEC Electronic Components Committee (CECC). CENELEC is the European Committee for Electrotechnical Standardization.

International certification and approval schemes
A third edition is now available of the popular publication International Certification and Approval Schemes from BSI Technical Help to Exporters. This edition presents revised data on nine major technical certification schemes which relate to a wide range of products in more than 90 countries. These schemes, which have been extensively revised (hence the need for a new edition) include the CB scheme for the safety of electrical equipment; the CENELEC Certification Agreement; the CEN Certification System; the CENELEC HAR Agreement; the CECC Harmonized System; the IECQ System; the ECE Harmonization and Conformity Scheme; EEC schemes under 'Article 100' Directives; and schemes coordinated by EFTA.

British Standards may be ordered from The Sales Department BSI Linford Wood MILTON KEYS MK14 6LE
Readers should also note that each country in the UK has at least one large Public Library where complete sets of British Standards are kept for general consultation.

Available free from Hitachi New Media Products is CD-ROM Directions, a quarterly journal which reports on the latest developments, standards, software, and available databases for Compact Disk-Read Only Memory optical disk drives. Apply to Nick Rogers, Hitachi New Media Products, Hitachi House Station Road, HAYES UB4 3DR. Telephone 01-848 8787.

Introducing Digital Audio
by Ian R. Sinclair
ISBN 1-870775-05-8
112 pages — 216 x 138 mm
Price £5.95 (soft cover)
This non-mathematical introduction to CD, DAT, and sampling is intended primarily for students, technicians, and enthusiasts. But, although the mathematical background and theory are omitted, the principles and methods of digital audio are explained in detail. These principles (and practices) over little or nothing to the traditional linear circuits of the past, and are much more comprehensible to today's computer engineer than the older generation of audio engineers.

Digital recording methods have existed for many years and have become familiar to the professional recording engineer, but the compact disc (CD) was the first device to bring digital audio methods into the home. The next step is the appearance of digital audio tape (DAT) equipment.

PC Publishing
22 Clifton Road
LONDON N3 2AR

Getting the most from your multimeter
by R.A. Penfold
ISBN 0-85934-184-4
102 pages — 178 x 110 mm
Price £2.95 (paperback)
The multimeter is probably the most useful test equipment for engineers, technicians, students, and enthusiasts alike. In spite of its assumed simplicity, a multimeter is of little use unless you understand how it can be put to effective use, and are aware of its limitations.

The book is aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, capacitors, and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current, and continuity checks being discussed.

Bernard Babani (publishing) Ltd
The Grampians
Shepherds Bush Road
LONDON W6 7NF

Shortwave frequency list
by C.J. Broth
ISBN 90-6082-289-7
96 pages — 175 x 120 mm
Price £6.95 (soft cover)
The easy tuning to, and locating of, transmitters on medium wave and FM is in sharp contrast to the bewildering mass of sounds of all descriptions on the shortwave bands.

This book is intended to help the shortwave listener in identifying the more important shortwave broadcast stations. It lists such stations in order of frequency: from 2,260 kHz to 21,810 kHz. In addition, the lists show the radiated power of most of the stations.

A 'must' for every serious shortwave listener.

PC Publishing
22 Clifton Road
LONDON N3 2AR

Newnes Audio and Hi-fi Engineer's Pocket Book
by Vivian Capel
ISBN 0-434-90210-1
208 pages — 190 x 90 mm
Price £9.95 (hardback)
Like its companion volumes (Electronics: reviewed in March 1987; Computer: April 1987; Radio and Electronics: October 1987; Television and Video: November 1987), this latest in the Engineer's Pocket Book series offers a concise collection of practical and relevant data. Topics covered include microphones, gramophones, compact discs, tape recording, high-quality radio, amplifiers, loudspeakers, and public address.

Acoustics is not often dealt with in audio books, nor is it too well understood by many audio engineers. Therefore, a lengthy section on this subject has been included, dealing with most aspects the audio engineer or technician is likely to encounter, from human hearing to sound insulation.

From this ancient art to the modern wizardry of digital recording and the compact disc is a enormous leap that illustrates the wide range of knowledge required of the audio engineer: one that encompasses mechanics, heat, magnetism, semiconductor technology, and electronics.

Newnes Audio and Hi-fi Engineer's Pocket Book is essential reading for sound-system engineers and technicians, hi-fi enthusiasts, dealers, and students.

Heinemann Professional Publishing
22 Bedford Square
LONDON WC1B 3HH
Global Type 2002

Global Specialties, a member of the American-owned Interplex Electronics Group, manufacture and retail a large variety of electronic test equipment, including oscilloscopes, power supplies, signal sources, and frequency counters. The Type 2002 Function Generator is one of a range of signal sources that extends from a portable 150 kHz generator, the Type 555, to a synthesized IEEE programmable generator, the Type 8230.

The design of the 2002 is fairly typical in both layout and size. An integral one-position stand enables the 2002 to be operated at an optimum angle when the instrument is not stacked. The stand is of man-made fibre but should be rugged enough for operation in most environments.

The 2002 uses an external a.c. adaptor which is connected to the generator by a 5-pin DIN plug. This somewhat unusual feature would not be an inconvenience if it offered the benefit of (optional) battery operation. The adaptor is set for 240 V a.c. (in the UK) and has no mains voltage selection facility (if operation from a different mains voltage is required, a different adaptor has to be used: this is available on request).

The multiplier ranges and various operating modes are selected by a number of very-closely spaced and somewhat cramped push-button switches. The tight spacing makes operation without pressing more than one switch difficult: the switches may be pressed from the side, but even this is not always successful until a certain measure of familiarization has been achieved.

The output frequency is set by the usual combination of a continuously-variable, logarithmically-calibrated control and seven push-buttons. The specified frequency range is 0.2 Hz to 2 MHz; in practice, 0.008 Hz to 2.022 MHz is obtained. Even at the lower frequency, reasonable symmetry and waveform shape are retained. Some frequency instability was apparent at frequencies below 0.2 Hz, but this amounted to nothing much and is in any case to be expected at such low frequencies.

Symmetry is variable over a range of about 1:10 and the invert facility gives added versatility to this. After the warm-up period (about 10 minutes), with a mark-to-space ratio of 1:3 and between the set frequencies of 60 kHz to 190 kHz, latch-up occurs, i.e., the output is a direct voltage at the most negative previous output level. Clearly, this is highly undesirable in any signal source and, although the effect does not occur when the output is inverted, could render the 2002 unusable as a pulse generator between these frequencies.

The general waveform may be selected from sine, triangle, and square, all of which may be varied in terms of symmetry across the range outlined before. In addition, a d.c. output (all mode switches off) is also available and should enable time to be saved in such applications as audio equipment servicing. Typical preset symmetry is accurately calibrated and within the quoted 1%.

Some distortion occurs on both the crest and the trough of a sine wave on all ranges, but this should not affect all but the most critical uses. Apart from this distortion over all ranges is well within the specified limits.

Level flatness is good with a maximum of variation over all seven ranges not exceeding -0.9 dB.

A -30 dB attenuator is provided to permit low-level signals with a minimum of noise and inconvenience to be obtained.

Minimum output in either output mode is effectively at ground level, although a small amount of noise is present. Distortion at the low output levels is very low for a generator of this class.

The rise time of TTL output is good, typically 9 ns (5 ns on the trailing edge). Rise times of the main output were a little higher at 65 ns and 50 ns respectively (these are still better than average). The VCF input allows a maximum output frequency of 3.2 MHz to be obtained at an input level of -5 V; an input of +10 V gives a sweep range of about 1500:1 on all but the lowest ranges. While this may be adequate for a large number of applications, it does not compare well with the range of 10000:1 (or higher) on some other generators in this class.

On the whole, the 2002 is solidly constructed and should be ideal for use in a wide range of operating environments. External construction is based on a man-made-fibre and aluminium enclosure, which should provide reasonable strength and ruggedness. Why the enclosure is fitted with ventilation vents is not clear.

Internal construction is based on a single PCB which fits snugly in the enclosure. Interconnecting wires between the board and the potentiometers on the front panel and the BNC sockets on the rear panel are kept to a minimum. The board is screened with component identifi-
Table 7
OPERATING RANGE
Frequency range: <0.2 Hz to 2 MHz in 7 calibrated ranges: fine adjustment by vernier, calibrated from 0.2 x to 2 x main setting.
Frequency accuracy: ±5% of full scale on 1 kHz to 1 MHz; better than ±8% on 10 Hz and 100 Hz ranges.
External sweep range: variable over >100:1 by 10 Vpp.
Input impedance: 10 kΩ
Maximum input: ±10 Vpp.

OPERATING MODES
Sine wave: distortion <1% from 10 Hz to 200 kHz.
Square wave: mark:space ratio 1:1 ±1% to 100 kHz.
DC range: ±5 V into 50Ω and ±12 V into 1MΩ.
DC off-set: variable ±5 V into 50Ω.

OUTPUTS
50Ω: <0.05 V to 20 Vpp from 50Ω ±1% source; <0.025 V to 10 V across 50 Ω load; switched attenuator reduces signal and d.c. off-set by 30 dB; output protected against short-circuits.
TTL: capable of driving up to 20 standard TTL loads.

GENERAL
Mains voltage: 110-120-220-240 VAC 50/60 Hz.
Power consumption: 12 VA.
Dimensions: 254 x 178 x 76 mm (W x D x H).
Weight: 1.0 kg.
Accessories supplied: mains adaptor; manual.
Warranty: 1 year.

The 2002 was supplied by Global Specialties, Unit 1, Shire Hill Industrial Estate, SAFFRON WALDEN CB11 3AQ, telephone (0799) 21682.

Conclusion
The main strengths of the 2002 are its low-level signal performance and its high grade construction. It also has several poor points, such as the difficulty in operating the range and mode selection switches, and the external power supply. Distortion and frequency range are satisfactory for an instrument in this price range. Moreover, the 2002 provides a good range of functions.

By the time this review is published, an updated version of the 2002 should have become available, which has an improved front panel layout and other features.

Other signal sources available in the Global range
Model 555 - fully portable; 20 Hz to 150 kHz; battery operated; £47.50.
Model 2001 - 1 Hz to 500 kHz frequency range; 20 Vpp output; £119.95.
Model 2005 - 50 mHz to 5 MHz sweep-function generator; 1000Ω linear or 10,000Ω log sweep; continuous, triggered and gated modes; distortion 0.5% on 1 kHz and 10 kHz ranges - 1% up to 100 kHz; variable sweep rate; £399.00.

Model 8120 - 1 mHz to 12 MHz AM/FM sweep/function generator; digital frequency read-out; attenuation to 80 dB; continuous, triggered, and gated modes; variable start/stop phase; distortion not greater than 0.5% from 12 Hz to 120 kHz; internal AM (1 kHz); amplifier input (dynamic range ±1 V peak a.c. + d.c.; £895.00.

Model 2005 - 1 mHz to 12 MHz AM/FM sweep/function generator at £1,895; 8230 - sweep/function generator with PLL counter at £2,295; 8230 - as 8230 but frequency synthesized from 20 Hz to 200 MHz at £2,495; 8230 - pulse/function generator and counter at £2,495.

Table 8

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Levell TG302

Levell have a long history of distributing high-quality test instruments for a large number of manufacturers. The Taiwanese-made TG302 is marketed under the Levell trademark and is only one of a large number of signal generators sold by the company. The TG302 retails at £136.00, excl. VAT.

The generator comes well-packed in a cardboard box, which also contains two probes and the manual. A good length of mains lead is supplied and this is terminated in an IEC plug. The mains voltage setting may be adjusted internally (110, 220, or 240 V a.c.). In contrast to some other instruments in this class, the TG302 is supplied with additional fuses to take account of the different currents that will be drawn at these mains voltages.

The integral 18-position stand conveniently swivels through 360°, enabling the generator to be operated either at an angle or stacked between other instruments.

The appearance of the TG302 is conventional with the function and range selectors mounted along the top of the front panel, with the continuously-variable controls and BNC connectors mounted beneath them.

The output frequency is selected on a logarithmic scale, which covers a ratio of about 50:1. Thus, the output frequency may be varied between 4 kHz and 200 kHz when the 100 kHz range is selected.

The multiplier range is selected by seven push-button switches and is calibrated from 0.02 Hz to 2 MHz. It may sometimes be necessary to increase the duty factor of the signal to bring the output down to 0.02 Hz. Considering the market at which the instrument is aimed, this very slight problem should not deter any users other than those who operate at these low frequencies.

All ranges overlap, so that a continuous range is provided throughout the frequency spectrum covered by the TG302. It should be noted that at the very far end of the scale (fully antiphase), the output frequency tends to become unstable.

As already mentioned, the duty factor is variable from a mark-space ratio 1:1 to one about 1:10 or 10:1, depending on the position of the invert switch. These two functions enable a wide range of waveforms to be generated, for instance, a 500 Hz sawtooth with a downward transition time of around 250 microseconds. Pulses can also be generated, although these are rather limited by the maximum mark-space ratio. Fortunately, the TTL output has typical rise and decay times of 10 nanoseconds.

The waveform may be selected from sine, triangle, or square, and these may be varied to pulse or sawtooth outputs by the variable duty-factor control.

Distortion is typically below 1% on the 0.2 Hz to 200 kHz ranges; outside these, it can rise to 4%. It was particularly noticeable at frequencies above 1.9 MHz, where a sine wave bears a distinct resemblance to a triangular one. Despite this, the waveform is still of reasonable purity and should prove acceptable for most purposes.

Symmetry is good over all ranges. The output level is flat up to about 1.2 MHz when a slight decrease in amplitude occurs which continues up to the maximum output frequency. At 2 MHz the decrease amounts to 0.8 dB and at the maximum output frequency to 0.95 dB.

When the −26 dB attenuator is not in use, some distortion occurs at output levels below 2 Vpp. When the attenuator is in circuit, the output level can be reduced to 40 mVpp before serious distortion sets in. Despite these few failings, the overall distortion of the instrument is well within specification and compares well with that of most other generators in this price range.

Frequency stability is good, although a noticeable change occurs when the output amplitude is varied. A VCF input facility is provided, which enables the frequency to be swept either up (positive input) or down (negative input) by up to three decades (1,000:1). The start frequency is set by the multiplying coefficient, and the offset by the input voltage: a potential difference of 10 V gives a 1,000:1 change in frequency.

Although only 18 pages long, the manual contains some very helpful service, initial set-up, and calibration information, in addition to a good circuit description and circuit diagram.

Internal construction is based on a single, silk-screened, glass-fibre PCB on which all the main components, such as the mains transformer, power supply, generator circuitry, are mounted. The construction is very neat with a minimum of connecting wires to the various potentiometers and output sockets. The board is easily removed, and this should make servicing straightforward.

There is a fair amount of heat generated around the mains transformer and regulator, and, although this should not present a serious problem, it should be taken into consideration if the instrument is to be used for long periods at a time.

The external casing is constructed from a two-part man-made-fibre enclosure and should allow the instrument to be used in most conditions. The swivel stand appears to be rather less robust.

Conclusion

At £136, excl. VAT, the TG302 should prove to be good value to most users who require a reasonably-well-built generator with good performance. The instrument has some useful facilities, such as the variable symmetry and the invert function. The manual is well prepared and should be particularly helpful for the servicing engineer.

On the negative side, distortion at higher frequencies and low output levels is rather higher than would normally be expected.

The TG302 was supplied by Levell Electronics Ltd, Moxon Street, BARNET EN5 5SD, telephone 01-440 8686.
Table 9

OPERATING RANGE

Frequency range: <0.02 Hz to 2 MHz in 7 calibrated ranges: fine adjustment by vernier, calibrated from 0.2 x to 2 x main setting.
Frequency accuracy: ±5% of full scale.
External sweep range: variable over 1000:1 ratio (>100:1 lowest range) by 10 Vpp.
Input impedance: 12 kΩ
Maximum slew rate: 0.2 V/μs.

OPERATING MODES

Sine wave: distortion <1% from 0.2 Hz to 200 kHz; harmonics <4% above 200 kHz; amplitude flatness <±0.1 dB up to 200 kHz, <±0.5 dB from 200 kHz to 2 MHz.
Square wave: mark:space ratio 1:1 ±1.5%.
DC range: ±5 V into 50Ω.
DC off-set: variable ±5 V into 50Ω.
Variable symmetry: ratio 1:15 or 15:1 by invert switch.

OUTPUTS

50Ω: <20 mVpp to 20 Vpp from 50Ω ±1% source; <10 mVpp to 10 V across 50Ω load; switched attenuator reduces signal and d.c. off-set by 20 dB; output protected against short-circuits.
TTL: capable of driving up to 20 standard TTL loads.

GENERAL

Main voltage: 110-120-220-240 VAC 50/60 Hz internally adjustable.
Power consumption: 10 VA.
Dimensions: 235 x 280 x 85 mm (WxDxH).
Weight: 2.0 kg.
Accessories supplied: mains lead (IEC terminated); manual; 2 test leads.
Warranty: 1 year.

Other signal generators available in the Level range

TG152 – Low-distortion sine-square wave generator; frequency range 3 Hz to 300 kHz in five ranges; maximum output amplitude 2.5 V r.m.s. (7 Vpp on sine wave); synchronization output; battery or adaptor operation; high-accuracy setting of output possible; TG152D (no output level meter): £110 excl. VAT;
TG152DM (output level meter fitted): £139 excl. VAT.

TG200 – Low distortion sine-square wave generator; frequency range 1 Hz to 1 MHz in 12 ranges; maximum output amplitude 7 V r.m.s. (20 Vpp on sine wave) can be reduced to 200 μV in seven switched steps; synchronization output; battery or adaptor operation; £149 to £185, excl. VAT, depending on options.

TG303 – as TG302 but includes 10 MHz counter and CMOS output; £236 excl. VAT.

Black Star Jupiter 2000

The Jupiter 2000 complements the already well-established Jupiter 500. Other Black Star products include a comprehensive range of frequency counters, digital multimeter, and a colour TV pattern generator.

The overall specification of the Jupiter 2000 is typical of a generator in this price range with a 2 MHz maximum output frequency, choice of 3 output waveforms, and variable symmetry. Not so typical are the 50-ohm and 600-ohm outputs and a switchable 0 dB, -20 dB, and -40 dB attenuator.

The front panel layout is clear and unambiguous with all the controls grouped neatly in sections for frequency, function, attenuation, and non-switched controls. The standard complement of seven overlapping frequency ranges is provided and these cover calibrated frequencies from 0.2 Hz to 2 MHz with a 10:1 vernier. Overall calibration accuracy of the vernier is reasonable and remains within the ±5% error limit over all frequency ranges.

Table 10

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<td>Ease of use</td>
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Manual
The instrument is fitted with a vernier allowing precise settings. The overall frequency accuracy is good, typically 15 nanoseconds and the decay wave). Quoted ±1% up to about 1 MHz (square wave). The effect of the d.c. offset control, which usually gives an offset of up to ±10 V (0 dB), is reduced proportionally in the -20 dB and -40 dB positions. There are three outputs available on the instrument: 50 ohms, 600 ohms, and TTL. The provision of two main outputs increases the ease of use, which is often reduced in instruments with only the usual 50-ohm output.

**Sweep**

Linear sweep ranges of over 1000:1 can be obtained on the 1 kHz, 10 kHz, 100 kHz, and 1 MHz ranges, while on the 100 Hz range the sweep range is restricted to typically 130:1, and on the 1 Hz and 10 Hz ranges to about 35:1. Non-linear sweeps can be carried out with ratios of up to 2,000:1, which increases the maximum output frequency to 4 MHz, although, obviously, level flatness and distortion are far from good at this frequency. Input sensitivity is slightly low at 17.1 Vpp or 19.1 Vpp for 10 kHz and 2,000 kHz sweeps respectively, but this is compensated to some extent by the instrument's above-average maximum input slew rate of 0.1 V/µs.

**Manual**

The 7-page manual contains brief and to-the-point operational information, and covers sweep operation in some detail. However, a circuit diagram or description, and calibration or service information are not included. A service manual is available separately.
Construction

The instrument is based on one double-sided PCB, which contains all the main components, although larger ones are mounted on the chassis. Interconnection between the board and chassis is in some instances by ribbon cable. Generally, the construction is of a high standard, and the quality of finish is first class throughout. Accessibility is good in all respects and this should make servicing fairly easy. External construction is based on a twopart man-made-fibre enclosure with aluminium end plates. The whole should prove sufficiently rugged for most applications.

Conclusion

At £149 (excl. VAT), the Jupiter 2000 is good value for money, offering a high standard of construction and a good standard of performance and facilities. Compared with other instruments in this price range, the Jupiter 2000’s choice of 50-ohm or 600-ohm outputs and three attenuation ranges make it worth special consideration.

The two main quirks of the generator are its linear frequency control (which, however, has its good and bad points), and the slight distortion on the peaks of the sine wave output. The latter should, however, not be of much consequence to most users who require a general-purpose function generator.

The instrument offers a wide range of facilities and these more than offset the slight failings just mentioned.

The Jupiter 2000 was supplied by Black Star Ltd, 4 Harding Way, St. Ives, HUNTINGDON PE17 4WR

Other signal sources available from Black Star

Jupiter 500 - 0.1 Hz to 500 kHz function generator; external AM and sweep facilities; distortion typically 0.5% to 100 kHz; 30 Vpp output amplitude; -20 dB attenuator; £110.00 excl. VAT.

Orion PAL colour bar/video pattern generator - price £199.00 excl. VAT.
REAL-TIME CLOCK PATCH FOR DCF77 ON THE COMMODORE C64

An experimental interrupt routine is discussed that enables the Commodore C64 home computer to display time and date information received from time standard service DCF77.

The publication in this magazine of a receiver, intelligent time standard, and locked frequency reference based on Federal Germany's time signal transmitter DCF77 (References 1. and 2.) has been a great success. Usable reception for synchronizing the microprocessor-driven clock in the intelligent time standard has been reported by numerous constructors in the UK, Ireland and Europe. Long-distance reception with synchronization taking place up to 10 times a day was reported from as far as Saudi-Arabia and central Sweden. Clearly, the Deutsche Bundespost has remained on the safe side when claiming that the transmitter's normal range is about 800 kilometres.

The DCF77 receiver and locked frequency standard was designed to operate in conjunction with the 8052AH-BASIC driven intelligent time standard. Since this is essentially a small microcomputer system that translates received time pulses in a time and date indication, it would appear logical to investigate how other computers can be programmed to accomplish this, keeping in mind that all the advanced features of the intelligent time standard will prove very difficult, if not impossible, to implement on a simple home computer such as the C64. From the onset it should be made clear that the program discussed here is experimental, and, therefore, aimed at C64 users thoroughly familiar with programming this home computer.

The real-time clock program is in fact an interrupt request routine. This means that it will work only in conjunction with programs that do not use interrupts. Most games for the C64 do, and can not, therefore, use the present clock program.

The RTC routine resides in RAM between CCOOH and CF00H. One peculiarity of the C64 is that interrupts are sometimes disabled, for instance, during disk operations. The result is that the clock is not updated temporarily, so that the time indication on screen does not correspond to the time transmitted by DCF77 (consult Ref. 2. for the structure of the time signals). Synchronization will be restored, however, within a minute after pulses. C64 programmers are no doubt familiar with the two CIA6526s which have a built-in real time clock (RTC). The RTC in CIA2 is used here to keep the clock running when the signal from DCF77 is temporarily lost.

Figure 2 shows that the time signals provided by the DCF77 receiver and locked frequency standard are fed to the C64 via User Port line PA2. This is programmed to function as an input line each time the processor enters the interrupt routine. Some programs use the PA2 line as a serial output, so that the CIA must be protected by a current limiting resistor as shown.

Operation

The RTC program uses only the minute, hour, day, month and year information transmitted by DCF77. The absence of a signal to mark the last second in each minute enables the program to recognize the start of the next minute. Next, the processor awaits the 21st second before updating the binary coded hour and date information on the basis of the received bit combinations. Logic bit levels are deduced from the pulse-width of the time signal, 100 ms corresponding to logic 0, and 200 ms to logic 1. The results of the bit-processing routines are not sent to the screen before the absence of the code for the 59th second is detected. At the same time, the RTC in CIA2 is synchronized. The sign @ appears on the screen in the location of hour and date to indicate that the RTC in CIA2 is not yet synchronized.

Error codes 1, 2, 3 or 4 may appear on the screen in inverse video. Their meaning is as follows:

1 = data pulse is too long;
2 = the difference between two successive minutes is other than 1;
3 = data is not coherent;
4 = synchronization lost (59th second missed or prematurely recognized).

The program has been simplified to keep it as short as possible. It has neither parity checking nor verification of received data at the beginning of the hour.

Interrupt handling

The drawing in Fig. 1 illustrates the basic operation of the time correction procedure on the C64. The main program is interrupted 60 times per second to analyse the structure of the received time pulses.
Listing of the real-time clock routine that enables the Commodore C64 to display time and date information received from DCF77.

References:
IEE Meetings

1 - 3 July History of electrical engineering
10 - 15 July Local telecommunications - Fourth vacation school at the University of Aston.
11 - 15 July Software engineering 88 - Exhibition and Conference at the University of Liverpool.
18 - 20 July Third International Conference on Image Processing and its Applications at the University of Warwick.
24 - 29 July Optical fibre communications - Fourth vacation school at the University College of Bangor.
31 July - 4 Aug Satellite communications - Fourth vacation school at the University of Surrey.
4 - 9 Sept Switching and signalling in telecommunication networks - Ninth vacation school at the University of Aston.
4 - 10 Sept Measurement technology (DC to VHF) - Vacation school at the University of Aston.
11 - 15 Sept Optical communication (EOC) - Fourteenth European conference and exhibition in Brighton.
11 - 16 Sept Telecommunication network design and performance - Vacation school at the University of Strathclyde.

Further details on the above events may be obtained from the Secretary, IEE, Savoy Place, LONDON WC2R 0BL, telephone 01-240 1871.

CONPAR 88 will be held on 10 - 16 Sept in Manchester. Further details from the British Computer Society, 13 Mansfield Street, LONDON W1M 0BP, telephone 01-637 0471.

The sixth international conference on Electromagnetic compatibility will be held at the University of York on 11 - 15 Sept. Further details from the Institution of Electronic and Radio Engineers, Savoy Hill House, Savoy Hill, LONDON WC2R 0JD, telephone 01-240 1871, Ext. 246.

An Artificial intelligence in real-time control workshop will be held at the University College of Swansea on 21 - 24 Sept. Further details from the Institute of Measurement and Control, 87 Gower Street, LONDON WC1E 6AA, telephone 01-387 4949.

The World Administrative Radio Conference on the use of the geostationary-satellite orbit and on the planning of space services utilizing it will be held in Geneva from 29 August to 5 October.

Leotronex, the Leeds Electronics Exhibition, will be held at the University of Leeds Electrical and Electronic Engineering Department: telephone (0532) 420339) on July 5 - 7.

A Mobile Radio Communications Exhibition will be held at Sandown Park, Esher, on 13 - 15 Sept. Further details from Framework, telephone 01-778 5656.

The Electronics Industry Exhibition will be held in Hong Kong on 15 - 18 Sept. Further details from ADG Exhibitions, telephone (0243) 29406.

The Electronics India Exhibition will be held in New Delhi on 6 - 11 Sept. Further information from GAMBICA, 8 Leicester Street, LONDON WC2H 7BN, telephone 01-437 0678.

The Canadian High Technology Week further details from Overseas Trade, telephone (01-437.0678.

ERA Technology is to organize a Conference on coil winding which will run in tandem with the Coil Winding International Exhibition being staged by Evans Steadman (Services) Ltd, 1 West Ruislip Station, RUISLIP WA4 7DW, telephone (08956) 34515.

This year's EPoS/EFTPoS (Electronics at the point-of-sale/electronics funds transfer at the point-of-sale) congress will be held at the newly refurbished Alexandra Palace, London, on 13 - 16 Sept. Further information from RDMP Ltd, 61 Ship Street, BRIGHTON BN1 1AE.
FREQUENCY READ-OUT
FOR SW RECEIVER

Although the circuit described here was designed as a frequency read-out for a short-wave receiver, it can also be used as a universal counter.

The circuit of the input and timing sections is shown in Fig. 3. The preamplifier ensures that the oscillator in the receiver is not loaded unduly and raises the oscillator signal to a level of about 1 V<sub>pp</sub> at the collector of T<sub>4</sub>. Preset P<sub>1</sub> serves to set the gain so that the counter operates in a stable manner, and also that T<sub>4</sub> does not go into saturation.

The amplified signal is fed to a Schmitt trigger, N<sub>4</sub>, via C<sub>3</sub>. Since the input of the trigger is at half the supply voltage level (R<sub>3</sub>-R<sub>4</sub>), the gate toggles readily at an input of 1 V<sub>pp</sub>. Whether the output of N<sub>4</sub> is passed to the counter via clock N<sub>3</sub> is determined by the Johnson counter IC<sub>3</sub>. The Johnson counter produces each 50 Hz pulse five symmetrical square waves that have a PRF of 5 Hz and are separated from one another by 20 ms spaces.

After the first clock pulse, Q<sub>1</sub> goes high, and as long as it remains so (for 100 ms), the signal to be measured is passed from N<sub>3</sub> to the latch, and thus to the display. To prepare the counter for the next measurement, N<sub>5</sub> transmits a pulse which is used to reset the counter, and this terminates the count cycle.
Fig. 1. Block schematic of the frequency read-out.

Fig. 2. Block schematic of the receiver parts relevant to the frequency read-out.

Fig. 3. Circuit diagram of the preamplifier and the timing section.
Fig. 4. Circuit diagram of the counter and display section, constructed from discrete components to reduce noise and other spurious emissions.
Discrete counting

The counter is constructed from discrete counter elements and display drivers (with built-in latch), as shown in Fig. 4. Each of the seven identical sections consists of four preset switches with pull-down resistors, a BCD counter, a BCD-to-seven-segment decoder/driver with latch, seven biasing resistors, and a seven-segment LED display.

Preset switches S1 to S7 set the BCD code to a value at which the counter starts counting. The pull-down resistors ensure that the preset inputs of the counter are provided with a 0 if the switch is open.

Counters IC5 to IC12 incl. are coupled asynchronously. This has the advantage that only the first counter (IC6) is supplied with a high clock frequency.

The result of the measurement is stored in latches IC13 to IC18 incl. These ICs ensure that the measuring result is made visible on the display, because they also have the BCD-to-seven-segment-decoder and a display driver on board. The position of the decimal point is determined by the location of R9. If this is in the position shown solid, the display reads in kHz; in the position shown in dashed lines, the read-out is in MHz.

Construction

The three printed circuits are housed on one board, as shown in Fig. 5. The three sections should be cut off as required. The circuits are single-sided, which gives rise to a fair number of wire links. These
are, of course, best put in place first. Construction is facilitated by Fig. 7, which shows the layout of the prototype. Several types of switch may be used for Si to S7. First, there are DIL switches, which are set according to the BCD code in Table 2. Note that the least significant bit is located at the left-hand side of the switch viewed from the display. Another, rather more luxurious, type is a BCD thumb-wheel switch. Rather expensive, but very useful if the switches are set often. If the switches are used only once, they may be replaced by wire links. Resistors R1 to R4 and DIL switches Si to S7 are then, of course, not required. Where a preset input must be 1, the wire link is fitted in place of the switch; if the preset input must be 0, the wire link takes the place of the relevant resistor. Take care that each preset input gets only one wire link — no more, no fewer.

The calibration of the read-out is carried out by turning Pi so that its wiper is at ground potential, and then turning it until a stable read-out appears on the display. Take care that T4 does not go into saturation with differing input signals at high frequency, because this will affect the bandwidth which may lead to erroneous measurements. Once Pi has been adjusted correctly, the frequency of the crystal oscillator must be set with the aid of C2. This is done most conveniently by tuning the receiver to a strong station whose frequency is known accurately: C2 is then rotated until that frequency is displayed.

### Accuracy

The accuracy of the read-out unit is determined mainly by crystal X1. Without special precautions, the frequency of the received signal is measured with an accuracy of within 200 to 300 Hz. The short-term accuracy may be improved by placing the crystal in polystyrene foam and tuning the oscillator (before any measurement) with the aid of a reference oscillator. This will guarantee good accuracy for up to an hour. If greater accuracy and stability are required, a crystal with a temperature coefficient of 20 to 30 ppm should be used. Bear in mind that the effect of temperature becomes greater at high frequencies.

**Table 2**

<table>
<thead>
<tr>
<th>BCD code</th>
<th>D</th>
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<td>7</td>
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<td>1</td>
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<td>0</td>
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<tr>
<td>1001</td>
<td>9</td>
<td>1</td>
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Fig. 6. Output signals of IC3, Ni, and Ns.

Fig. 7. Various views of the prototype frequency read-out.
Finally

The read-out lends itself readily to experimenting. It is, for instance, possible to use an external and very stable frequency source, such as the 'Intelligent Time Standard' (1) to enable measurements to be made with a resolution of 1 Hz. The (divided) external oscillator signal is connected across pins 6 and 8 (ground) of the socket for ICs (ICs and ICs associated components are, of course, nor required and may be omitted or removed). The frequency, \( f_o \), of the (divided) external signal is determined by \( f = \frac{5}{T_m} \), where \( T_m \) is the measuring time (\( = 1 \) s for a frequency of 1 Hz).

With these changes in the timing section, it may, of course, happen that it is no longer possible to place the decimal point at its correct position with \( R_9 \). In that case, the resistor will have to be mounted on the display PCB (track side) between the +5 V track and pin 5 of the relevant display module.

Speed is another aspect with which may be experimented. The maximum frequency the counter can handle is determined by the highest clock frequency to which ICs can react. The first thing to do is to try each of the seven modules in the ICs position; in the prototype one or two of the modules worked satisfactorily up to 25 MHz, although the data sheet indicated 17 MHz (Type 74190). The modules shown in Fig. 4 (Types 74HC190) can operate with clocks of up to 40 MHz. If even higher speeds are required, use a Type 74F190 in the ICs position, which is intended for operation with clock frequencies of around 90 MHz. The other ICs can remain HC types, because they need not work at these high frequencies. It is also possible to use HCT types: these are essential, by the way, if it is required to drive the counter from a TTL circuit.

It should be noted that the design of the counter circuit with discrete components is deliberate: a multiplexed integrated display unit is a source of noise and interference, which in a sensitive receiver is, of course, the last thing you want. None the less, it is still advisable to mount the read-out in a properly screened enclosure.

References:
(1) Elektor Electronics, November 1987, pp. 52-56.
(2) Elektor Electronics, February 1988, pp. 22-30.

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**RADIO & TV NEWS**

**DIRECT BROADCAST BY SATELLITE IN EUROPE**

**TOTAL HOUSEHOLDS 1989-1997**

The first DBS satellite, TV-SAT 1, was developed by the Eurosatellite consortium and launched in November, 1987. Eurosatellite is a French-German owned company. The next launch planned is France's TDF-1, followed by Luxembourg's medium-powered ASTRA satellite, Sweden's DBS satellite Tele-X and others, including a DBS satellite by the British Satellite Broadcasting (BSB) consortium.

For 1989, the first full year of European DBS and medium-powered satellite television, the Frost & Sullivan study forecasts a total audience of 700,000 households—rising to almost 19.5 million by 1997. The yearly growth rate, over 100% initially, will taper off to 28% on average between 1991 and 1997. Of course, audience growth will not be uniform across Europe. The already high level of cable penetration in Belgium and the Netherlands, for example, makes them barren territory for DBS. The U.K. is expected to be the largest DBS market in terms of both subscription revenue and home-receiver product revenue.

Frost & Sullivan sees subscription revenue from DBS and medium-powered satellite television in Western Europe soaring from $7.9 million in 1989 to over $702 million by 1997 (fixed 1987 U.S. dollars). The U.K., with annual subscription revenue of $190 million by 1997, will account for more than a quarter of the total. France ($147.6 million) and West Germany ($150 million) will each account for about a fifth. In addition, advertising revenue in Western Europe from satellite television is forecast to go from $7.3 million in 1989 to $608 million by 1997.

Looking at product revenue from the sale of receivers and outdoor units, the study predicts a rapid rise from $111 million in 1989 to a peak of $684 million by 1992, of which $424 million will come from receiver sales and $260 million from sales of outdoor units. The French product market, however, will be slower to take off and will peak later at $229 million in 1996. Product revenue will peak in 1992 at $362.4 million in the U.K. and at $116.9 million in West Germany. Annual product revenue overall in Western Europe will fluctuate from 1992 to 1997 above $400 million.

The study points out that DBS for all its advantages and disadvantages against competing systems, as well as low and medium-powered satellites. Cost factors certainly play a large part in this increasingly competitive market, but Frost & Sullivan predicts that DBS's success will depend ultimately on the range and quality of its programming.

This report compares in detail DBS and other systems, covering all aspects from political/regulatory constraints to the dramatic reductions in size and cost of dishes for receiving satellite television. Good reception can be achieved with dishes as small as 35 centimeters in diameter, costing around $320. Included in the study are analyses of equipment suppliers and industry structure.

Each of the DBS projects, as well as other satellite projects, is examined in depth as are the markets in various countries. The U.K. will likely be the most competitive satellite TV market. Luxembourg's ASTRA, due to go up in 1988, will have eight English channels. The U.K.'s own project (privately financed and operated), the BSB satellite, is scheduled for launch in 1989, providing three channels. Then, in 1990, Atlantic Satellites Ltd. plans to launch an Irish satellite, with five channels, competing for the U.K. market.
GaAs FET CONVERTER FOR 23 CM AMATEUR TELEVISION

The ultra-low noise figure of this SHF converter, in conjunction with its high conversion gain, enables it to outperform almost any combination of a 23 cm preamplifier and ATV converter based on bipolar transistors and a passive mixer respectively.

from an idea by G. Wehrhahn DD9DU

Transmission and reception of fast-scan television is among the most exciting and technically interesting modes available to the licensed radio amateur with an interest in UHF and SHF design and construction. The 70 cm band (430—440 MHz) has long been popular for amplitude-modulated ATV with vestigial sideband suppression, but its use for ATV (a wideband mode) is now under considerable pressure owing to the rising demand for frequency allocations for narrow-band and professional services (radar, mobile telephones, cellular radio). Forced to 'move up', ATVers started to explore the 23 cm band, in which the frequency range allocated to ATV (1250—1285 MHz) was found to offer plenty of space for AM as well as a new mode, wideband FM ATV. This mode, initially tried and used by French ATVers, allows transmitter output stages to operate in class C rather than A or AB, freeing the station operator from the output power restrictions imposed by the required ultra-linear operation of the entire transmitter, from video input to RF output. Hence, FM facilitates design of TV transmitters in general and semiconductor-based power output stages with acceptable efficiency in particular. The only disadvantage with respect to AM is the higher bandwidth (15—25 MHz instead of 7 MHz), but this is not generally a problem in the 23 cm band where narrow-band telephony is allocated 'up-band' between 1296 and 1298 MHz. A further interesting aspect of 23 cm ATV is that commercial equipment for this mode is hardly available.

Television relay stations
Over the past few years, the use of the 23 cm band for FM ATV has gained considerable popularity thanks to many groups of dyed-in-the-wool ATVers all over the UK and Europe building sophisticated relay stations (repeaters) installed in elevated locations. Repeater power output is usually between 5 and 10 watts, and the normally usable range between 15 and 50 km. There exist cross-band repeaters (70 cm AM input — 23 cm output, AM or FM) as well as in-band repeaters (1275 MHz FM input — 1252/1310 MHz AM output, or the other way round). During periods of favourable propagation (lift conditions), reception of 23 cm ATV repeaters — and, of course, privately owned and operated ATV stations — has been reported over distances up to 150 km.

ATV repeaters are so important because most of them have omnidirectional aerials, and can be remote-controlled to operate as a beacon transmitting a test chart. This facility enables a strong, steady 23 cm ATV signal to be used for setting up, comparing and testing aerials and converters locally.

In most countries, ATV signals may be received without a licence or permit. It may, however, be necessary to obtain a permit for installing the aerial. Because of the line-of-sight propagation of signals in the 23 cm band (1250—1300 MHz), the aerial should be mounted as high as possible without running into excessive cable losses. The construction and operation of a 23 cm transmitter or receiver represents a radical departure from established techniques on the shortwave bands, and for this reason the construction of the GaAs FET converter is recommended only to those who have experience working with microwave circuits.

Many of our readers are avowed radio amateurs, or have a general interest in the radio hobby. This fact obviates the need for an introduction into SHF techniques in general and fast-scan amateur
television on 23 cm in particular, which would be outside the scope of this article in any case. Readers unfamiliar with these subjects will find useful information and references at the end of this article. ATV stations can be found around 12.52 MHz (AM) and 1275 MHz (FM and repeaters).

A number of national and international contests are organized every year to boost the interest in ATV, and, of course, to enable participants to compete for the highest score measured as the total number of kilometres covered by the station. ATV activity is highest during these contests, and newcomers are recommended to listen on to the international ATV calling channels, 144.750 MHz (mode: FM) and 144.170 (mode: USB) in the 2 metres band.

Almost any operator of an ATV transmitter welcomes a reception report, and the fact that a contest is going on does not, in general, mean that there is no time and patience for sending a picture to a receive-only station ready to align a newly built converter. Contrary to the popular belief, there is nothing mysterious about GaAs FETs: in fact, their outlook, static and dynamic operation is very similar to that of well-known VHF or UHF dual-gate MOSFETs in the 3Nxxx and BF9xx series. The main advantage of the GaAs FET used here is that it can offer an in-circuit noise figure that remains below 2 dB for frequencies up to 1.5 GHz. Furthermore, gain is high but stable, and matching to tuned circuits is fairly simple thanks to the extremely low internal capacitance that results in a small reactive component.

The converter described here is the perfect introduction to 23 cm ATV because it is a relatively inexpensive and simple design. It has only one preamplifier stage, an active mixer, and a free-running, single-transistor local oscillator. Construction is also fairly straightforward thanks to the use of a small PC board with printed inductors (microstriplines).

All prototypes of the GaAs FET converter were found to give better results than a formerly used combination of a tuned two-stage stripline preamplifier for 23 cm using (very expensive) bipolar transistors Type NE64535 from NEC, and a 23 cm converter based on a crystal-controlled local oscillator chain and a Schottky diode mixer (designed by DJ5XA and described in edition 2/1975 of VHF Communications).

Interestingly, the cost of the GaAs FET converter is much lower than this (now technically outdated) combination of a preamplifier and a converter.

Only three transistors

The coming of gallium-arsenide semiconductors has enabled receiver noise figures to fall below values that are virtually impossible to achieve with bipolar transistors available to the radio amateur. The GaAs FETs used in the present converter are relatively inexpensive dual-gate types Type 3SK97. Types S2050 (Texas Instruments) and CF300 (Siemens) were also tried with excellent results. Contrary to the popular belief, there is nothing mysterious about GaAs FETs: in fact, their outlook, static and dynamic operation is very similar to that of well-known VHF or UHF dual-gate MOSFETs in the 3Nxxx and BF9xx series.

The circuit diagram of Fig. 1 shows that the aerial signal reaches gate 1 of pre-
amplifier $T_1$ via micro-stripline inductor $L_2$. Matching of the transistor to the cable impedance of 50 $\Omega$ is optimized by adjusting trimmer $C_7$. Preset $P_2$ allows adjusting the drain current of $T_1$ to obtain either high gain or a low noise figure. In most cases, a compromise between these will have to be found. The amplified 23 cm signal is passed to mixer $T_2$ via a three-element top-coupled micro-stripline filter, which is tuned by means of trimmers. It should be noted that $C_{10}$ and $C_{11}$ increase the total bandwidth of the filter to a value suitable for reception of 27 MHz wide FM ATV. For AM ATV, these capacitors may be omitted to achieve pure inductive coupling resulting in lower bandwidth. The local oscillator signal reaches gate 1 of $T_2$ via $R_{16}$ and a low-impedance tap on $L_5$. The intermediate output frequency of the converter can be chosen freely between 40 and about 200 MHz. In prototypes, the drain circuit of $T_2$ was tuned to 48 MHz by $C_{20}$-$L_{36}$-$C_{37}$ to enable the converter to be used for AM ATV reception with a portable colour TV set tuned to VHF Channel 2 (now no longer used for TV in the UK). Provided $C_{16}$-$L_{36}$-$C_{37}$ and $L_{10}$ are dimensioned accordingly, the intermediate frequency is simple to move up to, say, 180 MHz (Channel 6 in Band 3). Obviously, the higher the intermediate frequency, the better the image rejection of the mixer. A domestic television set is, of course, not suitable for receiving frequency-modulated ATV, which is gaining popularity because of the benefits already mentioned. For FM ATV, a special intermediate frequency amplifier will have to be made, followed by a wideband FM demodulator. The most commonly used IF for FM TV is 70 MHz, but here, the IF frequency can be chosen freely.

The single-transistor, varicap-tuned, local oscillator is a slightly modified version of that discussed in Ref. 1. Properly constructed, its stability is so good that an AFC circuit is not required. Presets $P_2$ and $P_3$ enable defining the tuning range of the converter. Capacitor $C_9$ is a coarse frequency adjustment, and also serves to stabilize the power output of the oscillator. This trimmer, which may not be needed in all cases, is simply 10 mm or so of straight wire positioned above the PCB surface (read the part on $C_9$ in Ref. 1). Although not apparent from the circuit diagram, the actual length of the anode lead of $D_1$ and the construction of $L_{9b}$ also determine the frequency of oscillation. The oscillator can be set to operate roughly between 1000 MHz and 1500 MHz. Finally, the dashed lines in the circuit diagram denote a screen around the local oscillator to prevent stray radiation.

**Construction**

Figure 2 shows the printed circuit board designed for the converter. In de description below, the upper drawing is called the component side of the board, and the lower drawing the reverse side (soldering side would be incorrect because a number of components are also soldered at the component side). Construction is fairly simple for those grown accustomed to the use of the leadless ceramic capacitors. The actual value of these is uncritical (anything between 470 pF and 1.5 nF will work; 1 nF is the most commonly available value). There are 7 of these capacitors in the converter — each is fitted vertically in a slot which is carefully jig-sawed or drilled and filed in the PCB. The length of the slots is such that the shoulders of the leadless capacitors rest on the PCB surface. The holes for the two GaAs FETs are drilled (to 3.5 mm), $T_3$ is not fitted in a hole.

The cross-sectional views of the PCB in Fig. 3 show the connections of the gate 2 and source terminals of $T_1$ to decoupling capacitors $C_6$ and $C_5$ respectively. Micro-stripline $L_s$ is connected to ground by a small piece of copper foil. All 1 nF capacitors (and $C_{10}$) not marked with a black triangle in the circuit diagram are miniature ceramic types with a lead spacing of 2.5 mm.

Input inductor $L_{10}$ is one turn of 0.5 mm dia. silver-plated wire. Choke $L_{10}$ is wound as 6 turns of 0.2 mm dia enamelled copper wire through a ferrite bead or small balun. Inductors $L_{9a}$ and $L_{9b}$ are formed by the wire terminals of $R_{15}$. $L_{9a}$ is 2 turns with an inside diameter of about 3 mm and a turns spacing of 1 mm. The other inductor, $L_{9b}$, is the straight-wire terminal soldered to ground, as shown on the component overlay. A 2 mm hole is made in the screen surrounding the local oscillator, so that $R_{16}$ can be soldered to a tap on $L_{9b}$, approximately 10 mm from where this is bent down and connected to ground. It is important that $R_{15}$ runs horizontally at about 4 mm above the PCB surface. Also make sure that it does not cause excessive strain on the emitter lead of $T_2$.

When required, coupling capacitors $C_{10}$ and $C_9$ are fitted direct onto the micro-

---

The most commonly used directional aerial for 23 cm is the so-called loop-yagi. This photograph shows a 24-element type scaled for 2304 MHz (13 cm).
Note: only T1, T2 and C1 are mounted at this side of the board.

Parts list

Resistors (0.25 W carbon film; ±5%):
R1; R5; R6; R11; R13 = 10K
R2 = 150K
R3; R4; R8; R10 = 100K
R7 = 1K
R8; R12 = 10K
R10 = 220K
R12 = 68R
R14 = 100K
P1 = 4K7 or 5K0 preset
P2; P3 = 10K preset
P4 = 10K linear potentiometer

Capacitors:
C1 = 1n0 chip or SMD (Bonex; Vero Speed; Cirkit)
C2; C6; C11; C13 = 3p subminiature trimmer
(manufacturer: Sky (C-I Electronics)
C3; C4; C8; C18; C20 = 1n0 ceramic
C5; C6; C7; C14; C15; C23; C30 = 1n0 leadless ceramic (Cirkit; Bonex)
C16; C12 = 1p0 (see text)
C17 = 10p
C18 = 68p
C19 = 10n ceramic
C20 = 0.47/16V tantalum
C21 = 0.1p
C22 = 0.1p/16 V feedthrough (solder type) (Cirkit; Bonex)
C29 = see text.

Inductors:
L1 = see text.
L5; L6; L7; L8 = micro-stripline on printed circuit board.
L8 = Neosid BV5045 (yellow-blue; 0.9 μH; 50 MHz) (C-I Electronics).
L9 = 10μH axial choke.
L10 = see text.
L11 = see text.
L12 = see text.

Semiconductors:
D1; D2 = 88405G (Bonex; C-I Electronics)
IC1 = 78L09
T1; T2 = 3SK97 (C-I Electronics)
T3 = BF9W2 (Cirkit)

Miscellaneous:
K1; K2 = BNC socket (BNC type).
PCB Type 880123 (not available ready-made through the Readers Service).
Tin-plate box with top and bottom lids. Size: 111 x 74 x 50 mm

Fig. 2. Double-sided printed circuit board for the converter.
Setting up

The simplest way of aligning the converter is to ask for the assistance of a radio amateur licenced to transmit ATV on 23 cm. Alternatively, in the UK, get in contact with the BATC (British Amateur Television Club) to find out if there is a repeater within 20 km or so of your home. For the following description, it is assumed that a 23 cm AM ATV signal is available, and that the converter is used in conjunction with a TV transmitter supplies about 10 W in an omnidirectional bat-wing aerial fitted on the balcony of the 50 m high local water-tower. PI6ATR was built by PA3AOG, PA2AAD, PE1CHY, N1.5184 and PA2ENG. The station was recently upgraded with a 70 cm AM ATV in-band FM/AM compatible 23 cm ATV repeater in Aalten, the Netherlands (QTH !orator JO31GW). The transmitter supplies about 10 W in an omnidirectional bat-wing aerial fitted on the balcony of the 50 m high local water-tower. PI6ATR was built by PA3AOG, PA2AAD, PE1CHY, N1.5184 and PA2ENG. The station was recently upgraded with a 70 cm AM ATV input.
Table 4 shows how the logic level at the control input of the DAC selects between two ways of dividing the twelve bits between two bytes (CTRL = 0: left justified data; CTRL = 1: right justified data). Digital-to-analogue conversion is started when new data is written to the least significant byte.

**Circuit description**

The circuit diagram of Fig. 7 is really quite straightforward because of its resemblance to the previously discussed block diagram (see Part 1). Bus buffer IC2 is an inverting type to save on ICs. Inverted address lines are applied to PAL (Programmable Array Logic) IC4, which is programmed to provide all chip select signals required on the card.

Ports A and C in PPIs ICs and IC8 are wired to the I/O connector. Port B is used for generating control signals for a number of chips on the card. Binary counter IC7 derives the clock signal for the PIT from the system clock. DIL switches S1...S5 connect one of four counter outputs, or the system clock, to the clock inputs of the timers (S1, S2, S3) and the I/O connector.

Lines RUN and STATUS control the conversion process in A-D converter ICs. The computer can check for completion of the conversion process by reading STATUS (0 = conversion complete and data available for reading; 1 = conversion not complete). When input RUN is held logic high, conversion cycles are automatically started every 2 ms. When STATUS goes low, the ADC runs an internal autozero procedure, which takes 1.75 ms. The computer can read the conversion result during this interval. Normally, then, the converter needs about 2 ms for completing the conversion and autozero phases. The actual conversion time, however, is shorter, depending on the measured value. The redundant part of the conversion phases can be skipped simply by making RUN low immediately after detecting the low level on STATUS. The zero level of the output voltage, \( U_{zero} \), is made clear by the equation

\[
U_{zero} = U_{ref} \left( \frac{R_s}{R_t + R_s} \right) [V]
\]

which shows that the ratio \( R_s/R_t \) affects the zero level of the output voltage.
When this ratio deviates from 1, offset becomes impossible to compensate by means of P2. Ratio $R_9/R_7$ determines the difference between the maximum and minimum output voltage. For optimum results, this ratio should work out as 2.

The D-A converter obtains its reference voltage from an external source, IC12, because the internal source of ADC IC9 is unsuitable in this application. The DAC has two adjustments: zero preset P2, and maximum output voltage preset P3. An R-C filter at the analogue output removes digital interference from the analogue signal. It should be noted that the R-C time of this filter may have to be slightly reduced when the DAC is operated at "top speed".

The supply on the I/O extension card is perhaps more elaborate than would be expected. The circuit adopted is required, however, to ensure an interference-free supply for the analogue chips on the card. Digital components are fed direct from the 5 V rail provided on the computer bus.
Parts list

Resistors (±5%):

- R1 = 47 kΩ
- R2 = 18 kΩ
- R3 = 1 MΩ
- R4 = 10 MΩ
- R5 = 220 kΩ
- R6 = 47 kΩ
- R7: 11 s; Re = 4 off matched 20 kΩ; 1% resistors.
- See text.

- R10...R21 incl. = 100 kΩ
- Pt = 5 kΩ or 47 kΩ multiturn preset
- P2 = 10 kΩ multiturn preset
- P3 = 100 kΩ multiturn preset

Capacitors:

- C1, C2, C10, C11, C12...C27 incl. = 100 nF
- C3 = 1 μF; MKT
- C4, C5 = 10 nF
- C6 = 330 nF
- C7 = 15 pF
- C8, C9 = 100 nF; 25 V; radial
- C13, C14 = 100 nF; 10 V; radial

Semiconductors:

- D1, D2 = 1N4148
- D3: D4 = zener diode 6 V; 400 mW
- IC1 = 74HCT245
- IC2 = 74HCT240
- IC3 = 74HCT244
- IC4 = PAL 15L8. Available ready-programmed through the Readers Services under order number ESSS61 (unprogrammed chips: ElectroMail order no. 635-527).
- IC6, IC8 = 8255-5 (Technomatic; Cricklewood)
- IC7 = 74HCT40
- IC9 = 8253-5 for 8254; see text (Technomatic; Watford Electronics; Cricklewood)
- IC10 = PM-7548 (Precision Monolithics; incorporated. U.K. distributors are listed on InfoCard 502: EE May 1987. Also available from C1 Electronics).
- IC11 = OP-215 (PMI) or AD712 (Analog Devices; U.K. distributors are listed on InfoCard 502. Also available from ElectroMail; stock no. 637-810).
- IC12 = REF-02CP (PMI; C1-Electronics)
- IC13 = 4051
- IC14 = 7805
- IC15 = 7905
- IC16 = 7908

Note: Intel's CMOS 8 MHz versions of the 8253 and 8255 may be used for PCs offering a turbo mode.

Miscellaneous:

- Si...Ss incl. = 8-way DIL switch block.
- K1 = 50-way male header with eject handles.
- K2 = 26-way angled header (male) with eject handles.
- K3 = phono socket.
- X1 = quartz crystal 4 MHz.

PCB Type 860038 (see Readers Services page). This PCB is double-sided, through-plated and provided with gold-plated bus contacts.

Fig. 9. Component mounting plan of the I/O extension card for PCs and compatibles. Note the screen around the analogue circuitry.
Fig. 10. Use this GWBASIC program to test the card for correct operation.

Construction

The I/O card is relatively simple to build, provided the soldering work is done with care and precision. It is recommended to use sockets with turned pins for all ICs. The double-sided, through-plated PCB supplied through the Readers Services (Fig. 9) is a type with gold-plated bus contacts as usual for extension IBM extension cards.

The analogue circuit section is screened as shown by the dashed lines on the component overlay. This requires boding voltage regulators ICn...ICn incl. towards Rn and Rn. Beware of shortcircuits between metal tabs of ICn, ICn and the screen and/or the resistor terminals. Components Rn and Cn should be fitted as close as possible to the socket Ki as shown in the photograph of Fig. 11.

Table 5. Programming data for the PAL, which combines the functions of a number of SSI logic gates.
Fig. 11. The filter components at the analogue output of the card are soldered direct to the centre pin of phono socket K3.

Mapping the card
The I/O extension can be addressed in block 30xx (jumper A) or 31xx (jumper B). Table 6 shows the address assignment in the I/O block.

The PPIs should be initialized by writing 100xx00x2 in the control register of ICs, and 100xx01x2 in that of IC6. Bits x are programmed to requirement. Port E is always used in the output mode, Port F in the input mode. The other ports can be set to input or output.

Adjustment and testing
In view of the 12-bit accuracy required, a good quality 3½-digit digital multimeter is essential for adjusting the ADC and DAC. The former is adjusted by applying 4 V to it and having the computer print the conversion result on screen with the aid of a programmed loop. Adjust P1 until the decimal value of the conversion results corresponds to the voltage read by the DMM.

The DAC is adjusted as follows: set the DMM to the appropriate voltage range, and connect it to the analogue output, K3. To begin with, the zero level must be set. Write 800H to the DAC, and adjust P2 for an output voltage of nought. Next, write FFFH, and adjust P3 for the desired maximum value.

The I/O extension card can be tested with the aid of the GWBASIC program listed in Fig. 10. Use 10 kΩ resistors for connecting Port A to Port D, and Port B to Port C. The bit-order is reversed in these connections, i.e., bit 0 of Port A goes to bit 7 of Port D, bit 1 to bit 6, etc. R

Table 6.
I/O card register overview:

<table>
<thead>
<tr>
<th>Address (hex)</th>
<th>Read</th>
<th>Write</th>
</tr>
</thead>
<tbody>
<tr>
<td>3x0</td>
<td>not allowed</td>
<td></td>
</tr>
<tr>
<td>3x1</td>
<td>MS byte of ADC</td>
<td></td>
</tr>
<tr>
<td>3x2</td>
<td>LS byte of ADC</td>
<td></td>
</tr>
<tr>
<td>3x3</td>
<td>not allowed</td>
<td></td>
</tr>
<tr>
<td>3x4</td>
<td>Port A</td>
<td></td>
</tr>
<tr>
<td>3x5</td>
<td>Port E</td>
<td></td>
</tr>
<tr>
<td>3x6</td>
<td>Port B</td>
<td></td>
</tr>
<tr>
<td>3x7</td>
<td>not allowed</td>
<td></td>
</tr>
<tr>
<td>3x8</td>
<td>Port C</td>
<td></td>
</tr>
<tr>
<td>3x9</td>
<td>Port F</td>
<td></td>
</tr>
<tr>
<td>3xA</td>
<td>Port D</td>
<td></td>
</tr>
<tr>
<td>3xB</td>
<td>not allowed</td>
<td></td>
</tr>
<tr>
<td>3xC</td>
<td>Timer 0</td>
<td></td>
</tr>
<tr>
<td>3xD</td>
<td>Timer 1</td>
<td></td>
</tr>
<tr>
<td>3xE</td>
<td>Timer 2</td>
<td></td>
</tr>
<tr>
<td>3xF</td>
<td>not allowed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(but o.k. for</td>
<td></td>
</tr>
<tr>
<td></td>
<td>82S54)</td>
<td></td>
</tr>
</tbody>
</table>

Note: x = 0 or 1 depending on address allocation (jumper on card).

Reference:

IBM PC is a registered trademark of International Business Machines Incorporated.
Intel is a registered trademark of Intel Corporation.

PEOPLE

Mr Tony Ventrella, Legal Adviser to BEAMA, has taken up the additional appointment of Company Secretary. He takes over from Mr Derek Shrivell, Company Secretary and Financial Controller, who is retiring after 18 years’ service with BEAMA.

The financial duties will be undertaken by Mr Richard Leishman, who has been BEAMA’s Chief Accountant for six years.

Mr Derek P. Hornby has been appointed Chairman of the National Accreditation Council for Certification Bodies (NACCB) in succession to Professor John Ashworth, who is retiring at the end of his three-year period of office. The appointment carries with it ex-officio membership of the BSI board.

Mr Heinz Suisse has been appointed European Technical Director for CORCOM, the well-known manufacturer of mains interference suppression filters. Based at CORCOM HQ in Munich, he will also be responsible for applications support in the UK via the CORCOM operation in East Kilbride.

Siliconix has appointed Brian Wadsworth as European Distributor Marketing Manager, responsible for the company’s network in the UK and Europe. Mr Wadsworth will be based at Siliconix’ European HQ at Newbury, Berkshire.

Cox Associates Ltd (CAL) has announced the appointment of Alan Luxton as Production Manager with responsibility for all the company’s manufacturing activities.
The results of our recent Readership Survey have confirmed the popularity of construction projects and informative articles on every aspect of modern telecommunications. In particular, RTTY is a well-liked subject, and for good reasons, because the combination of simple circuits and a computer offers many advantages over the mechanical telex machine.

In addition to a low-cost telex converter plus tuning aid and powerful decoding software, we present a precision, phasesynchronous, AFSK generator for radio amateurs in possession of a licence to transmit RTTY.

If you have never worked with telex for fear of complex circuits, this is the time to take the decisive step into the fascinating world of long-distance communication where messages originate from press bureaus, radio amateurs, navigational, meteorological and utility stations in the shortwave bands. In this article it is assumed that the reader is familiar with the concept of RTTY, but just for convenience a short recapitulation is offered on the structure of the serial data format.

Baudot code and FSK
RTTY information is composed of characters that are transmitted sequentially to the format shown in Fig. 1. One dataword is composed of 7 bits:

- 1 start bit, which is always low;
- 5 data bits, which represent the character;
- 1 stop bit, which has a duration 1.5T rather than T used for the start and data bits.

Five databits offer 32 (2^5) possible combinations. There are, however, 26 letters in the alphabet, 10 numbers, and a number of punctuation marks and symbols, so that 32 positions would appear too few. A solution to this problem is offered by the Baudot system, which reserves a special code for distinguishing between letters on the one hand and figures, punctuation marks or signs on the other. This means that a number of available databit combinations can represent either a letter or a number, depending on the group selection code, which is transmitted after pressing the Ltrs or Figs key on the teletype machine (cp the caps lock function on a typewriter).

The bit combinations in the Baudot system are listed in Table 1 for reference. It should be noted that there exist many other systems and standards for RTTY, with variations in transmission formats, pulse duration and bit combinations. The majority of telex stations, however, use the Baudot code.

The speed of the RTTY transmission is called the baud rate. This is defined as the number of bits transmitted per second. For instance, a 75 baud station can transmit nearly 11 characters per second. On the shortwave bands, the modulation used for RTTY transmission is usually frequency shift keying (FSK) — depending on the logic level of the bit (mark or space), frequency f1 or f2 is transmitted. The difference between these frequencies is called shift.

Figure 2 summarizes the above by showing the units required for over-air transmission of a telex message. This article will deal with the construction of the RTTY converter, AFSK generator and
PLL-based RTTY converter and tuning aid

The function of the RTTY converter is to translate the mark and space notes received into the appropriate logic levels. It is decided to set it up around a phase-locked loop to keep the circuit as simple as possible. Without compromising versatility, it was decided to set it up around an integrated circuit of the XR2211, the present application of the XR2211, the Type XR2211 from Exar.

The operation of the converter is best explained with reference to the internal circuit of the XR2211 shown in Fig. 4, and the circuit diagram in Fig. 5. Note that the small circles and numbers in Fig. 4 are the pins of the chip — the resistors and capacitors are external components. Basically, a phase-locked loop will attempt to make the frequency of the internal voltage-controlled oscillator (VCO) equal to that of the input signal. The two frequencies are compared by the quad and/or loop detector, and the error signal produced by one of these is used for controlling (i.e., tuning) the VCO until the difference between VCO frequency and input frequency is nought. The VCO control signal is, therefore, a measure of the frequency of the input signal provided by the shortwave receiver tuned to an RTTY transmission. In the present application of the XR2211, the on-board quad detector is not used. The circuit diagram of the converter is very similar to the block diagram of the XR2211. The input signal enters the IC via R-C network R-C-C, and is fed to an amplifier driving the loop detector, whose output signal is used for controlling the VCO via potential divider R-Rs, and driving comparator 1 via Re-Ca. The comparator uses the input voltage to decide whether the received frequency is f1 or f2 (mark or space). Its output signal needs filtering, however, because the PLL is so fast that it also responds to interference in the input signal. Comparator 2, in combination with low-pass R-C, ensures a filtered, rectangular output signal. The amplitude of the output signal of comparator 1 (fed to pin 3 via R-Ca) is much greater than that supplied by the quad detector, which is thus rendered ineffective. Comparator 2 has complementary outputs Q and Q, which are useful for selecting between stations transmitting standard and inverted RTTY signals (logic high = f1; logic low = f2). This selection is accomplished by toggle switch S1.

It will be clear that the mark and space tones can only be decoded correctly when the receiver is accurately tuned to the telex transmitter. Figure 6 shows the circuit diagram of a bar-graph tuning indicator which will prove indispensable for RTTY reception. Based on a VU meter IC, it indicates centre tuning as well as shift employed by the transmitter. The display indicates frequency of the mark and space tones by means of LEDs to the right and left of the centre, respectively. The centre two LEDs are illuminated when the input signal from the converter has a frequency of 1500 Hz. When the receiver is correctly tuned, LEDs at equal distance from the centre will be seen to flash rapidly. The distance between the illuminated LEDs is a measure of the shift employed by the RTTY transmitter.
Power supply and computer interface

It will be noted that the supply voltage for the RTTY converter is 5 V, whereas that for the display unit is 12 V. The latter is optional, so that the converter may be fed from the computer's built-in 5 V power supply. When the display is used in conjunction with the converter and a computer, it is essential that the converter is fed from 12 V rather than 5 V. This can be done with impunity using the power supply of Fig. 7 and the simple computer interface of Fig. 8 (the latter reduces the converter's output voltage swing of 12 Vpp to 5 Vpp). The serial bitstream from the converter is applied to the computer's joystick port as shown in Fig. 9. To prevent interference from the computer, it can be suppressed by winding the serial data and supply cables onto a ferrite ring core.
Fig. 11. Printed circuit board for the single-chip RTTY decoder.

**Parts list**

**RTTY DECODER. CIRCUIT DIAGRAM: FIG. 5.**

Resistors (±5\%):
- R1, R2, R6 = 10K
- R3 = 1K0
- R4, R5 = 2K2
- R7, R8 = 22K

Capacitors:
- C1 = 4n7
- C2 = 10n
- C3, C4 = 180n
- C5 = 100n
- C6 = 8n2
- C7 = 33n

Semiconductor:
- ICl = XR2211 (Manufacturer: Exar. Listed by Maplin, Cricklewood Electronics, Universal Semiconductor Devices)

Miscellaneous:
- S1 = miniature SPDT switch.
- PCB Type 87686X (not available through the Readers Services).

Fig. 12. Printed circuit board for the RTTY tuning aid and power supply.

**Setting up**

Apply the output signal of a sine wave generator to the converter. Adjust the generator between 1 and 2 kHz, and use a scope or a voltmeter to find the frequency at which the output of the converter toggles. Leave the generator set to this frequency, and adjust P2 and P3 in the display circuit until the two centre LEDs light. Then correct the settings until 1 kHz corresponds to the leftmost LED, and 2 kHz to the right-most LED. The preset adjustments will be found to interact, and care should be taken not to shift the centre frequency indication away from D1 to D2. If necessary, repeat the adjustments.

When a sine wave generator is not available, connect the converter to the receiver, and tune to a station that transmits an unmodulated carrier.

digital interference from the computer entering the converter circuit, it is recommended to wind the cable between the converter and the computer onto a medium-size ferrite ring core as shown in Fig. 10.

**Parts list**

**TUNING AID AND POWER SUPPLY. CIRCUIT DIAGRAMS: FIGS. 6 & 7.**

Resistors (±5\%):
- R2 = 18K
- R9 = 1K5
- R10 = 1K2
- R11 = 3K3
- P2, P3 = 2K5 or 2K2 preset

Capacitors:
- C27 = 1p0; 16 V
- C28, C29 = 47n
- C30 = 100n; 25 V
- C31 = 10p; 16 V

Semiconductors:
- D1 ... D16 incl. = rectangular LED
- D17 ... D22 incl. = 1N4001
- IC1 = 7812
- IC2 = UAA170 (listed by Maplin, Cricklewood)

Miscellaneous:
- F1 = 250 mA fuse, delayed action, with chassis-mount holder.
- T1 = mains transformer, 15 V; 280 mA.
- PCB 86019 (not available through the Readers Services).
Switch to SSB, and tune the receiver until the output of the converter toggles. The note produced by the receiver then has a frequency of about 1500 Hz, and P2 - P3 may be adjusted slowly so that the centre LEDs light. Table 2 lists a number of meteorological services that use a shift of 1 kHz, enabling the maximum shift indication of the display to be set as discussed above.

Table 2

<table>
<thead>
<tr>
<th>speed</th>
<th>frequency (kHz)</th>
<th>service</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>3038</td>
<td>Meteo</td>
</tr>
<tr>
<td>50</td>
<td>13530</td>
<td>Meteo</td>
</tr>
<tr>
<td>75</td>
<td>2474</td>
<td>Marine</td>
</tr>
<tr>
<td>75</td>
<td>4260</td>
<td>Marine</td>
</tr>
<tr>
<td>100</td>
<td>7980</td>
<td>Meteo</td>
</tr>
</tbody>
</table>

Although the menu is mostly self-explanatory, a short discussion will be given of the various options available.

- **ASCII**: when this mode is selected, the computer switches to decoding 8 databits and 2 stop bits. Since this is a non-standard format, the mode is called ASCII rather than ASCll. It can be tried by tuning to the news bulletin of radio amateur station W1AW on 14.095 MHz in the 20 m band. This North American station transmits at 110 baud, and is one of very few not to use the Baudot code.

- **Baudot**: it was already noted that the Baudot code has two special characters for switching between figures/punctuation marks/signs (Figs). When shift normal is selected from the menu, switching between these character sets takes place when the relevant code is received. When, owing to interference, the computer does not receive one of these codes, it will produce illegible text. To prevent this, select Unshift On Space (UOS), to automatically switch to letters following the reception of a space character. This is particularly useful for stations that transmit mainly text, e.g. press bureaus. The reverse is also possible: Shift On Space (SOS) causes the 'figures' set to be selected following a space, aiding in the reception of, for instance, meteorological data, which is mainly clusters of figures and signs.

- **Invert data**: this is the software equivalent of operating the polarity switch, S1, on the RTTY converter.

- **Baud rate selection**: available speeds are arranged in order of frequency of use.

- **Read Text buffer**: text read by the computer is stored in memory. When the computer is in the RX (receive) mode, the memory contents can be examined and, if required, sent to a printer. The text buffer mode is selected by pressing M on the keyboard. Decoding of incoming data is inhibited in this mode, which can be left by pressing R.

User-selected parameters are loaded by pressing the space bar to enter the receive (RX) mode. When the settings are correct, and the converter is properly aligned, text will appear on the screen. If there appears no text, or only garbled data, the parameters must be changed by returning to the menu — press RETURN.

An interesting feature of the MSX RTTY software is its ability to decode Russian stations using an extended version of the Baudot code. A number of additional shift characters are used in this to enable using the Cyrillic alphabet, which has more than 26 letters. The software translates these in characters that are relatively little used on computers. For instance, the ampersand sign, &, represents the sound /s/ (Sa&a), while the exclamation mark, !, stands for /e/ (lektrik). There are more replacement signs, but a discussion of all of these is beyond the scope of this article. Actually receiving Russian stations is the best way of getting accustomed to the special signs, since their sound and meaning can be learned fairly rapidly by deduction from the context. Recommended frequencies are around 8,350 kHz (evenings and night) and 12,500 kHz (daytime). Other useful frequency allocations are given in Table 3.

### Table 3

<table>
<thead>
<tr>
<th>speed</th>
<th>frequency (kHz)</th>
<th>country</th>
<th>time (approx., GMT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>16046</td>
<td>USSR</td>
<td>9.00 — 13.00 h.</td>
</tr>
<tr>
<td>50</td>
<td>15633</td>
<td>N. Korea</td>
<td>12.00 — 13.00 h.</td>
</tr>
<tr>
<td>50</td>
<td>13780</td>
<td>N. Korea</td>
<td>12.00 — 13.00 h.</td>
</tr>
<tr>
<td>50</td>
<td>13524</td>
<td>Iran</td>
<td>13.00 — 17.00 h.</td>
</tr>
<tr>
<td>75</td>
<td>13770</td>
<td>USA</td>
<td>13.00 — 17.00 h.</td>
</tr>
<tr>
<td>75</td>
<td>7960</td>
<td>Iran</td>
<td>19.00 — 24.00 h.</td>
</tr>
<tr>
<td>75</td>
<td>5460</td>
<td>USA</td>
<td>0.30 — 3.30 h.</td>
</tr>
<tr>
<td>75</td>
<td>6941</td>
<td>USA</td>
<td>0.30 — 3.30 h.</td>
</tr>
</tbody>
</table>

![Fig. 13. Menu screen shown by the RTTY decoding program for MSX computers.](image-url)
Finally, it will be understood that usable results are only obtained by using a good-quality SSB receiver connected to an outdoor aerial. Everything possible must be done to eliminate sources of interference, since these give rise to decoding errors even when the telex station received has sufficient field strength locally.

The RTTY decoding program for MSX computers can be obtained through the Readers Services under number XSS100 by sending a formatted 3½-inch diskette containing MSXDOOS.COM and COMMAND.COM to our Brentford office. The cost of programming this diskette is stated on the Readers Services page in this issue. A stamped, self-addressed envelope must be included for return postage (overseas readers: please include 5 IRCs). Listings or tape versions of the program are not available.

AFSK generator for VHF RTTY

Contrary to a good many other designs, the audio frequency shift keying (AFSK) generator described here is not only quartz-controlled, but also phase-synchronous, ensuring very high signal quality and accurate definition of the tone frequencies. Most AFSK generators used by radio amateurs incorporate R-C or L-C oscillators, which often suffer from poor stability and accuracy. Many PLL-based and computer-driven AFSK generators are also remarkable for their low signal quality and deviation from the prescribed mark and space frequencies, making it impossible to achieve proper decoding when the receiving station uses filters that are known to be accurately dimensioned to the relevant RTTY standard. As a result, a poor signal-to-noise ratio is obtained, and there are station operators who attempt to cure this by switching over to AMTOR or other error-correcting systems, while the trouble originates clearly from their poorly designed AFSK generator.

The circuit described here is simple to build from a handful of fairly common parts, and can produce virtually any frequency used for AFSK at a resolution of a few hertz.

AFSK generator: principle of operation

The block diagram of Fig. 14 shows that a quartz-controlled 10 MHz oscillator clocks two counters/dividers, whose divide ratio can be preset to any value between 1 and 256. The counters are, of course, configured to give signals of different output frequency, which are applied to an electronic toggle switch composed of NAND gates. The position of this switch is controlled by the logic level of the signal applied to the TTL input. The frequency of the signal at the output of the electronic switch changes with every change in the logic level of the TTL input. In this arrangement, phase disturbance will occur because of the abrupt switching between the output frequencies. The result is an annoying click, which is particularly troublesome when SSB is used, because it easily causes sideband splatter. These switching problems are also frequently encountered in PLL-based AFSK generators, where the oscillator is constantly on the verge of losing lock owing to the fast changing AFSK frequency.

The present generator offers an elegant way round the above difficulties. The output signal of the electronic toggle switch is not fed direct to the circuit output, but is first applied to a :64 divider. When, owing to the switching at its input, the :64 divider receives one pulse too many or too few, the toggling of the output will be delayed or speeded up by only 1/64th of the period of the signal applied. This results in negligible pulse-width distortion whilst ensuring that the output signals of the divider are phase-synchronous. After filtering in a low-pass, an RTTY signal is obtained that is much cleaner than one produced by a PLL-based generator.

AFSK generator: circuit description

The practical circuit diagram is shown in Fig. 15. The 10 MHz clock oscillator is set up around T1, which drives counters IC1 and IC2. The divisor of each of these can be set by means of Sa, ...Sn and S1, ...Sm respectively. The user is left free to use either (DIP) switches or wire links in these positions. The previously mentioned NAND gates that form the electronic toggle switch are found in IC3, while IC4 is the :64 divider. The circuit around T2 and T3 forms an interface between the TTL input and IC3. TTL signals are limited by D1 and inverted by T3. T5 once more inverts the signal. Switch S5 allows selecting normal or reverse signal polarity. Harmonics and interference at the output of divider IC2 are eliminated in low-pass filter L1-L2-C1-C2-C3-C4. The amplitude of the AFSK signal can be set with Pt.

Construction and use

The AFSK generator is relatively easy to construct on Veroboard. In practice, it will be found that a number of configuration switches may be omitted because a fixed set of AFSK frequencies often suffices.

Standard AFSK frequencies and associated shifts are listed in Fig. 16. It is seen that the step size is 85 Hz. Formerly very popular frequencies were 2125 Hz and 2975 Hz. These multiples of 425 Hz, and those of 170 Hz, were long used by American telegraph companies. Dividing these frequencies reveals that they are all multiples of 17 Hz, which is important to remember for accurately setting the AFSK generator. The need for the new AFSK frequencies in Fig. 16 arose from the fact that amateur radio receivers incorporated AF filters too narrow to pass 2975 Hz, so that many RTTY hams were forced to use lower frequencies.

It should be noted that some stations use shifts other than those shown, e.g. 85 Hz or even shifts which are not a multiple of 17 Hz (70 and 240 Hz). When the AFSK generator is used with an SSB transmitter, the absolute frequencies are not important, only the shift. For FM
transmitters (VHF), however, it is desired to approach standardized AFSK frequencies as closely as possible. This can be achieved by setting IC1 and IC2 to the highest possible divisor, so that the output frequencies can be altered in small steps, and having IC4 divide by 32 instead of 64 at the cost of a small increase in pulsewidth deviation.

The following example shows how to set the DIP switches in the AFSK generator to obtain mark/space frequencies of 1200 and 2400 Hz. Arithmetically, it makes no difference which of the divisors is defined first. To begin with, there is the fixed divisor at the output (IC4): 10 MHz divided by 64 equals 156,250 Hz. This, in turn, must be divided down, with divisors between 1 and 256 available (IC1; IC2). For instance, in

Fig. 15. Circuit diagram of the audio frequency shift generator for RTTY transmitters.

Parts list

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistors (±5%):</td>
<td></td>
</tr>
<tr>
<td>R1 = 1kΩ</td>
<td></td>
</tr>
<tr>
<td>R2 = 33Ω</td>
<td></td>
</tr>
<tr>
<td>R3; R6; R7; R22 incl. = 2kΩ</td>
<td></td>
</tr>
<tr>
<td>R4; R5; R23 = 1kΩ</td>
<td></td>
</tr>
<tr>
<td>R1 = 2kΩ or 2kΩ preset</td>
<td></td>
</tr>
<tr>
<td>Capacitors:</td>
<td></td>
</tr>
<tr>
<td>C1 = 80p trimmer</td>
<td></td>
</tr>
<tr>
<td>C2; C11; C12; C13 = 330p poly (styroflex)</td>
<td></td>
</tr>
<tr>
<td>C14; C15 = 180n</td>
<td></td>
</tr>
<tr>
<td>C16 = 150n</td>
<td></td>
</tr>
<tr>
<td>C17 = 270n</td>
<td></td>
</tr>
<tr>
<td>C18 = 150n</td>
<td></td>
</tr>
<tr>
<td>C19; C20; C21; C22; C23 = 10n</td>
<td></td>
</tr>
<tr>
<td>Inductors:</td>
<td></td>
</tr>
<tr>
<td>L1; L2 = 47mH (e.g. Toko 181LY-473; Cokin)</td>
<td></td>
</tr>
<tr>
<td>Semiconductors:</td>
<td></td>
</tr>
<tr>
<td>D1 = WA14B</td>
<td></td>
</tr>
<tr>
<td>IC1; IC2 = 74HC40103</td>
<td></td>
</tr>
<tr>
<td>IC3 = 4011</td>
<td></td>
</tr>
<tr>
<td>IC4 = 4024</td>
<td></td>
</tr>
<tr>
<td>Diode = 1N4148</td>
<td></td>
</tr>
<tr>
<td>T1 = BF494</td>
<td></td>
</tr>
<tr>
<td>T2; T3 = BC547B</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous:</td>
<td></td>
</tr>
<tr>
<td>X1 = 10 MHz quartz crystal (series resonance)</td>
<td></td>
</tr>
<tr>
<td>S1; S2 = 8-way DIL switch block.</td>
<td></td>
</tr>
<tr>
<td>S3 = miniature SPST switch.</td>
<td></td>
</tr>
<tr>
<td>Veroboard as required.</td>
<td></td>
</tr>
</tbody>
</table>
the case of IC1, the result should be as close as possible to 2400 Hz. Dividing 156,250 by 2400 gives 65.1042, which is rounded off to 65. Due to the internal structure of the 74HCT40103, the set divisor becomes 64 instead of 65. This means that binary code 0100 0000 is applied to inputs J6... J1 incl. (J0=LSB, J7=MSB). In other words, only J6 is held logic high.

The decimal values with J6, J5, J4, J3, J2, J1 and J0 are 1, 2, 4, 8, 16, 32, 64 and 128 respectively. Any divisor between 1 and 256 can, therefore, be set by closing one or more switches.

**THE BLACK JAGUAR**

**BJ200 MK2 POCKET SCANNER**

An AM/FM 16-channel synthesizer-controlled pocket scanning receiver, the Black Jaguar BJ200 Mk2, is now available from Nevada. The pocket scanner is supplied complete with an instruction manual, a wall-type battery charger, a built-in NiCd battery pack, carrying case, helical rubber aerial, earphone and TNC-to-BNC adaptor to connect an external aerial. The main technical specifications of the scanning receiver are shown in the Table.

One of the remarkable features of the BJ200 is its ability to receive stations on frequencies outside the stated scan ranges. It is, for instance, possible to select, say, 24.5 MHz by entering this frequency on the keyboard. The receiver does not accept it, however, as an upper or lower limit of the scan range.

The outstanding points of the review sample supplied by Nevada are:

1. Given the wideband design of the input stage, sensitivity is excellent on all
available bands. For instance, in the 2 m amateur band (144 - 146 MHz), sensitivity of the review sample was only marginally lower than that of a Type FT227RA synthesizer-driven FM transceiver from Yaesu.

2. Programmed frequencies, channel lock-out, delay and the associated demodulation (AM/FM) are retained in memory even when the battery is completely exhausted. All the programmed settings are available immediately again when the receiver is switched on after charging the batteries.

3. The LC display is well laid-out and clearly legible under virtually all lighting conditions. In the scan mode, only the channel numbers, Lock Out, Delay and AM/FM symbols are displayed to save power. When a station is received, the relevant frequency is shown.

4. Operation is simple and readily learned. The rubber keys have tactile feedback when pressed.

5. The receiver is housed in a rugged ABS enclosure; the keys are recessed and the display is protected by a transparent plastic window. A minor short-coming is the absence of protective hoods on the two AF output sockets.

6. The built-in battery pack will last for 6 to 8 hours of operation, and can be charged within 12 hours.

7. Frequency ranges provided are useful and definitely the most popular. AM demodulation is available on all bands, and should be of particular interest for VHF airband reception (108 - 125 MHz). The squelch also works in the AM mode.

The sample BJ200 also exhibited some (mainly minor) deficiencies:

1. The most serious shortcoming of the receiver is its inadequate suppression of harmonics and spurious emissions generated by the built-in synthesizer. When the search mode is used to scan a user-defined frequency range for activity, the receiver will be blocked by its own spurious products which occur at all multiples of 9 MHz. This means that the scanner halts at 27.000 (HF band), 63.000 MHz, 72.000 MHz (VHF low), and so on, right up into the UHF band. The harmonics are so strong as to make reception on and around these frequencies impossible.

2. Spurious products generated by the multiplexed liquid crystal display are particularly troublesome in the HF band (26 - 30 MHz). Digital noise is picked up on and around 27.0750, 27.215, 27.355, 27.500, 27.640, 27.780 and 27.920 MHz, and a good many other frequencies towards the end of the search range, 29.990 MHz. This interference clearly originates from the LCD because the whirring note produced changes when the Lock Out or Delay function is activated, and the corresponding LCD symbol lights. Like the previously mentioned synthesizer harmonics, LCD interference halts the scanner indefinitely in the search mode, so that the user is forced to skip the relevant frequency by pressing the UP key.

Fortunately, LCD interference is less severe in the VHF and UHF bands. None the less, it can be heard on some channels as a soft background noise on demodulated speech.

3. When a certain frequency range is scanned for activity (search mode), the receiver halts when the signal strength exceeds the threshold set with the squelch control. In the case of a strong local NBFM signal, scanning is halted before the receiver has reached the actual carrier frequency. This means that it produces unintelligible splatter typically heard when an FM receiver is not properly tuned to a transmission. In this reviewer's opinion, this shortcoming would have been relatively simple to eradicate by controlling the search stop function from the centre tuning output of the FM detector in conjunction with the fieldstrength threshold, thereby ensuring that scanning does not stop until the carrier frequency is reached.

4. Although the receiver was actually observed to switch off its display and audio amplifier on several occasions when the battery was exhausted, the flashing LO BATT symbol did not appear on the LCD as stated in the instruction manual. This is not a serious problem, however, and may have been a fault in our review model.

5. Considering the use nowadays of many different pre-emphasis standards in NBFM telephony services, a continuously variable tone control would have done better than the two-position selector provided on the BJ200. In some cases, the sound produced lacks brightness, and this is only aggravated by pressing the tone switch, which activates a low-pass AF filter.

6. Local oscillator suppression at the input of the BJ200 is inadequate: a spectrum analyser connected to the aerial socket measured a LO level as high as -35 dBm in the UHF band. Synthesizer sidebands were also clearly observed.

7. Selectivity and image rejection were just about acceptable, although a mobile telephone repeater at a distance of about 2 km was received on 433.920 MHz (in the 70 cm amateur band), while the actual transmit frequency was 443.920 MHz, i.e., 10 MHz higher. The receiver was unable to keep two strong signals from local cellular radio repeaters apart at a channel spacing of 15 kHz.

Conclusions

Notwithstanding the above criticisms, which are mainly inherent to the wide-band design, the Black Jaguar BJ200 MK2 is well worth its cost. The high sensitivity, ruggedness and the well laid-out LCD make the BJ200 a good choice for portable use, although it will function equally well in a fixed location, connected to an external aerial. It is a very compact and reliable receiver with good external finish. The accessories for it are useful and need not be purchased separately, as is often the case with competitive products.

The recommended retail price of the Black Jaguar BJ200 MK2 scanning receiver is £225. Further information is available from:

Nevada  •  189 London Road  •  North End  •  PORTSMOUTH  PO2 9AE.  Telephone: (0705) 662145.
NEW COMPUTER SYSTEM ENHANCES TEXTILE PRODUCTION

by Anna Kochan, BEng

An integrated computer system that can warn of production bottlenecks a year ahead and can be used by an operator with no experience of data processing has been on the market since late last year.

Made by McGuffie Brunton Northern, the first installation is at the northeast England textile manufacturing mill of the J.H. Walker Company, which collaborated in the design. Walker specializes in silver pile fabric and jersey fleece.

McGuffie started as a partnership in 1981, became a limited company two years later and developed an annual turnover of £1.8 million by 1986. Its first products were the Trader 25 and Jobber 25 software packages for the wholesale and distribution industries, and make-to-order, finish-to-order and jobbing manufacture, respectively.

These are now installed in more than 250 businesses in the United Kingdom. The new package has evolved from these two earlier versions to suit the requirements of weavers, spinners, dyers, yarn extruders and finishers.

For the past years the firm has been licensed to sell certain ICL computers and it is the ICL System 25 range of business minicomputers that the new package for the textile industry has been chosen to run on.

Textile 25, as the new integrated company management control system is known, covers the needs of production control and costing, stock sales orders and financial accounting with comprehensive management reporting.

Total control

The system is modular and can be installed progressively from a modest beginning. The modules are designed in such a way that they can be used by an inexperienced operator and the programs lead the operator through the systems by means of conversational English screen prompting.

Within the Textile 25 system, 27 different modules are included and they fall into six broad categories as follows:

* Sales order control: sales order processing, telephone selling option, order intake analysis, production batch-to-sales allocation, despatch control and invoicing.
* Stock control: stock recording, batch
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* Stock control: stock recording, batch
* Production control: job and batch estimating, works order documentation, batch costing and labour
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ing.

* Financial control: sales ledger, sales analysis, purchase ledger, nominal ledger, fixed ledger, fixed assets, payroll and BACS (bankers automatic
  clearance system) link.
* Data and security link: menu system and data management system.

Avoiding bottlenecks

J.H. Walker uses this new system in the manufacture of a range of high-quality knit
ted fashion fabrics for the clothing and upholstery trade. The company's two major
manufacturing ranges are a jersey and a sliver fabric. The jersey fabric is
knitted and stored in a 'gege' (natural) state, and then dyed and finished to
individual customer orders. The sliver fabric is finished and sold in one
pass to the customer's requirements. This involves special fibre
blending and very precise quality control.

So far, Walker has implemented the first
phase of Textile 25 for production, order control and tracking system. A network
of factory data collection terminals distributed throughout the production area and connected to the ICL system 25
minicomputer has been installed for this purpose.

As customers' orders are received they
are entered on to the computer. The Textile 25 order processing module is
specially adapted to handle the many
thousands of quality and colour combi-
nations that are possible without the
need to store each one. Production
batches can be planned and allocated to
orders well in advance of start. The re-
quirements planning module highlights
potential bottlenecks and material short-
ages for up to one year ahead, allowing
timely action to be taken to rectify the
situation.

As work on a production batch is
started, it is booked on to a knitting
machine. Pieces coming off the machine
are then weighed and measured. The sys-
tem assigns a piece number and prints a
bar-coded ticket immediately to identify
the piece and accompany it around the factory. As operations are completed, the piece bar code is read and completion
of the operation automatically recorded.

Accurate information

At the final inspection, extra informa-
tion such as quality, net weight and
net length are entered via the factory ter-
minal, and a new bar code roll card is
printed to accompany the completed
piece into store.

Customer despatches are carefully con-
trolled by the system. Each roll card be-
ing despatched is bar-coded read and
checked to be of the correct quality,
shade and so on, for the order. Despatch
documentation is printed instantly giv-
ing the customer full details of roll
lengths. Invoicing then follows auto-
matically, quickly and accurately.

At any time the firm can view the current
state of a production batch and customer order. Reports highlight over-
production and under-production or
potential late delivery situations. Com-
prehensive yield analysis and raw material location control monitors costs and
minimizes waste.

The system has enabled Walker to im-
prove its customer service levels in terms
of meeting delivery deadlines and ac-
curate despatches. Usage of raw
materials stocks has been improved and
stock holding has been reduced. The sys-
tem operates 24 hours a day, six days a
week and is proving to be reliable and
resilient.

In the future, Walker plans to introduce enhancements to its system to cover fibre
blending, time and attendance recording
and automatic machine motoring.

References:
1. J.H. Walker Ltd, Ravensthorpe Mills,
   Calder Road, DEWSBURY WF13 3SJ.
2. McGuffie Brunton Northern, The
   Granary, 50 Barton Road, Worsley,
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Current 100 ma
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Battery and instruction manual inclded £6.80

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DC volts 0.05 to 2000
1000V isolated with 2mm plug
Battery and instruction manual inclded £6.80

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DC volts 0.01 to 2000
1000V isolated with 2mm plug
Battery and instruction manual inclded £6.80

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- Suitable for paralel or direct connection
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- Horizontal scales: 1nsec/division
- Input impedance: 1MΩ
- Max input voltage: 2000V
- Frequency range: 200 kHz
- Input protection: 10kV
- Sweep range: 10ms to 100sec
- Power supply: 230V
- Dims: 150 x 200 x 100mm
- Battery and instruction manual inclded £116.00

LOGIC PROBE HYD78
- Suitable for paralel or direct connection
- CRT screen: high vertical sensitivity of 10nV/division
- Horizontal scales: 1nsec/division
- Input impedance: 1MΩ
- Max input voltage: 2000V
- Frequency range: 200 kHz
- Input protection: 10kV
- Sweep range: 10ms to 100sec
- Power supply: 230V
- Dims: 150 x 200 x 100mm
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