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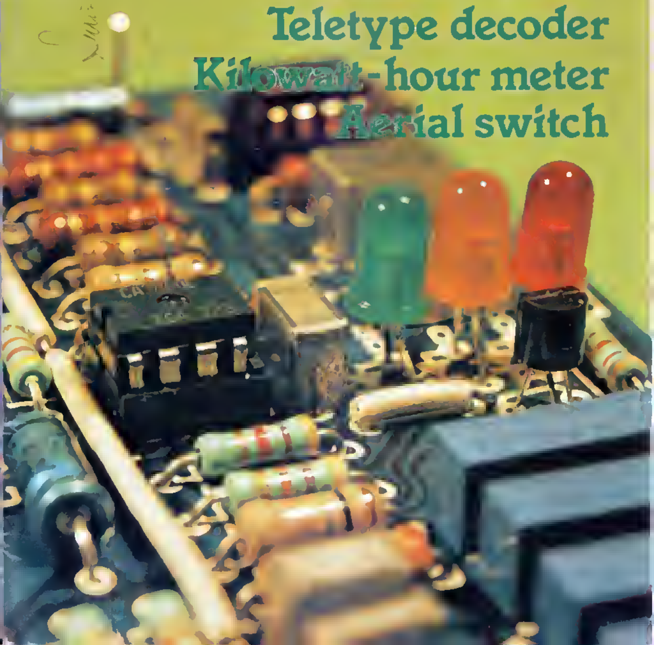
Aerial switch



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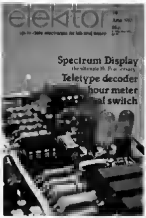

As LEDs have now been commercially available in red, green and orange/yellow for some time, they are found in many electronic applications. None the less, our front cover does not mean that we have gone into the miniature traffic light business. What is shown are the 'signal trafficators' used in the Radio Teletype decoder featured in this issue.

selektor

Raindrops and radar

A new type of radar is able to probe rain to measure the drop-size distribution and rate of rainfall and to distinguish rain from ice cloud. It is an important research tool for the study of climate and of the effect rain may have on high-speed aircraft and radio communication.
Radar has proved a remarkable tool to tell us, rapidly, how rain is distributed over large areas. It also enables us to examine what rain there is well above ground level. While the data it provides is good enough for general weather forecasting, it contains too much ambiguity to be used in estimating the rainfall *rates* in areas of heavy rain. Such information is important to research into flash flooding, crop damage and the attenuation of signals along paths of radio communication.
Ambiguity is there because the rainfall rate, and the amount of radar signal reflected by the rain, may represent a heavy concentration of small drops on the one hand or relatively few but large drops on the other; it is the statistical distribution of drop sizes that governs the relationship between the rainfall rate (or attenuation of a radio wave) and the reflectivity, or echo of the radar signal.

Dual polarisation

To overcome these problems a unique, dual-polarisation radar has been built at Chilbolton, in the South of England, and it is now in use there to map rainfall rates rapidly and accurately in three dimensions. It has a high spatial resolution, that is, an ability to separate reflections by angle and range, and clearly distinguishes between regions of ice clouds and rain. It has a pencil beam only a quarter of a degree wide, made possible by its fully-steerable antenna, 25 metres in diameter. Because radio waves at the very short wavelengths normally used for radar are heavily attenuated by rain, a relatively long operating wavelength of 10 cm has been chosen so that distant rain can be measured accurately without the signal being attenuated by other rain between it and the radar.
All radio waves comprise an electric field and a magnetic field, oscillating in planes at right angles to each other and to the direction of propagation of the wave. This is shown in figure 1, where E is the electric field and H the magnetic one.
The plane in which E oscillates is called the plane of polarisation of the wave. If it is vertical, the wave is said to be vertically polarised, and if horizontal, it is said to be horizontally polarised. The polarisation can be selected at the aerial system which transmits (and receives) the wave.
The basis of the dual-polarisation technique is that the balance between aerodynamic and surface tension forces on the raindrops causes them to flatten as they fall, whereas small drops tend to remain spherical, as shown in Figure 2. When a region of mainly big drops is illuminated by radar pulses consisting alternately of horizontally and vertically polarised waves, the power back-scattered by the horizontally polarised wave is larger than that when using vertical polarisation. Conversely, for a region of mainly small drops, the back-scattered power is similar for both polarisations.
Research in the USA, suggested that the *differential* reflectivity, which is the ratio of the powers in the back-scattered and vertically polarised waves, is directly related to the mean of the statistical distribution of drop sizes in rain. Being able to measure this differential reflectivity accurately is the big advance which has been made.

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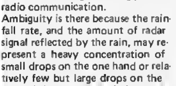

Figure 1. An electromagnetic wave has an electric field E and a magnetic field H, at right angles to each other and to the direction of propagation. In this representation the wave is travelling from left to right. All the E vectors lie in the vertical plane and all the H vectors in the horizontal plane. The plane in which the E vector moves is called the plane of polarisation.

2

Figure 2. Because large raindrops become distorted as they fall, they give a lot more back-scatter from horizontally polarised waves than they do from waves with vertical polarisation, whereas small drops, remaining almost spherical, back-scatter both types of wave in sensibly equal amounts.

Typical data

Figure 3 shows data the radar gave when scanning vertically through rain. In (a) we see a measure of the radar reflectivity of the rain, termed the absolute reflectivity factor Z, measured with horizontal polarisation only. This is precisely what a conventional radar (using single polarisation) would show, assuming that it operated on a 10-cm wavelength and had an antenna 25 metres in diameter, similar to ours. Prominent is the region of high reflectivity extending to a height of 8 km at a range of 35 km.
In (b) we see the spatial distribution of the additional *differential* reflectivity Z_{DR} data (using dual polarisation), the rain being sampled at the same time as in (a). The column of high reflectivity at a range of 35 km has a high Z_{DR} (it is greater than 2 dB) up to 2 km above ground, but Z_{DR} is low (the mean value is only 0.13 dB and the standard error 0.27 dB) at heights between 2 and 4.5 km. Such an abrupt change in Z_{DR} is often found close to the 0°C isotherm, and marks the transition from ice particles to water drops.
Icy particles that have a low density, for example mixtures of ice and air such as snow, have a low refractive index; unless they are very asymmetric, they show a low Z_{DR}. Furthermore, compact ice particles which have a high density inevitably give low values of Z_{DR} if they are nearly spherical; but if they have an irregular shape they are likely to tumble at random and they also show low Z_{DR}.

Polarisation switch

Our fast switching system to polarise the radar pulses in the appropriate

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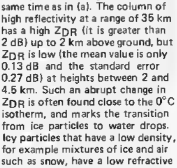

Figure 3. These vertical scans of the radar beam give a comparison of (a) data obtained using single polarisation and (b) data from dual polarisation. The information about ice cloud and rain below it was not resolved in (a).

way is based on a rapidly-rotating chopping vane, as shown in figure 4. Pulses from the transmitter arriva at a T-junction in the waveguide, from which they are passed alternately by open windows in the vane to one or other of two discrete pathways shown as vertical and horizontal polarisation arms; the windows open in synchronism with the generation of the pulses.

The paths merge again at a turnstile polariser, which is a sort of waveguide 'cross-roeds'. Two of the four 'roeds' are short stubs of waveguide, one of which is helf-a-wavelength long and the other only e quarter-wavelength. The ends of the stubs are closed, so energy seeking to travel along them is reflected back to the junction. But, because of the difference in stub lengths, the waves arrive back in such a wey that, when the anergy racombines, all of it becomes directed into a circular waveguide leading to the aerial system, one pulse being vertically polerised and the next one horizontally polarised, and so on. Finally, the pulsed weve is 'fired' into the aerial's peraboloid reflector by e scalar feed, which is shaped to distribute the energy into the reflector. The pattern of the pencil beam formed by the reflector, with its diameter of 25 m, is identical for both polarisations. Waves returning to the receiver follow precisely the same path as for transmission, but in the reverse direction.

The mechanical vane was used because no eveilable solid-state device was capable of switching the 500-kW pulses at a pulse repetition rate of 610 pulses/second. Switching has to be that fast, for the raindrops are continuously in motion relative to one another and interference between the reflections contributed from individuel drops gives rise to repid fading of the returned wave; the data samples for both polerisation have to be obtained in e short enough time for such fluctuations to have no effect.

The technique requires Z_{DR} to be measured precisely; the measured standard deviation of the random errors lies between 0.05 and 0.1 dB, depending on the mean value, with a corresponding fixed error (inherent to such a measuring system) of less than 0.1 dB. Corresponding errors for Z are 0.75 and 1.0 dB, respectively. This means that estimated errors in measured rainfall are less than 40 per cent, and only about 10 per cent in the measured rate at which a radio wave is attenuated along its path by the rain.

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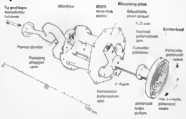

Figure 4. Dual polarisation switch and feed assembly. Windows in the rotating chopper vane pass the radar pulses from the transmitter alternately to the vertical-polarisation and horizontal polarisation arms. When the energy reaches the turnstile polariser, some of it passes into the quarter-wave arm and some into the half-wave arm. Energy reflected from the terminations of the arms recombines in such a way that the pulses fed to the aerial via the scalar feed are polarised alternately in the vertical and horizontal planes.

Satellite communications

The aim in building the radar was to examine the way that small zones in intense rain affected radio links, particularly links between ground stations and satellites, so that theoretical models could be produced for use in planning communications systems. The ability to observe rein over large areas and up to considerable altitudes gives rader an immediete advantage over rain gauges on the ground. Attempting to predict attenuation by rein elong the communications path from reflectivity data obtained by conventional rader means making an assumption about the distribution of the raindrop sizes. Furthermore, such data ere likely to be misinterpreted when hydrometeors other then rain, for example snow or hail, ere present. Dual-polarisation radar overcomes these problems. Only rein within a few tans of metres from the direct path of communication contributes to ettenuation, so relatively small but intense features in the structure of the rein may produce short but deep fades. Knowing the drop size distribution is particularly important, beceuse it changes quite rapidly within the rein zone.

Verification

To test the technique, deta from the radar was compared with those from a satellite-to-ground radio link operated at a frequency of 12 GHz (gigahertz) by the UK Independent Broadcasting Authority et a station five kilometres from the radar site. Figure 6 shows how Z and Z_{DR} varied during one set of measurements. The two ordinate scales show the slant renge r along the communication peth end the corresponding altitudes.

$A_c(r)$ is the summetion of ettenuation ceused by rain along the path, progressively from the ground station. It is seen that the rate of increase in $A_c(r)$ is highest at slent ranges between two and four kilometres from the station, where the rein is most intense. In that region, both Z end Z_{DR} are high. At an altitude of three kilometres and a slent range of six kilometres there is a region of high Z and apparently high Z_{DR}. This is the altitude et which felling ice crystals or snow melt to become raindrops. The large, wat snowflakes are sometimes more easy to recognise from their differential reflectivity than from their ebsoluta reflectivity. In this instance, rain below this altitude contributes 2 dB of attenuation, whereas the attenuation caused by wet snow has to be evaluated by other means becaude we are no longer dealing with drops of water. Tests have been done for light rain on only a few occasions the drop sizes are generally small; and in such conditions the technique is least accurate, but almost all values of radar-derived attenuation computed so far heve been within 0.5 dB of direct measurements, the standard deviation being only 0.3 dB.

In the small, intense cells of rain which accompany thunderstorms and which cause the highest ettenuation, drop sizes ere usually larger and the accuracy may be expected to be greater. For rain examined, the estimation of the attenuation using the absolute reflectivity alone (all that is available from a conventional radar), and assuming a constant statistical distribution for the drop sizes, produced en error factor of ebout two.

In small regions of rein, the corresponding error factor in computing the rate of increase in $A_c(r)$ was four. Subject to wider-ranging tests, it is expected that the dual-polarisation technique will improve the modelling of attenuation by rain over a range of radio frequencies, and enable severel studies to be made of how to keep tha effects of rain on future communications systems to e minimum.

Other applications

The technique should be important to other work, too. Measurements have shown that the largest drops in intense rain heve a diameter

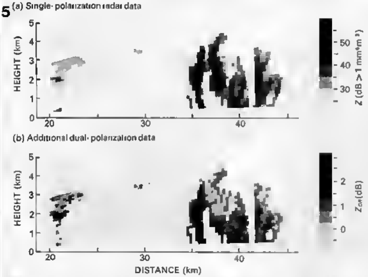

Figure 5. Here a pillar of supercooled water is seen to extend up through the melting layer (at an altitude of 1.9 km) to a height of 3.5 km. Such phenomena are a hazard to aircraft, causing ice to form.

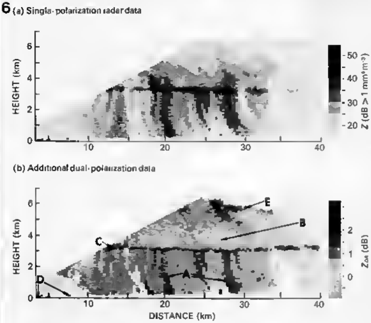

Figure 6. Vertical scan of the radar beam showing rain (A), ice clould (B), the melting layer (bright band), echoes from ground (D), and zones of high Z_{DR} (E) well above the melting layer.

of more than 0.8 cm. In the particular conditions investigated, if we assume an exponential distribution of drop sizes, one drop in the rate of 0.55 to 0.65 cm diameter would occur per 2.4 m^3 volume of rain, and one in the range of 0.65 to 0.75 cm would occur per 7.0 m^3. This sort of information is useful to scientists interested in the effect that raindrops have on high-speed aircraft and to others seeking to assess what heavy rain might do to crops.

Detecting regions of supercooled water is potentially valuable in aeronautics, for they can cause ice to accumulate rapidly and disastrously on aircraft. Figure 6 contains an example of high Z_{DR} values extending to the top of the region of high Z. This indicates a convective column of supercooled drops up to an altitude of 3.5 km, nearly twice the height of the melting layer. Without dual-polarisation measurements, it would not be clear whether such regions of high Z represented ice cloud or drops of water.

We are also thinking about how the technique could be used to avoid certain problems met with when using radars to forecast how rain is likely to travel in the following hour or two. Although it is not essential to know the drop size distribution in rain accurately if we want to estimate average rainfall over a large area, the dual-polarisation technique is likely to help us automatically distinguish rain from non-precipitating ice clouds (and from ground echoes, too, because they are characterised by the large variance of their Z_{DR}. The variance includes quite large negative values not found in echoes from other sources).

There is also a great deal in the technique to interest cloud physicists. Figure 6 shows vertical sections through rain, ice cloud, the melting layer (bright band) and echoes from ground. It also shows, well above the melting layer, zones of high Z_{DR} which probably contain horizontally-orientated plates of ice crystals; later, the crystals aggregate and tumble as they fall, giving near-zero Z_{DR}.

Basic studies of drop sizes in rain are being made on the ground with the aid of a drop-sizing device known as a Joss distrometer and a rain gauge, while measurements of drop sizes in the air are being made with a 2-D Knollenberg distrometer carried in a research aircraft of the UK Meteorological Office. Data collected directly in that way, when combined with data from the radar, are revealing how well we may except a simple model to behave when used to describe the statistical distribution of drop sizes in various kinds of rain.

Another promising application lies in providing reference data with which to compare the remote-sensing of clouds by satellites. Observations from the satellites may cover the whole of the Earth's atmosphere, but where they fall within the range of the radar, the radar data can be used to calibrate those from the satellite in terms of rainfall below the cloud and, perhaps, the type of hydrometeor within the cloud.

Martin Hall, Spectrum

(870 S)

energy meter

from watt to kilowatt-hour meter

Energy costs money and these costs are rising in line with the demand and shrinking resources. Nobody escapes these costs and it is therefore of interest to all but very wealthy consumers to know how much energy a certain appliance has consumed over a certain period of time. A (kilo)watt-hour meter will tell you accurately. This knowledge will also help in determining the cost-effectiveness of energy-saving measures. In this article we will tell you how the watt-meter featured in our May issue can be expanded to become an energy meter.

If you want to know how much energy an appliance has drawn from the mains supply over a given period, you have to multiply the power consumed by the appliance in watts with the time in seconds or hours. Unfortunately, the power consumed by many appliances is not constant; in the case of a refrigerator, for instance, the motor only runs when the thermostat tells it to and even then it does so with varying loads. The calculation is then no longer so simple: first the mean power consumed will have to be determined and that is a matter of averaging or integration. Multiplying the mean power so found with the time will give the amount of energy used.

The use of a measuring instrument like the energy meter described in this article will obviate the need for these calculations: fairly simple electronic circuits will average the power consumed and multiply this by the time. The block diagram in figure 1 shows the principle of operation. The input circuit is fed with the VCO output signal of

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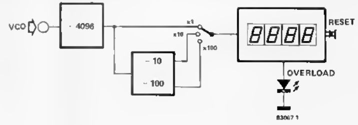

Figure 1. Block schematic diagram of the circuit necessary to expand the watt-meter published in our May issue into an energy meter. The extension consists of a digital counter which counts pulses produced by a VCO in the watt-meter. The number of pulses is directly proportional to the measured power and time.

the watt-meter. Tbe frequency of the VCO signal is in direct proportion to the power measured by the watt-meter: the higher the power, the higher the frequency. To convert the watt-meter to an energy meter only the addition of a fairly simple digital counter is needed. The VCO frequency is first divided by 4096; dependent upon the desired meter-scale, it is then divided by 10 or 100 (this increases the measuring range by 10 and 100 respectively). The dividers are followed by the actual counter which gives a four-digit read-out. Finally, there is a reset switch for resetting the circuit to zero.

Assuming that the watt-meter is connected to a refrigerator, the moment the motor of this appliance starts to run, the VCO in the watt-meter will provide countpulses to the expansion circuit which are directly proportional to the power consumed by the fridge. If that power varies, the VCO frequency will change. When the fridge motor switches off, the VCO ceases to generate pulses and the last counter position is retained. When the fridge switches on again, the VCO fires and the counter resumes counting. After a while the counter will indicate exactly how many watt-hours of energy the fridge has used.

The counter has a maximum capacity; the overload indicator gives warning that the counter bas gone through this maximum and started egain: if there were no such indicator, the displayed count could be misleading.

As stated, the VCO frequency is first divided by 4096. In principle, this divider could be omitted by operating tbe VCO at a lower frequency. However, not only does the higher frequency lie in a more suitable range for the oscillator, but it also has the advantage that the switch-on periods of an appliance can be averaged out mucb more accurately. This is of particular importance in the case of appliances which, within the period of measuring, switch on and off quite frequently.

The VCO

A description of the operation of the VCO was not included in the article on the watt-meter in the May issue, and this follows now. The circuit diagram of the VCO is shown in figure 2. Although in fact it is not a voltage but a current controlled oscillator, its operation remains the same.

The VCO is designed round an operational transconductance amplifier (OTA), A6, and operational amplifier A4 which is connected as a comparator. Dependent upon the measured power, transistor T1 provides the OTA with drive current. The current from T1 also charges capacitor C1 in e time which is again dependent upon the measured power. The resulting voltage level across C1 is applied to the input of comparator A4 via the buffer stage contained in the OTA stage. It this voltage exceeds the upper threshold, the output of the comparator goes nagative. At the same instant the input current (pin 3) of the OTA also becomes negative, which causes C1 to *discharge* at a speed which is dependent upon the drive current at pin 1. In this way the VCO provides a square-wave at its output of which the frequency is directly proportional to its drive current, that is, the measured power. The hysteresis of the comparator, and consequently the frequency of the VCO, can be edjusted by means of potentiometer P4. This is of importance during the calibration of the meter which is discussed later in this article.

Energy meter extension

The circuit shown in figure 3 enables the watt-meter to be converted to a kilowatt-hour or energy meter. As stated, the input of the circuit is connected to the output of the VCO in the watt-meter. The VCO signal is applied to the input of 1 : 4096 divider IC2 via voltage divider R2-R3. The divided square wave is again divided by 10 or 100 in IC3. Dependent on the required scale,

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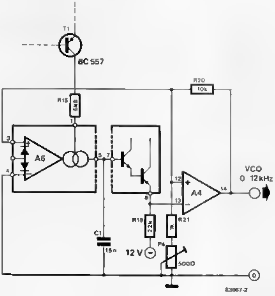

Figure 2. The VCO which is located on the printed circuit board of the watt-meter consists of en OTA (A6) and an op-amp (A4) which is connected as a comparator with hysteresis. Dependent on the power consumed, the OTA is fed with a certein drive current and arranges, in combination with the comparator, for the successive charging and discharging of capacitor C1. The output of the comparator therefore consists of a square wave of which the frequency is dependent upon the measured power.

switch S2a can apply the output of IC2 to counter IC5 either directly or via IC3. The integrated counter drives a four-digit 7-segment display. The decimal points of the display are determined by the position of S2b (the meter range switch).
The counter is reset by pressing push-button switch S1; at the same time the two dividers IC2 and IC3 are reset to the zero-position.
To get an indication when the counter has reached its maximum capacity, use is made of its 'carry out' terminal (pin 14). At the moment the counter changes from 9999 to 0000, the logic bit at pin 14 changes from 1 to 0, which causes capacitor C3 to charge via resistor R5. When the resulting voltage at the clock-input (pin 3) of bi-stable IC4 reaches logic 1, its output Q also becomes 1 (+5 V). Transistor T1 is then fired and LED D4 lights, indicating that the counter has gone past its maximum at least once. It should be noted here that when the counter and dividers are reset, the bi-stable should also be reset to zero.
Although highly desirable, the reset facility is not fitted on electro-mechanical kilowatt-hour meters provided by Electricity Boards, for obvious reasons. On the meter described, the facility is not just useful, it is essential: at the onset of each measurement, the meter is reset so that noting down the reading at the start becomes unnecessary.
As far as meter ranges are concerned, switch S2 makes possible the selection of threv. The scale factor is a somewhat more difficult problem, as this is dependent upon the divide factor and the shunt resistance in the watt-meter. This problem will be returned to later in this article.

The watt-meter and kWh extension can be fed from one 2 x 15 V, minimum 0.7 A, transformer. The voltage stabiliser, IC1, of the kWh section reduces the voltage rectified by diodes D1 and D3 to 5 V. The stabiliser is protected against overload by resistor R1. This resistor is replaced by a wire-bridge if the kWh extension is fed by a separate transformer of 2 x 8 V or 2 x 9 V (minimum 700 mA) transformer.

Construction and adjustment

Readers who took our advice of delaying the fitting of the watt-meter in a box, can now house it together with the kWh extension in one case, which, from a safety point of view, should be made from a material that is a good insulator.
If the kWh section gets its own case, the connection between it and the watt-meter needs special attention. As the zero potential of the watt-meter circuit is connectad electrically with the mains supply during measurements, the cable between the two cases must be capable of carrying 220 V AC. If a plug and socket connection is desited, these must not be of the ordinary household variety. There are many good quality 220 V handling types available which can be used and in effect prevent the units being inadvertently connected to the mains supply. When a plug and socket connection is chosen, the extension must, of course, have its own power supply.
To revert to the scale factor of the meter and the way S2b should be connected to the decimal points of the display, see figure 3. When the watt-meter gives full-scale deflec-

Figure 3. With this circuit the watt-meter is converted to an energy meter. The pulses generated by the VCO are applied to the input. The meter range is increased by connecting a further divider (IC3) between the input and counter IC5 by means of range switch S2. LED D4 lights up when the counter has reached its maximum capacity. Switch S1 is included to reset the circuit to zero.

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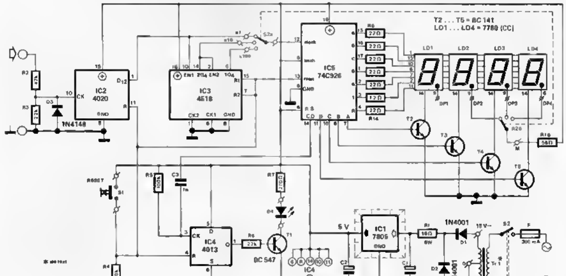

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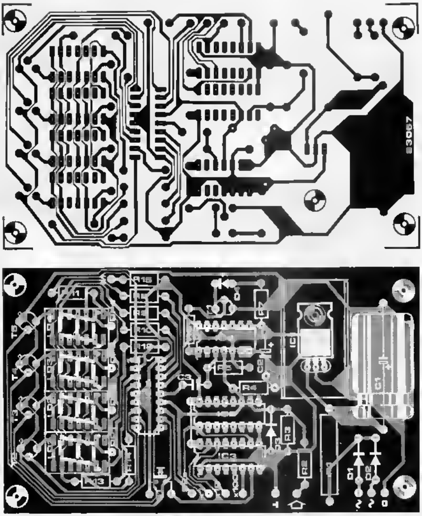


tion (FSD) at 100 watts and S2b is set to the lowest divide factor (as drawn), the display will read the maximum of 9999 after 1 hour. In round figures, this means that 100 watt-hours of energy has been used, so that for a read-out in Wh decimal point DP2 must light (99.99 Wh). When FSD is increased tenfold (S2 in position x10), the display will reach maximum after 10 hours, that is, when 1000 watt-hours of energy have been used. If Wh are to be read out, decimal point DP3 must light (999.9 Wh). It will be clear that with S2 in position x100, decimal point DP4 should light; FSD is then 10 kWh. The shunt resistance of the watt-meter has been calculated to give an FSD of 1000 watts: a larger FSD is for practical reasons not advisable as the required low value of the shunt resistance cannot be realised with sufficient accuracy. Even for an FSD of 1000 watts, the shunt resistance has a value of only 0.047 Ω. Resistors of that value are not available and can only be obtained by three 0.15 Ω resistors in parallel or by using resistance wire.

Finally, the calibration, which only concerns potentiometer P4 in the watt-meter. Assuming that that instrument has been calibrated correctly, connect the energy meter (that is, watt-meter + kWh extension) to a resistive load with a constant power consumption of, say 100 watts (NOT a thermostatically controlled appliance, but for instance a light bulb). Using an insulated screwdriver, set P4 such that the display after 0.1 hour (= 6 minutes) reads 10Wh. This procedure will have to be repeated several times for optimum results. Subsequently, repeat the adjustment for 1-hour periods when the read-out should be 100 Wh. Too low a reading is corrected by turning P4 clockwise (and too high a reading by turning it anti-clockwise).

A comparison with the Electricity Board kWh meter can, of course, also be made and this should give a very satisfactory calibration. The only point to remember in this method is that all other appliances connected to the mains supply must be switched off.

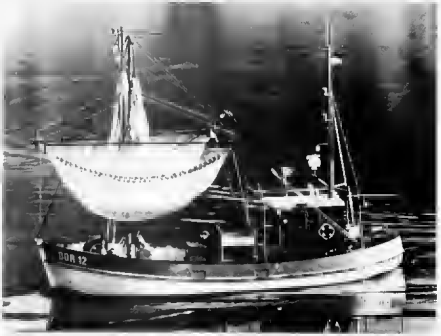
Parts list

Resistors:
R1 = 15 Ω/3 W (see text)
R2 = 47 k
R3,R6 = 22 k
R4 = 10 k
R5 = 100 k
R7 = 270 Ω
R8 . . . R14 = 22 Ω
R15 = 56 Ω

Capacitors:
C1 = 1000 μ/40 V
C2 = 10 μ/16 V
C3 = 1 n

Semiconductors:
T1 = BC 547
T2 . . . T5 = BC 141
IC1 = 7805
IC2 = 4020
IC3 = 4518
IC4 = 4013
IC5 = 74C926
D1,D2 = 1N4001
D3 = 1N4148
D4 = LED (red)
LD1 . . . LD4 = 7760, 7-segment display (comm. cath.)

Miscellaneous.
S1 = push-button switch, 1 make
S2 = range switch, 2-pole, 3-way
Tr = mains transformer
a) 2x16 V, minimum 0,7 A
b) 2x16 V, minimum 0,7 A, with taps at 8 V or 9 V
} for watt-meter + kWh extension
(c) 2x9 V, minimum 0.7 A (kWh extension only) see text
heat sink for IC1
equipment case (watt-meter only) = BOC440
(watt-meter + kWh extension = BOC445)
(available from West Hyde Developments Ltd)



switching channel for radio control

The proportional radio control systems which are available to modellers today are ideal where it concerns the control of speed end steering mechanisms. Meny models, particularly model ships, have, however, a number of non-proportionel on/off functions which modellers would like to control remotely: interior lighting, search lights, sirens, water cannon, and many more. The switch described in this erticles offers the possibility to control five such functions over one channel without the need for servo-mechanisms and micro-switches.

pulse-width controlled switch

Proportional remote control systems operate by pulse-width detection. The position of the joystick results in a certain width of the transmitted pulses (between 1 and 2 milliseconds). The width of the pulse is translated in the recaiver to a cartain position of the servo control.
This type of proportional sarvo-control lends itself eminently to the continuously variable regulation of speed and steering, but the control of switching functions is somewhat more difficult, unless the use of a channel for every one or two such functions is acceptable. Fortunately, a small electronic circuit can improve the situation considerably; it consists of a ona-gate oscillator, a decimal counter and a few buffars. Its principle is simple: when a pulse is received, a counter with fiva outputs operates; at the and of the pulse, one of the five outputs is active — which one depends on the width of the pulsa.
The circuit diagram of the pulse-width controlled switch is shown in figure 1. The transmitted pulses have, as already stated, a width varying between 1 and 2 ms and are repeated at intervals of about 20 ms. As soon as such a pulse arrives at the input of the circuit, two things happen in quick succession. The positive edge of the pulse (that is, the very start) switches on counter IC2 via gata N4. Almost immediately afterwards, when the pulse reaches logic 1, the clock oscillator around N3 starts and IC2 commences counting. The clock oscillator provides a 5 kHz square-wava, which can be adjusted by means of P1. As long as the oscillator is working, therefore, IC2 is clocked every 0.2 ms.
IC2 is a decimal counter working as a shift register, which, in principle, can provide up to ten switched outputs; only five are used in tha present circuit (because the pulse-width lies between 1 and 2 ms). Starting from zero, IC2 switches every 0.2 ms to the next successive output. After 1 ms, therefore, output 5 will be logic 1, after 1.2 ms output 6, and so on. It is seen, therefore that on the command of the pulses produced by clock oscillator N3, all outputs of IC2 become logic 1 in succession.
The sequential switching of the outputs

Figure 1. Circuit of the pulse-width controlled switch. As soon as a pulse arrives at the input, outputs 5 . . . 9 become active (logic 1) sequentially. When the pulse ceases, the output which was active at that moment, retains logic 1. This particular output is determined by the width of the incoming pulse.

N1 . . N4 = IC1 = 4093
N5 . . N9 = 5/7 IC3 = ULN 2003

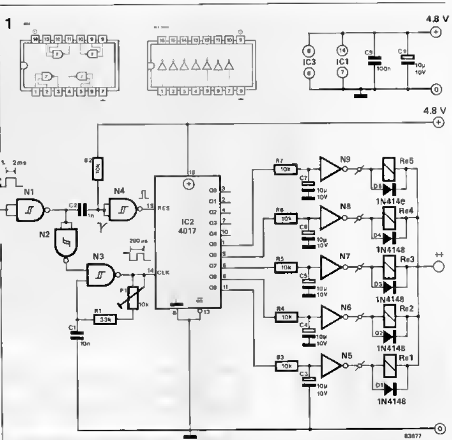
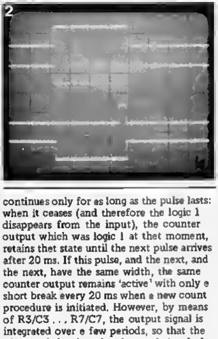


Figure 2. This picture shows that reality differs somewhat from theory: the input pulse (upper trace) fires the oscillator (second trace). The first period is a little longer than normal because C1 was fully discharged at that moment. This additional delay is compensated partly by the positive edge caused by the stopping of the oscillator and partly by the fact that the first positive edge occurs already after half the period. Trace 3 shows the signal at output 8 and trace 4 that at output 9. The latter was active (logic 1) and becomes 0 because IC2 resets at the rising edge of the input pulse; during the ninth positive edge of the oscillator, output 9 becomes 1 again and remains so until the next input pulse.



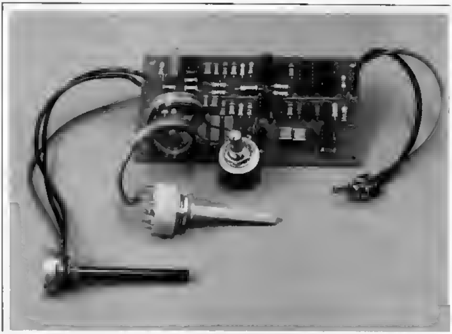
continues only for as long as the pulse lasts: when it ceases (and therefore the logic 1 disappears from the input), the counter output which was logic 1 at that moment, retains that state until the next pulse arrives after 20 ms. If this pulse, and the next, and the next, have the same width, the same counter output remains 'active' with only a short break every 20 ms when a new count procedure is initiated. However, by means of R3/C3 . . . R7/C7, the output signal is integrated over a few periods, so that the effects of the short break are obviated. At the open-collector output of gates N5 . . . N9 a logic 0 is therefore available at all times. The switching of small lamps (drawing less than 400 mA) can be effected by connecting them between one of the outputs of these gates and the positive supply line. Other switching functions are possible by the use of a relay: the relay coil, which should preferably be more than 100 Ω and on no account less than 20 Ω, is then connected between one of the outputs and the positive supply line.

Operation

The circuit works very well in practice, not in the least due to the impossibility of short interfering signals or the effects of missing pulses reaching the output. Also, the current consumption of only a few mA is hardly a drain on the battery. Connecting the circuit to the receiver should pose no problems as it is connected in exactly the same way as a normal servo.

Adjusting the circuit is also a straightforward affair. Preset potentiometer P1 is adjusted such that all channels switch correctly when the joystick is moved from one extreme to the other. It would be useful to draw some lines beside the joystick to mark the position where the switch-over from one channel to the next occurs. During operation all that has to be done then is to set the joystick between two of the lines to ensure correct operation.

A final remark: output gates N5 . . . N9 must not switch more than 400 mA and preferably considerably less; this prevents unnecessary problems and premature repairs. It is, however, possible to utilize the two unused buffers of IC3 to either treble the permitted output current of one of the outputs or double that of two of the outputs. All that is required to do so is to connect the appropriate output(s) to the relevant buffer input. ◼



RTTY decoder

Interest in Radio Teletype (RTTY) traffic has grown appreciably over the past few years. One of the reasons for this is that micro-computers, such as the Elektor Junior Computer, which find their way into more and more homes, lend themselves readily to this absorbing hobby. Such a computer can become an effective RTTY Decoder by the addition of a small electronic circuit and a suitable program.

teletype reception by computer

Our last issue contained articles on the decoding of morse signals by means of the Junior Computer and the Elektor Z80A card. In this issue it is the turn of teletype enthusiasts.
Owners of an expanded Junior Computer can save themselves the purchase of a costly teleprinter and RTTY converter. A simple interface and an EPROM with the rigbt program will translate the teletype gibberish on thort waves into a clear text on the screen.
The principle of transmission and decoding in teletype is not much different from that in morse. Digital coded information is transmitted by interrupting a radio carrier wave: this is called CW (keyed Continuous Waves). In morse transmissions, the interruptions are in accordance with tha by today's standards somewhat cumbersoma morse code; in teletype, with the logically constructed 5-unit CCITT Code No. 2, better known as the Baudot code. A more detailed treatment of this subject can be found alsewhere in this issue.

Apart from tha codes, there is another fundamental difference between morse and telatype operation. In morse, only one carrier is transmitted whicb is interrupted in tbe rhythm of the dots and dashes of the morse code. In teletype operetion two carriers are used, of which one is used for the transmission of the logic 1s and the other for the 0s. It is as if two transmitters are operating side by side, but aach working on a different frequency. When the transmitted bit is 1, one of the transmitters is switched on, while the other is off; when tha transmitted bit is 0, tha first transmitter is off and the second is on. In reality only one transmitter is used of which the output frequency is shifted, according to whether a 1 or a 0 is transmitted. This method of operation is tberefore called Frequency Shift Keying (FSK).
In teletype, logic 1 is called 'mark' and logic 0, 'space'. The trensmission containing all tbe bits 1 is called the 'mark signal' and that containing only 0's, the 'space signal'. The mark and space signals are very close to one another: the frequency separation is called the 'shift'.
The output of the receiver therefore contains two different audio frequencies: ona represents logic 1 (mark), the other logic 0 (space). When both are present simultaneously, there is a fault in the transmission.

The RTTY interface

The signals emanating from the short-wave receiver are not suitable for driving the computer as this, as a norm, requires square-wave inputs. To modify the receiver output signals to the required shape, an interface is needed. This interface must be capable of differentiating between the two received frequencies and of transforming them into a digital signal. For this purpose use is made of a tone decoder followed by an integrator and Schmitt trigger. Two such set-ups are required in the RTTY interface because it has to cope with two different audio signals. With reference to figure 2, the level of the incoming audio signals is set as required by means of potentiometer P7 at the input of the circuit. Then follows a level indicator stage consisting of transistor T1 and a red LED, D1. The input signal is fed to two decoders, IC1 and IC2. Whereas tone decoder IC1 is alignad to one audio frequency, by means of potentiometer P8, decoder IC2 can be aligned to six different frequencies. This enables it to be switched to teletype transmissions with differing frequency shifts. Tone decoder IC1 is aligned to a nominal frequency of 1275 Hz. The frequency of decoder IC2 is then 1275 Hz ± the shift frequency. Table 1 gives the shift- and audio-frequencies normally encountered in RTTY traffic.

Table 1. Most frequently used audio and shift frequencies in RTTY traffic.

signal	set with:	frequency (audio) Hz	shift-frequency (Hz)
mark	P8	1275	0
space 1	P1	var.	var.
space 2	P2	1445	170
space 3	P3	1575	300
space 4	P4	1700	425
space 5	P5	2125	850
space 6	P6	2275	1000

The output circuit of the tone decoders contains three indicator LEDs: D2 (green) for the mark signal (IC1), D3 (red) for the space signal (IC2) and D4 (yellow) for the situation when a mark and space occur simultaneously. Because the frequency is shifted between mark and space, the overlap between the two signals during good reception is very small and D4 therefore lights rarely if at all. Bright lighting of D4 indicates a faulty adjustment or bad reception.

1

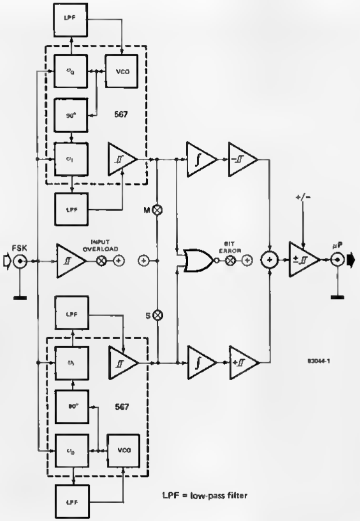


Figure 1. Block diagram of the RTTY interface. The interface consists of two tone decoders with follow-on integrators and triggers for noise and interference suppression. Its output contains an adder circuit which will deliver a usable signal even when one of the two audio signals (mark or space) is missing. The NOR connection of the tone decoder signals ensures an indication of transmission failure. With correct settings, the LED indicators for mark and space light alternately at maximum brightness, whereas the error LED lights only dimly.

2

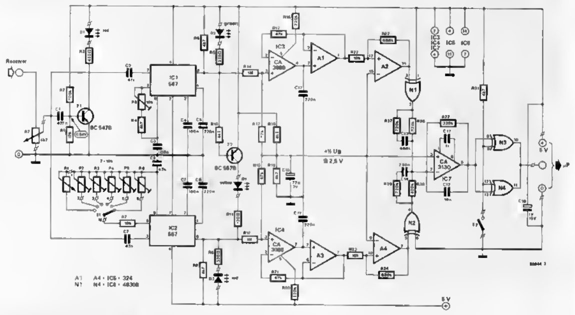


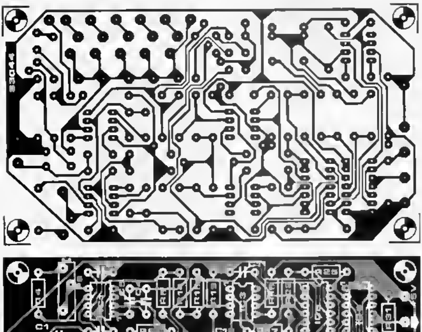
Figure 2. The interface circuit for teletype reception via the Junior Computer. It contains two tone decoders because in teletype operation two audio frequencies are keyed.

Both tone decoders are followed by OTA integrators IC3 and IC4, buffers A1 and A3, and triggers A2 and A4. The high-impedance buffers prevent the overloading of capacitors C11 and C12. The integrator and trigger section is identical to that of the morse interface described in our May issue.
Gate N1 is connected as an inverter, N2 does not invert because pin 6 has a 0 input. This is important in respect of operational amplifier IC7. This stage makes use of the fact that when one of the two signals, mark or space, is missing, the required teletype information in still fully available in the other signal. The space signal is out of phase with the mark signal but otherwise identical to it. If mark is logic 1, space is logic 0. Because N1 inverts the mark signal, whereas N2 passes the space signal unchanged, the output of tha two gates contains two in-phase signals.
IC7 combines these signals in its inverting input circuit. If one of the signals is missing because of interference, the other will still be sufficient to drive the op-amp. Capacitor C15 in the negative feedback loop of IC7 ensures further integration of the audio signal by suppressing any residual unwanted signals. Gates N3 and N4 improve the slope of the square-wave output of IC7 so that a TTL compatible signal is available at the output of the interface. These gates also enable reversal of the polarity of the output signal. When S2 is open, both gates function as inverters, while when S2 is closed, they operate as non-inverting buffer stages. The setting of S2 is dependent on the teletype signal being received.

Presetting and adjustment

Once the RTTY decoder has been constructed on the printed circuit board shown in figure 3, it can be preset and adjusted by means of an audio generator and frequency meter. Both these instruments should be connected to the input (P7) of the interface.
Set P7 to its mid-position, tune the generator to 1275 Hz (as indicated by the frequency meter) and adjust the generator output voltage until D1 just lights. It should now be possible to find a small range of travel of potentiometer P8 at which D2 lights. The correct position of P8 is in the centre of that range. It is also possible to reduce the generator output further and further while searching for a position of P8 where D2 lights. The position so found is the correct one.
Next, the adjustment of tone decoder IC2. Adjust potentiometers P2 . . . P6 in the same way as described for P8 above, but with the generator tuned to frequencies in accordance with table 1 (space frequency = 1275 Hz ± shift frequency).
Adjurting and presetting without using an audio generator and frequency meter is fairly difficult. When attempting to do so, it is best to set P7 to its mid-position and determine the shift-frequency of each transmission experimentally by adjusting potentiometer P1 with switch S1 set to position 1.
Once the above operations have been carried out, the interface can be connected to the audio output of a short-wave receiver. Search for a teletype transmission and adjust P7 so that LED D1 just lights. Then tune the receiver so that D2 lights as brightly as possible in rhythm with the incoming signal. Then select the correct frequency shift with switch S1. If the shift is not known, try all positions of S1 until one is found where D3 lights as brightly, and D4 as dimly, as possible. If such a position cannot be found, the shift is non-standard. In that case, set S1 to position 1 and adjust P1 to the shift of the incoming signal. When

3



Parts list

Resistors:
R1 = 12 k
R2 = 100 k
R3 = 470 Ω
R4,R5,R9,R10,R18,
R19,R31 = 4k7
R6 = 270 Ω
R7,R22,R23 = 10 k
R8 = 330 Ω
R11 = 120 Ω
R12,R14 = 1 M
R13,R15,R17,R21 = 47 k
R16, R20,
R27 . . . R29 = 220 k
R24,R25 = 680 k
R26,R30 = 470 k
P1 = 10 k 10-turn
potentiometer
P2 . . . P6,P8 = 10 k
10 turn preset potentiometer
P7 = 4k7 (5 k)
potentiometer

Capacitors:
C1 = 470 n
C2,C6,C9 = 47 n
C3,C4,C7 = 100 n
C5,C8,C11,C12 = 220 n
C10 = 22 μ/3 V
C13,C14 = 680 n
C15 = 10 n
C16 = 1 μ/6 V
C17 = 1 n

Semiconductors:
D1,D3 = LED red
D2 = LED green
D4 = LED yellow
T1 = BC 547B
T2 = BC 557B
IC1,IC2 = LM 567
IC3,IC4 = CA 3080
IC5 = LM 324
IC6 = 4030B
IC7 = CA 3130

Miscellaneous:
S1 = rotary switch,
1 pole, 6 way
S2 = single-pole switch
toggle

Figure 3. The RTTY interface is constructed on this printed circuit board. The preset potentiometers are used for the setting of the various audio frequencies.

4

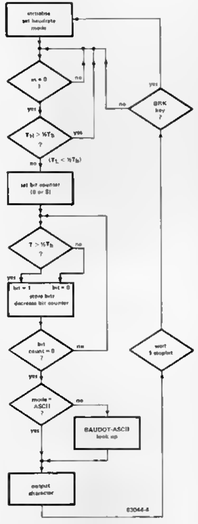


Figure 4. Simplified flow chart of the RTTY program. The 'heart' of the program is the bit counter. In contrast to an UAR/T which only scans the (calculated) centre of a pulse (unit of teletype signal), the counter determines whether the input signal during the pulse is longer than half the pulse duration for logic 1. If that is the case, it is taken to be 1, otherwise as 0. This system gives an appreciably lower susceptibility to interference, and therefore error rate, than is the case with UAR/T's.

Table 2. Print-out after starting the RTTY-program

```
BAUDRATE:

Ø=45.45 BAUD
1=5Ø
2=57
3=75
4=1ØØ
5=11Ø
DO YOU LIKE TO CHANGE IT? <Y/N>Y
SELECT THE BAUDRATE: 1
ASCII RECEIVER? <Y/N>N
FILE BUFFER? <Y/N>Y
AUTO LETTER MODE? <Y/N>
LIST THE FILE BUFFER? <Y/N>
::
```

Table 3. Starting addresses for the copy procedures.

Junior versions	starting address	copied from	to address
expanded	ØE88	Ø8ØØ	4ØØØ
DOS	EE72	E8ØØ	4ØØØ

reception is satisfactory and the interface is working correctly, the LEDs will flicker in rhythm with the incoming signal.
All that remains is the presetting of the baud rate (at the computer) and the polarity of the incoming signal (set by S2). Both are a matter of trial and error as firm rules cannot be given.

The RTTY decoder program

The program of the RTTY decoder can be contained in an EPROM type 2716. This EPROM is then suitable for use with the expanded Junior Computer as well as the DOS Junior.
The RTTY interface is connected to pin PB7 of the Junior Computer. The RTTY program is so arranged that both 5-unit Baudot and 7-unit ASCII codes can be received. Moreover, the program allows up to six baud-rates.
The received data are stored in a file buffer. When the buffer is full, an error signal is given. The contents of the buffer can, of course, be read out.
A further useful feature is the Auto-Letter-Mode: when receiving Baudot code, the letter sign is often lost. This results in letters being erroneously translated as numerals. In the Auto-Letter-Mode, the decoder automatically switches back to the letter mode when a blank space is received.
Figure 4 shows the program structure in a flow chart.
When the program has been started with the address 4ØØØ, possible baud rates are displayed as shown in table 2. The computer will ask some questions which should be answered by Y (Yes) or N (No = Return).
The baud-rate setting is effected by the keying in of a number between 0 and 5.
On reception of an ASCII transmission, the question 'ASCII Receiver?' must be answered by Y, because if the answer N is given, the decoder will be set to Baudot code.
After questions as to file buffer, Auto-Letter-Mode, and file buffer print out have been answered, the computer is ready to receive a serial signal across PB7; this is indicated by the display ': :'.
If the first question 'Do you like to change it?' is answered by N, the start procedure will be shortened. The decoder will then proceed in the Baudot mode with a baud rate of 50, indicated by the disappearance of the symbol ': :' from the screen.
If you want to find out the mode of operation after the program has started, simply press the Break key on the ASCII keyboard. Reset or Change of Mode of Operation is effected with the NMI key.

Operating instructions for the RTTY program

The program requires a storage capacity from 4ØØØ up to 7FFF (RAM). A (dynamic) 16K RAM card on the Junior bus will be suitable.
The starting address is 4ØØØ.
As the DOS Junior has a storage capacity which differs from that of the expanded Junior, the program for it has been put

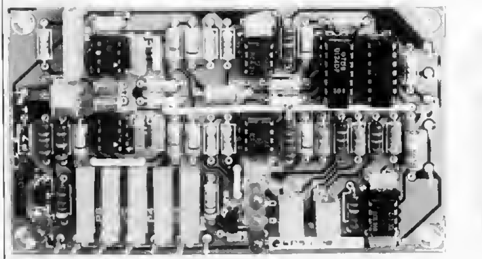


Table 4. Amendments for the DOS junior.

Address	Data
4Ø38	A3
4Ø39	FE

Table 5. Amendments for the expanded junior.

Address	Data
4ØC2. .	EA, EA, EA
4Ø38	34
4Ø39	13
4Ø41	1A
4Ø57	AE
4Ø58	12
44DA	1A
44Ø8	1A
44E4	1A
44E7	1A
44EC	1A
44F1	1A
44F6	1A
4581	1A
4589	1A
4598	18
458E	18
45C8. . .	EA, EA, EA
45D1	1A
45CF	1A
45EØ	18
46Ø8	18
46ØD	18
464Ø	18
4646	18

Table 6. The hexdump of the RTTY decoding program.

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
800	4C	0D	43	43	01	00	00	00	00	00	00	00	00	00	05	00
810	40	FF	7F	01	00	00	00	00	00	3F	35	00	09	F0	55	20
820	4E	00	44	15	34	10	37	01	23	4C	3C	40	0D	61	23	40
830	C9	00	F0	00	20	F8	44	30	43	23	60	60	AD	06	40	2D
840	00	FA	F0	F0	A3	FF	9A	20	E8	41	4C	19	44	AD	14	40
850	40	A9	00	0D	14	40	20	10	FE	20	2C	40	AA	60	0D	14
860	40	0A	60	60	05	F0	60	05	F9	AD	14	40	40	A9	00	0D
870	14	40	E6	F8	D0	02	06	F9	A0	00	01	F0	C9	00	F0	04
880	20	2C	40	4C	72	40	60	0D	14	40	A5	F9	40	A5	F0	40
890	60	30	61	40	0D	0A	42	41	55	44	4F	54	20	00	60	20
8A0	63	40	0D	0A	41	51	41	49	49	20	00	60	20	63	40	52
8B0	45	41	45	49	54	45	52	0D	0A	00	60	20	61	40	30	42
8C0	41	55	44	0D	0A	00	40	20	63	40	34	15	2E	34	35	00
8D0	69	20	41	40	35	10	00	20	41	40	35	37	00	60	20	63
8E0	63	40	37	35	00	60	20	61	40	31	30	30	00	60	20	63
8F0	40	11	11	10	00	60	20	63	40	4E	4F	20	00	60	20	63
900	40	0D	0A	52	45	43	45	49	56	45	44	30	43	40	41	53
910	41	43	54	45	52	51	20	41	52	45	0D	0A	51	54	4F	53
920	45	44	30	49	4E	20	42	55	46	46	45	52	0D	0A	00	60
930	20	61	40	41	55	54	4F	20	4C	45	54	45	52	20	40	4D
940	4F	44	45	00	60	20	61	40	0D	0A	00	60	AD	14	40	8D
950	16	40	A9	00	8D	14	40	AD	0F	40	AE	10	40	C5	FA	D0
960	1D	E4	F9	D0	19	30	61	40	0D	0A	46	49	4C	45	20	45
970	4D	50	54	59	0D	0A	00	AD	16	40	8D	14	40	60	05	FA
980	06	F0	20	45	41	A9	00	0D	10	40	A0	00	01	FA	C9	FF
990	F0	E5	40	30	2C	40	20	E4	41	30	A5	FA	ED	11	40	A5
9A0	F0	ED	12	40	60	90	16	20	61	40	0D	0A	46	49	4C	45
9B0	30	4F	56	45	52	46	4C	4F	57	0D	0A	00	60	C9	0D	D0
9C0	C9	20	2C	40	EE	1A	40	AE	1A	40	EC	1C	40	90	09	20
9D0	4D	40	C9	45	F0	A1	D0	AD	A9	0A	D1	FA	F0	AC	20	2C
9E0	40	4C	0A	41	E6	FA	D0	02	E6	FB	60	20	45	41	30	45
9F0	41	AD	03	40	C9	43	D0	06	20	91	40	4C	01	42	30	9F
A00	40	20	AC	40	AD	04	40	D0	06	20	C7	40	4C	3A	42	C9
A10	01	D0	06	20	D1	40	4C	3A	43	C9	02	D0	06	30	D0	40
A20	4C	3A	42	C9	03	D0	06	20	DF	40	4C	3A	42	C9	04	D0
A30	06	20	E4	40	4C	3A	42	30	0E	40	20	09	40	AD	14	40
A40	F0	0C	30	FE	40	AD	17	40	F0	0A	20	10	41	60	05	F6
A50	40	4C	42	42	20	F6	40	4C	4A	42	C9	1F	F0	19	C9	10
A60	F0	0F	AE	13	40	F0	05	AA	0D	7D	43	60	AA	0D	90	42
A70	60	A9	00	0D	13	40	60	0D	11	40	A9	00	60	00	45	0A
A80	41	20	51	49	55	0D	44	53	4A	46	46	43	40	54	5A	4C
A90	57	40	50	50	51	4F	43	47	00	4D	50	54	00	00	33	0A
AA0	2D	20	27	38	37	0D	34	34	07	2C	00	1A	20	15	30	39
AB0	33	00	36	30	31	19	3F	00	00	4D	50	56	00	30	A0	44
AC0	A3	FF	9A	A9	05	0D	0E	40	A9	43	0D	01	40	A3	01	0E
AD0	04	40	0E	13	40	CA	06	14	40	0E	17	40	20	63	40	0D
AE0	0A	45	4C	45	40	54	4F	53	30	52	54	54	59	30	44	45
AF0	43	4F	44	45	53	0D	0A	0A	43	41	55	44	53	41	54	45
B00	1A	0D	0A	0A	30	30	34	35	20	34	35	30	42	41	55	44
B10	0D	0A	31	3D	35	30	0D	0A	33	30	35	37	0D	0A	33	3D
B20	37	15	00	0A	34	38	31	30	30	0D	0A	35	3D	31	31	10
B30	0D	0A	44	4F	30	59	4F	55	30	4C	49	4B	45	30	54	4F
B40	30	43	48	41	4E	47	45	30	44	54	3F	30	3C	50	3F	4E
B50	36	00	20	4D	40	C9	50	D0	5A	30	63	40	0D	0A	53	45
B60	4C	45	41	54	20	54	40	45	30	42	41	55	44	53	41	54
B70	45	3A	30	00	30	4D	40	C4	10	90	DE	C9	36	00	DA	29
B80	0F	0D	04	40	20	63	40	0D	0A	41	51	41	49	49	30	52
B90	45	43	45	49	56	45	52	1F	20	3C	59	2F	4E	1F	00	30
BA0	4D	40	C9	59	D0	10	A9	07	0D	0E	40	A9	41	0D	03	40
BB0	4C	C0	41	4C	74	44	A9	05	0D	0E	40	A9	43	0D	03	40
BC0	30	61	40	0D	0A	46	49	4C	45	20	42	55	46	46	45	52
BD0	1F	20	3C	59	3F	4E	1F	00	20	4D	40	C9	59	D0	06	0D
BE0	14	40	4C	EA	43	29	00	0D	14	40	30	63	40	0D	0A	41
BF0	55	54	4F	20	4C	45	54	54	45	53	20	4D	4F	44	45	1F
C00	30	3C	59	2F	4F	1E	00	20	4D	40	C9	59	D0	06	0D	17
C10	40	4C	19	44	29	00	0D	17	40	30	63	40	0D	0A	4C	49
C20	51	54	20	54	40	45	30	46	49	4C	45	20	42	55	46	46
C30	45	53	3F	30	3C	59	2F	4E	3E	00	30	4D	40	C9	59	D0
C40	01	20	4C	41	30	43	40	0D	0A	3A	3A	0D	0A	00	4C	74
C50	44	A9	00	0D	10	40	30	75	45	AF	01	40	E0	42	D0	01
C60	30	5A	42	AE	10	40	EC	19	40	B0	09	EC	1A	40	90	11
C70	C9	20	D0	0D	A9	0D	20	3C	40	A9	0A	20	2C	40	4C	51
C80	44	C9	0A	F0	0C	C9	0D	D0	02	A9	20	20	2C	40	EE	10
C90	40	AE	17	40	F0	07	C9	20	D0	01	0D	13	40	4C	56	44
CA0	70	AD	0F	40	AE	10	40	85	FA	04	F0	A0	FF	90	C0	91
CB0	FA	20	E4	41	AD	11	40	E4	FA	D0	F4	AE	13	40	E4	FE
CC0	D0	ED	91	FA	0C	15	40	0C	14	40	AD	0F	40	AE	10	40
CD0	05	FA	04	F8	A9	1C	A2	40	0D	7C	FA	0F	7D	FA	A9	9D
CE0	A3	42	8D	7A	FA	0E	7B	FA	A9	07	0D	02	FA	A9	3F	0D
CF0	01	FA	A0	00	0D	01	FA	60	AC	15	40	D0	1E	C9	00	F0
D00	1A	AC	14	40	F0	15	A4	FA	CC	11	40	D0	07	A4	F0	CC
D10	13	40	F0	08	A0	00	91	FA	30	E4	41	60	A0	01	0C	15
D20	40	20	A7	41	20	63	40	0D	0A	42	55	44	46	45	53	30
D30	4F	56	54	50	55	54	3F	20	3C	59	3F	4E	3E	00	30	4D
D40	40	C9	59	D0	09	20	45	41	20	45	41	20	4C	41	30	63
D50	40	0D	0A	51	59	53	54	45	4D	30	53	45	51	45	54	3F
D60	30	3C	59	3F	4E	1E	00	20	4D	40	C9	59	F0	01	60	4C
D70	0D	42	4C	3C	40	9A	40	90	40	A6	0E	40	AD	06	40	3D
D80	00	FA	F0	EE	AD	05	40	2D	02	FA	D0	F0	20	4A	46	20
D90	CC	45	80	E0	20	4A	46	A9	40	2D	0D	F0	F0	F9	20	FC
DA0	45	30	CC	45	66	0D	40	CA	D0	F6	30	A9	46	FD	06	40
DB0	AA	4E	0D	40	CA	D0	FA	20	1D	46	A9	40	2D	0D	F9	F0
DC0	F9	66	A0	60	AA	AD	0D	40	0D	63	21	60	AD	05	40	3D
DD0	03	FA	F0	1D	E6	00	40	D0	03	EF	0C	40	A0	40	3D	0D
DE0	F0	F0	69	30	AD	00	40	ED	09	40	AD	0C	40	ED	0A	40
DF0	60	EE	09	40	90	01	66	0A	40	4C	DC	45	AD	04	40	0A
E00	A0	69	1D	40	0D	04	F0	C0	09	1D	40	0D	05	F0	A9	00
E10	0D	09	40	0D	00	40	0D	0A	40	0D	0C	40	60	AD	04	40
E20	0A	A0	69	1D	40	0D	07	40	C0	09	1D	40	0D	00	40	4E
E30	00	40	4E	07	40	40	00	40	6E	07	40	AD	07	40	0D	04
E40	F0	AD	00	40	0D	05	F0	4C	00	46	AD	04	40	0A	A0	E9
E50	1D	40	0D	07	40	C0	09	1D	40	0D	00	40	4C	35	46	A3
E60	00	A0	00	D1	00	91	03	00	D0	F9	E6	01	E6	03	CA	D0
E70	F0	40	A9	00	A3	E0	95	00	06	01	A9	00	A3	40	05	02
E80	06	03	20	5F	66	4C	00	FC	A9	00	A3	00	05	00	06	01
E90	A9	00	A2	40	05	02	06	03	20	96	06	4C	1D	1C	A2	09
EA0	A0	00	01	00	91	03	00	D0	F9	66	01	E6	03	CA	D0	F0
F00	60															

into an EPROM which should be plugged into socket IC4 on the Junior expansion card.

As the DOS Junior has a storage capacity which differs from that of the expanded Junior, the program for it has been put into an EPROM which should be plugged into socket IC4 on the Junior expansion card.

In the expanded Junior the program is stored from Ø8ØØ to ØFFF; in the DOS Junior, between E8ØØ and EFFF. Before the program can be started, it must be transferred from the EPROM to the RAM. The required transfer procedure are already contained in the EPROM. The addresses for the various transfer procedures are given in table 3.

After transfer of the program, some bytes have to be changed by hand as shown in detail in table 4 (DOS Junior) or table 5 (expanded Junior).

After these amendments, the program can be started: it is possible to copy it from the RAM onto an audio cassette or floppy-disc (DOS Junior) for simpler re-use at a later date.

Readers who want to program the EPROM themselves will find the Hexdump listing in table 6. ◼

electronic aerial switch

simple and loss-free

from an idea by
C. Abegg

Many radio- and TV-amateurs have often wished they had a simple means of switching from ona aerial to another. The normal solution is to do this by means of plug and socket arrangements, because a loss-free switch for changing aerials is not as simple as it sounds. This article shows that aerial switching is possible without introducing losses into the signal paths.

1

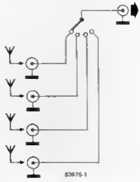


Figure 1. At medium- and short-wave frequencies, a normal switch can be used, but this would not be satisfactory at VHF and UHF.

2

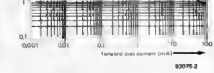


Figure 2. Characteristic of RF resistance vs forward bias current of a typical PIN diode.

The problem revolves around the losses caused by a mechanical switch. At relatively low frequencies (medium- and short-wave) such losses are not serious, but in the VHF and UHF bands they become a nasty problem. Even so, the most obvious and by far easiest way of selecting one of a number of aerials is by means of a mechanical switch as shown in figure 1.
There is, however, a means of obviating the disadvantages of a mechanical switch at high frequencies and that is by using PIN diodes which are ideal for this purpose.

PIN diodes

What are PIN diodes? Briefly, they are special switching diodes of which the most important property is a very low self-capacitance while at high frequencies they are virtually purely resistive. The resistance can be varied between 1 and 10,000 Ω by means of a direct current, the so-called forward bias current, as shown in figure 2. It is clear from this figure that the resistance of such a diode changes linearly over a wide range of values of current. This characteristic is ideal for a number of applications: by varying the forward bias current, the PIN diode can be used for the attenuation, equalisation or even amplitude modulation of high frequency signals; by switching the forward bias current, pulse modulation and phase-shifting of high frequency signals becomes feasible.
In the aerial switch described here, the PIN diodes are used in a simple way: as a high frequency switch. The forward bias current is set relatively high and, apart from this current, the only requirement is a switch. Figure 3 shows how this works: when the switch is closed, the diode conducts; when the switch is open, the diode is cut off.

Circuit description

Using PIN diodes, the switching between four aerials does not, therefore, present a real problem. All that is required is a current supply, a 4-position switch and four PIN diodes (see figure 4).
In practice, there is, of course, a little more to it, but not much, as can be seen from the complete circuit diagram in figure 5. The required forward bias current can be obtained from a normal +12 V supply (mains transformer, bridge rectifier and stabiliser IC, for instance). LEDs D5 . . . D8 are connected in series with the supply to give a ready indication which aerial has been switched in.
Depending upon the position of switch S1, the forward bias current first passes through one of the LEDs, subsequently through one of the chokes L1 . . . L4, then through the relevant PIN diode (D1 . . . D4) and finally to earth via choke L5 and resistor R1. This latter resistor determines the value of tha current; at 680 Ω, as in figure 5, the current is 15 mA which is sufficient to ensure reliable switching of the diodes and satisfactory lighting of the LEDs.
Capacitors C1 . . . C4 and C9 are necessary

to prevent DC appearing at the input and output of the circuit. Chokes L1 . . . L5 prevent the HF signal leaking to earth via the power supply line. Capacitors C5 . . . C8 decouple the power supply line for HF. Resistors R2 . . . R5 ensure that the anodes of the diodes not in use are earthed so that mixing of the various aerial signals is impossible.

Construction

In view of the small number of parts, the construction of the electronic aerial switch is a fairly simple matter. The only point which needs watching is that all wiring must be kept as short as possible to ensure satisfactory operation.

Chokes L1 . . . L5 can be wound on a ferrite bead: using enamelled copper wire of 0.3 mm diameter, two turns will suffice for UHF and five for VHF inputs. It is, of course, possible to buy them ready-made: 1 μH is required for UHF and about 5 μH for VHF.

The circuit has been designed for aerial input impedances of 50 . . . 75 ohms. Isolation between the various inputs is not less than 30 dB. Although the loss caused by switch S1 is minimal, the PIN diodes will deteriorate the noise factor of the receiver a little, but this will not be more than 1 dB.

3

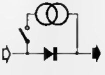


Figure 3. Principle of PIN diode switch.

4

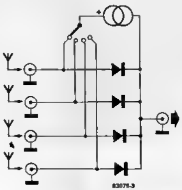
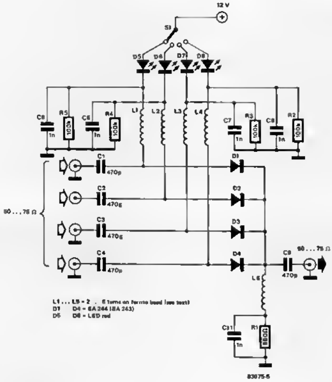


Figure 4. Aerial switch using PIN diodes. With the use of a 4-position switch and a power supply, one of the diodes can be switched on as required.

5



parts list

Resistors:
R1 = 680 Ω
R2 . . . R4 = 100 k

Capacitors:
C1 . . . C4,
C9 = 470 p ceramic
C5 . . . C8,
C11 = 1 n ceramic

Semiconductors:
D1 . . . D4 = PIN diode BA 244
D5 . . . D8 = LED, red, 5 mm

Chokes:
L1 . . . L5 = see text

Miscellaneous:
S1 = switch, 1-pole, 4-way
aerial input and output connectors

Figure 5. Complete circuit of the electronic aerial switch. LEDs D5 . . . D8 indicate which aerial has been switched in.

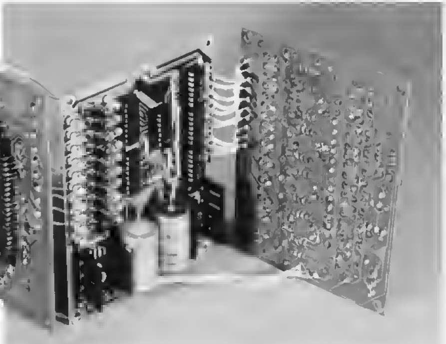


Photo 1. This illustrates the method used for interconnecting the three printed circuit boards. This enables all the boards to be freely accessible.

spectrum display

a graphical frequency spectrum display

We are all familiar with the usual line-o'-LEDs type of display that is so beloved by the manufacturers of contemporary Hi-Fi equipment. They are very pretty and, if interpreted correctly, do their job very well. However now that every 'solid state' meter is a series of different-coloured LEDs, either verticel or horizontal, the whole 'LED display' theme is becoming a bit old hat. But where do we go from here?
This erticle points the way! The display here consists of ten vartical columns providing an indication of not just the power output of the Hi-Fi system but the peak levels of ten frequencies throughout the audio spectrum. The displey does not consist of row upon row of LEDs but one special fluorescent displey metrix. This makes construction far simpler and provides a very professionel appearence.

A spectrum display is really a sort of super VU meter with the advantage that peak values for a number of frequencies can be seen in a graphical form. Apert from being aesthetically appealing it can be very useful. A problem with magnetic recording tape is that it saturates more readily at higher frequencies than at lower frequencies. A spectrum display used for a recording meter would thus give a very good indication of exactly where in the frequency spectrum the peaks are occurring. Other uses spring readily to mind, such as a power meter and, of course, a VU meter, but its real attraction will be . . what is it . . . a fairly useful something to look at!
At this point it must be stated that the circuit has no pretentions to being e high performance spectrum analyser. The circuit for an instrument of this type is far more complex and would require far more critical components than are used in the design here. However, the performance is surprisingly good and, as the prototypes proved, is accurate to about 5%.
The display consists of ten columns having nominal centre frequencies of 32 Hz . . . 16 kHz. The signal strength is indicated vertically in 14 discrete steps of 1.4 dB. The resulting matrix therefore contains 10 x 14 = 140 points and could be constructed using 140 LEDs. However, the current consumption of a display matrix of this size using LEDs would be fairly

10 frequencies:
32-63-125-25-500-1 k-2 k-4 k-8 k-16 kHz
Amplitude read-out in 14 discrete steps of 1.4 dB
Input sensitivity:
90 mV . . . 1.8 V
Input impedance:
47 k

high. Construction would be fraught with a few problems and the overall finished appearance would leave a lot to be desired. All these disadvantages are overcome by the use of a fluorescent display that contains the correct number of picture dots (or pixels) and, of course, one such 'animal' does actually exist – the DM4Z from Futaba. With 10 vertical columns of 14 pixels, it could almost have been made to order . . . !

Design fundamentals

The block schematic of figure 1 illustrates the basic sections of the circuit. The incoming signal is divided into 10 frequency bands by the 10 band-pass filters with the centre frequencies mentioned earlier. The output of each filter is followed by a simple rectifying circuit consisting of a diode and a capacitor and then fed to a 10 into 1 multiplexer. The multiplexed output signal is fed to 14 comparator stages which also act as the driver stages for the 14 horizontal lines of the display matrix. A 1 into 10 multiplexer drives the 10 columns of the matrix. Both the multiplexers are clocked with a common clock signal to ensure that they are always exactly in step with each other. This means that the 10 into 1 multiplexer always connects that filter to the comparator stages that correspond to the column selected by the 1 into 10 multiplexer. Therefore a number of pixels in each column will light depending on the conditions of the 14 outputs of the comparator stages. In essence, the number of pixels lit in a column will depend on the voltage level across the capacitor in the rectifier stage following the filter corresponding to that column.

So far so good, but the circuit itself is not quite that simple because we now require 10 band-pass filters, 10 rectifier circuits, 2 multiplexers and their clock oscillator, 14 comparator stages, a power supply and, of course, the display itself. However, before despair sets in, construction is vastly simplified by the use of printed circuit boards.

The band-pass filters

As only ten centre frequencies are to be displayed it is not necessary for the band-pass filters to have very steep slopes. This is definitely an advantage because only the simple active filter circuit shown in figure 2 is required. This is a filter with multiple path feedback in which the Q factor, the amplification and the centre frequency can each be selected by the choice of 3 resistors R1, R2

1

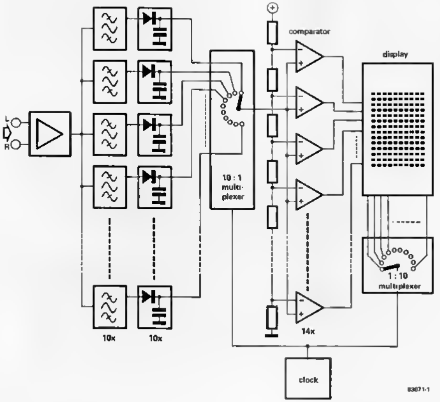


Figure 1. The block schematic diagram of the Spectrum Display. The input signal is divided into ten frequencies by means of band-pass filters, rectified and taken to a multiplexer which feeds the ten voltage levels sequentially to a comparator. The comparator drives the lines of the display while the columns are controlled by a second multiplexer.

and R3, and capacitor C. The formulae for the filter are given in figure 2. The amplification of the filter is set at 7 dB and the Q factor at about 3. No special components are used in the circuit and therefore some small deviation of the centre frequency and the Q factor can be expected but this can be ignored. The frequency response curves for the filters are shown in figure 3.

The circuit diagram

The complete circuit diagram for the spectrum display will be found in figure 4. At first sight it may appaar to be rather complex but, as we already know, most of it is just repetition.

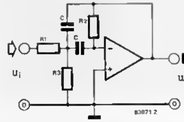
The input circuit is formed by op-amp A1 which is arranged as a mixer-amplifier. Both the left-hand and the right-hand signal are connected to the related input terminals: the output of the op-amp then contains the sum of these two signals. It is, of course, possible to connect a mono-signal to one of the two input terminals; the other terminal can remain 'open'. The amplification of A1 can be adjusted between 0 dB and 13.5 dB. At maximum amplification, the input sensitivity of the stage is 90 mV.

The output of A1 is connected to the inputs of the ten band-pass filters, A2 . . . A11. The centre frequency of filter A11 is about 32 Hz, that of A10 around 63 Hz, and so on, until that of A2 is around 16 kHz. The output signals of the filters are rectified and smoothed by diodes D1 . . . D10, resistors R34 . . . R43 and capacitors C23 . . . C32 respectively.

The 10-to-1 multiplexer which follows is a 'discrete' design consisting of ten analogue switches ES1 . . . ES10. These are driven by the output of counter IC13, of which more later. The outputs of all analogue switches are connected together and terminated in R45 and potentiometer P2. The total value of R45 plus P2 determines the discharge time of the capecitor which at any one moment is connected to R45 and P2 via one of the switches. Each of these capacitors could have been given its own discharge resistor, but in this way a saving of nine resistors is made and, in addition, it has become possible to set the discharge time of all capacitors by means of only one potentiometer. The value of the potentiometer determines the decay time of the meter, that is, the speed with which a column drops after an indication.

The multiplexed signal is then taken to a

2



centre frequency $f_0 = \frac{1}{2\pi C}\sqrt{\frac{R1+R3}{R1\,R2\,R3}}$

gain at f_0 $-A_0 = \frac{R2}{2R1}$

Q-factor $Q = \pi\,R2\,C\,f_0$

bandwidth $B = \frac{1}{\pi\,R2\,C}$

Figure 2. This shows the circuit of the active band-pass filter. The centre frequency, the amplification and the Q-factor can all be set seperately by the correct values of resistors R1 . . . R3 and capacitor C.

3

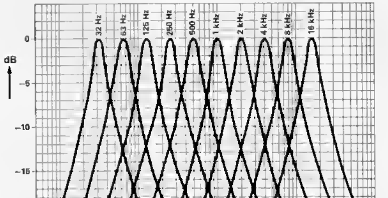


Figure 3. The frequency characteristics of the ten band-pass filters.

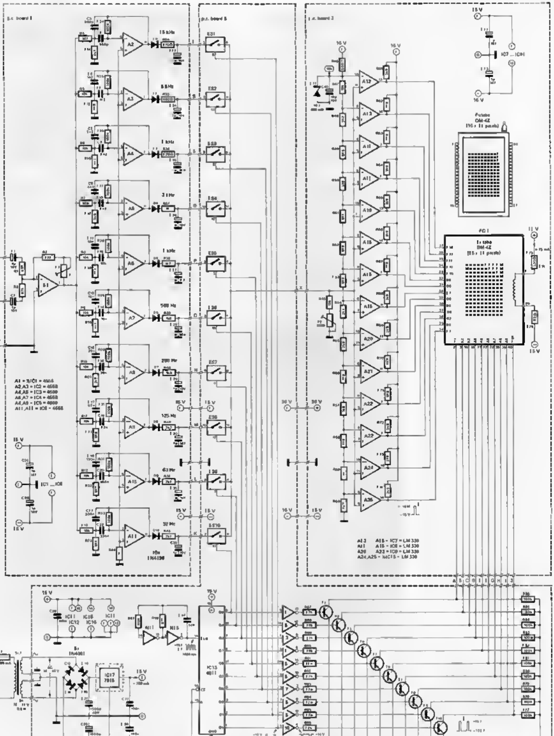


Figure 4. The complete circuit diagram of the Spectrum Display. Which parts of the meter are located on each of the three boards is indicated by the hatched line.

14-stage comparator, A12 . . . A25. The voltage at the non-inverting input of each op-amp, that is the multiplexed signal, is compared with a reference voltage at the inverting input of the amplifier. The reference voltages are derived from 10 V DC which in turn is derived from the 15 V supply by means of R46 and zener diode D11. The reference voltages for the op-amps are obtained from a voltage divider consisting of R47 . . . R60.

5

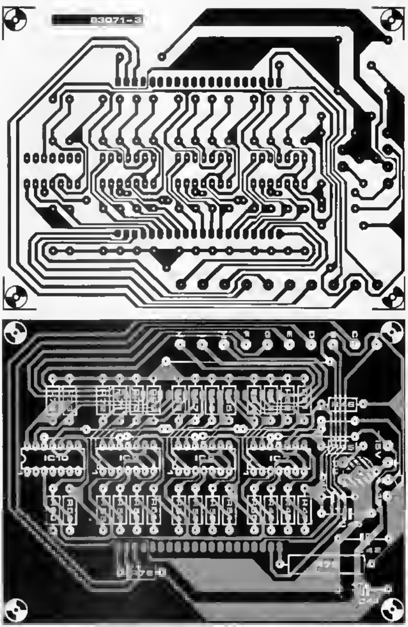


Figure 5. The component layout and track pattern of the printed circuit board for the filters and signal rectifiers.

Parts list

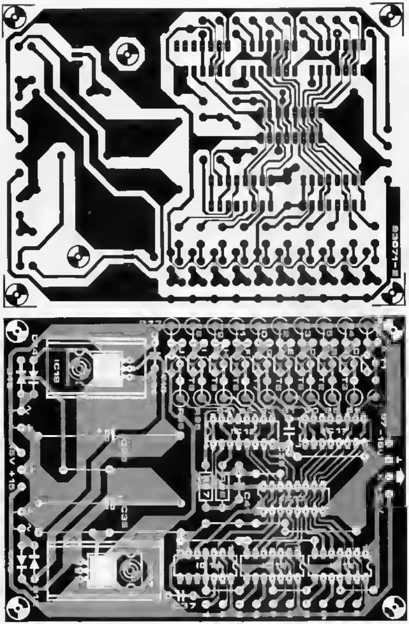
Resistors:

R1 . . . R3 = 47 k
R4 . . . R13,R45,
R47 = 10 k
R14,R16,R19,R51 = 4k7
R15,R17,R20,R22,R52,
R60 . . . R74 = 3k9
R18,R21,R23,R43,
R53 = 3k3
R24 . . . R33, R77 . . . R86,
R97 = 100 k
R34 = 470 Ω
R35,R46 = 680 Ω
R36 = 820 Ω
R37,R44,R59 = 1 k
R38,R58 = 1k2
R39,R57 = 1k5
R40,R56 = 1k8
R41,R55 = 2k2
R42,R54 = 2k7
R48 = 8k2
R49 = 6k8
R50 = 5k6
R75 = 330 Ω/5 W
R76 = 33 Ω
R87 . . . R96 = 22 k
R98 = 33 k
P1 = 1 M preset potentiometer
P2 = 100 k preset potentiometer

These resistors are normal, commercial types which results in the logarithmic division not being exactly the same value for each step (the average step value is 1.44 dB, but individual steps may vary between 1.3 and 1.8 dB). For this application, it is not necessary to spend more money on high-precision resistors.

Comparators A12 . . . A25 have an open-collector output which is why each of these outputs is connected to the positive supply line via one of the resistors R61 . . . R74. These resistors should be ¼ W types as their dissipation amounts to .23 W if the output voltage of the op-amp is −15 V. When no input signal is present (0 V at point X), the outputs of all comparators are at −15 V (they are fed symmetrically). This means that all dots of the display are extinguished. If an input signal is present, one or more comparators are inhibited, so that the grids of one or more columns of dots become about +8 V causing the relative dots of those columns to light.

The controlling element in the multiplexing process is IC13 which is wired as a 'ring' counter. This means that a logic 1 travels continuously along its Q0 . . . Q9 outputs at the frequency of the clock counter formed by gates N11 and N12. The '1' appearing at the counter outputs is used to select (or switch on) each of the vertical



Capacitors:
C1,C2,C23 . . . C34,C42, C43 = 1 μ/16 V
C3,C4 = 560 p
C5,C6 = 1n2
C7,C8 = 2n2
C9,C10 = 4n7
C11,C12 = 10 n
C13,C14 = 18 n
C15,C16 = 38 n
C17,C18 = 82 n
C19,C20 = 150 n
C21,C22 = 330 n
C35,C36 = 1000 μ/40 V
C37 . . . C39 = 100 n
C40 = 10 μ/16 V
C41 = 12 n

Semiconductors
D1 . . . D10 = 1N4148
D11 = 10 V/400 mW zener
D12 . . . D15 = 1N4001
T1 . . . T10 = BC557B
IC1 . . . IC6 = 4558
IC7 . . . IC10 = LM339, CA 339, μA 339
IC11,IC12 = 4009
IC13 = 4017
IC14 . . . IC16 = 4066
IC17 = 7815
IC18 = 7915

Miscellaneous.
FD1 = DM-4Z Futaba fluorascent display (Regisbrook)
Tr1 = mains transformer 2 x 15 . . . 18 V/400 mA
F1 = 500 mA slow-blow fuse
heat sink for IC17 and IC18 (36 x 20 x 15 mm)

Figure 8. This printed circuit board contains the multiplexers, the column drivers and the power supply. It should be remembered that the heat sinks for IC17 and IC18 must not touch C37 and C38.

columns of the display. However, it can't do it directly since the fluorescent display is in fact switched between 0 and −15 V and some sort of interface is therefore required. This is conveniently taken care of by inverters N1 . . . N10 and transistors T1 . . . T10 which act as drivers and level translators.

The ring counter also drives the analogue switches ES1 . . . ES10. As already explained in the description of the block schematic diagram, these connections are arranged such that at all times only the band-pass filter corresponding to a driven column is connected to a comparator circuit.

Readers may remember the article on fluorescent displays in our March issue in which it was explained that this type of display operates by means of a filament. The filament current is provided by the symmetrical power supply and limited by R75. Resistor R76 ensures a small positive potential difference between cathode filament and anode and grid which prevents unwanted lighting of the pixels.

A simple power supply is required for the +15 V and −15 V levels and for this the usual voltage regulator ICs are used, IC17 and IC18. The supply is capable of providing a current of at best 250 mA.

7

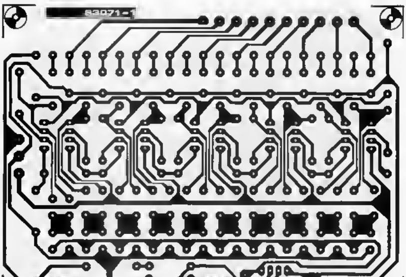


Figure 7. The ten comparators and the fluorescent display are located on this printed circuit board. Both the display and preset P2 are mounted on the foil side of the board.

Construction

The spectrum meter is constructed on three printed circuit boards es illustreted in figure 4. One board contains the filters end rectifier circuits, the second contains the power supply, the multiplexers end the level translators for the column drives, the final board carries the comparators and the display itself. Three boards were decided on in order to keep overall size down to convenient proportions. It elso enables separete sections of the circuit to be used for other purposes, or indeed, further additions such es higher performance band-pass filters if desired.

Construction can be started with the components of the power supply circuit on printed circuit board 2. ICs 17 end 18 must be fitted with heatsinks end care must be taken in their choice with regard to physical dimensions. Too large e size will find capacitors C37 end C38 hanging off the boerd! With just the power supply components mounted on the board, the transformer can be wired up and e check carried out.

The first point to note is that if a transformer with two secondary windings is used it is obviously importent thet they are wired to the board correctly. This is very easy to check by measuring the voltege across the (total) secondary winding. If the reading is ebout zero volts then

simply reverse the connections of one of the secondary windings. The +15 V and −15 V rails can now be verified.
The remaining components on the board and those on printed circuit board 3 can now be fitted. Resistors R77 . . . R96 are mounted vertically saving a great deal of space. The preset P2 and the display are mounted on the foil side of printed circuit board 3. It will be noted that no holes exist in the board for the display and this is quite deliberate. It effectively prevents the pins of the display from protruding through to the component side of the board and causing all sorts of untoward happenings! Even so, mounting the display will present no problem.
The small nipple (via which the display is evacuated during manufacture) must be located at the side of potentiometer P2. The display is then held in position and one or two pins are soldered to the relative positions on the boards. If the display appears to be sited correctly, all other pins can be soldered. After that, the connections between boards 2 and 3 can be made. The interconnections between A . . . J on both boards are made with short lengths of flexible wire; those between 15 V, −15 V, ⊥ and X can be made with somewhat longer pieces of wire (6 . . . 7 cm). The boards can then be folded apart to give good accessibility (see photo 1).
The time has now come to check whether the display will light correctly. First, P2 is set to maximum (100 k) and then a 10 k potentiometer is connected between +15 V and 0 V. The slider of the potentiometer is connected in turn with terminals K . . . T (in that order). With the slider connected to K, the left-hand column of the display should begin to light when the potentiometer is adjusted for a higher voltage; once the voltage is high enough, all 14 dots of the column should light. When this is found to be working correctly, the other columns should be checked in a similar fashion. When all columns are found to be functioning correctly, it indicates that the display-drive, the multiplexers, the clock and the comparators are in good working order.
The remaining board, PCB1, can now be completed. The capacitors C23 . . . C32 and resistors R4 . . . R23 and R34 . . . R43 are mounted vertically. Then terminals K . . . T, +15 V, ⊥ and −15 V are interconnected: the last three preferably by somewhat longer pieces of wire to enable to boards to be 'opened' as in photo 1.
The complete set of boards can now be fitted together like a double sandwich by means of 4BA threaded rods, nuts and spacers as shown in photo 2.

Finally . . .

. . . some further points to note. The circuit contains two preset potentiometers, aptly labelled P1 and P2! The first is used to adjust the input sensitivity while P2 controls the decay time of the display. Preset P2 was deliberately positioned just above the display (and on the foil side of the board) to enable the decay time to be adjusted through a small hole in the front panel above the display window. It is also, of course, possible to use full size potentiometers in place of the presets and mount them on the front panel. It is strongly advised that a screen of some sort is used for the display window. A piece of green perspex for this would probably present the best appearance. In the event that the completed Spectrum Display is too large to be fitted into a desired space, it is possible to mount the display remotely from the circuit boards. An appropriate length of 26 way ribbon cable would be ideal for the interconnection between the boards and the display.
Where is the input connected to? If possible it would be best to use the tape – record – monitor output of the preamplifier where the output level remains fairly constant and is independent of the various controls of the preamplifier. This has the advantage that the input sensitivity of the Spectrum Display need only be set once. If the signal is taken from the preamplifier outputs to the power amplifier stage (the so-called pre-power link) it will be necessary to adjust P1 every time the volume level is altered. Not a happy situation!
It is, of course, possible to build a 'stereo' Spectrum Display. This simply consists of two independent Spectrum Displays and uprating the transformer to an 800 mA type. The two circuits are then fed from the two channels of the tape record output of the preamplifier.
Now for Quadrophonic . . . but thats going a bit too far!

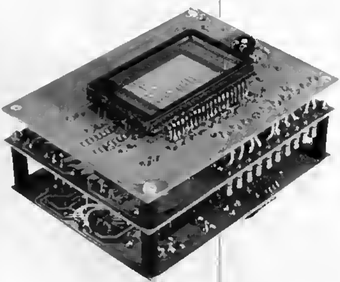
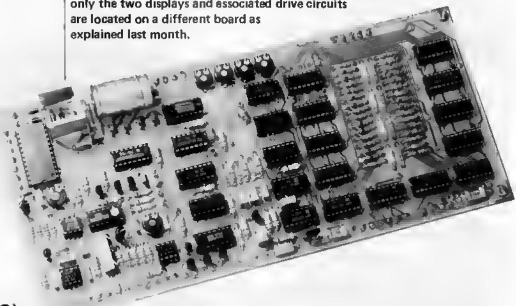


Photo 2. The final construction of the Spectrum Display is illustrated here. It is also possible to mount the display remotely if desired.

Following the description of the complete Maestro remote control and the construction of the transmitter in our May issue, we continue with the construction, fitting and adjustment of the receiver. Virtually the complete receiver is contained on a double-sided printed circuit board; only the two displays and associated drive circuits are located on a different board as explained last month.



(part 2) Maestro

the receiver board

The receiver board is not small, but in view of the complexity of the circuit that is not unexpected: after all, it contains 29 IC's, 15 transistors, 9 diodes and a fair number of resistors and capacitors. The board is shown in figure 1. It is advisable to check the through-plating of the holes (with a resistance meter) before any other work is commenced, because any faults are virtually impossible to find once the board has been soldered.

Construction

After the board has been checked thoroughly, the components can be mounted. All IC's should be fitted in good-quality sockets.

Capacitors C22 and C23 are mounted vertically. The two 7-segment displays and associated driver circuits, resistors and decoupling capacitors are located on the display printed circuit board, the design of which was dealt with in last month's issue.

As explained last month, IC14 can be omitted if the 'extra' functions are not required. If this is the case, IC15, T7 . . . T10, T15, R42, R44 . . . R50, D8 . . . D11, and half of the keyboard for the transmitter (or the 'function select' key) can also be left out. Where T15 would have been located a jump wire must be soldered between the emitter and collector connections.

In part 1 it was described how the display board should be fitted behind the front panel. This board can be connected to the receiver board by an 11-way ribbon cable. The LEDs are connected to the printed circuit board by ordinary single-core insulated wire; D4 . . . D7 have a common cathode connection, D8 . . . D11 a common connection to the + line, and D12 . . . D15 have a common anode connection. The volume counter on the receiver board should be preprogrammed by four jump wires. Note that as this is a CMOS device, none of its inputs should be left floating as this might cause the device to burn out. The receiver diode, which is located behind the receiver window, is connected to the board by two short pieces of wire.

If the power outputs to other equipment are to be used, three relays, Re1 . . . Re3 are needed to switch the mains supply. Diodes D_x, D_y and D_z should be connected directly to the coils of the relays. The relays can be fitted in the case of the Maestro or in the equipment to be powered (where they continue to be driven by the low power signals from the Maestro). The maximum permitted current per relay is 100 mA.

As regards the tape recorder connections, Q1 . . . Q7, there is no cut-and-dried universal layout that will suit every tape recorder. Some tape recorders work by setting some lines to ground, while others connect the relevant lines to +24 V. So there is only one

A word to Prelude constructors:
Printed circuit board designs for the buffer stages described in our May issue will be published in the July/August 'Summer circuits' issue.

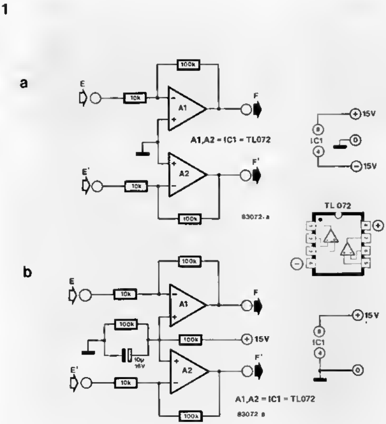


Figure 1. If the Interlude is used without the Prelude, an extra stage of amplification is required. The circuit of such a stage for use with a 15 V symmetrical supply is shown in 1a; in all other cases the circuit of 1b should be used.

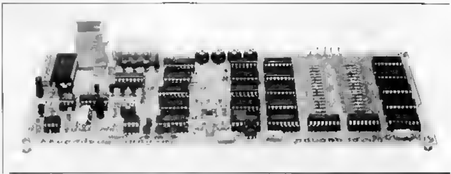
answer to this problem: have a look at the circuit diagram of the tape recorder which is to be controlled and see how each particular function (play, fast forward, record, and so on) is controlled. It may be necessary to design a small interface between the Maestro and the tape recorder. Note that the Q outputs are all logic 1 (+15 V) when the corresponding key is pressed and that these outputs can only deliver a few milliamperes.
Finally, a connector is needed for linking the receiver with the Interlude pre-amplifier. This connector must have at least 9 pins and the sensible thing to do is to use the same kind as is used for the Prelude. The connector is fitted at the rear of the Maestro case and a 9-way ribbon cable used to link the Prelude and Maestro.

Adjustment

Before the Maestro can be used, a few potentiometers must be preset.
After switching on the mains, press the 'on' button to make sure that the unit is not on stand-by. To tune the receiver to the transmitter frequency first set potentiometers P1 and P2 to their mid-positions. Use the remote control to increase and reduce the volume. Turn P1 slowly until a position is found where the display correctly follows the operations of the push buttons (that is, the count on the display increases or decreases immediately the volume up or down button is pressed). Then, watch LED D9 and while pressing the 'power 1 on' and 'power 1 off' buttons alternately, adjust P2 such that the LED reacts properly to which button is pressed.
Next, the output voltages of the D/A converters must be set. Connect the Maestro to the Prelude/Interlude and set potentiometers P3 . . . P6 to their minimum positions. Then set all counters - volume, balance (tone) high end low - to 99 after which the remote control should not be touched until the adjustments have been completed. Connect a voltmeter between test point TP on the Interlude board and output H of the Maestro. Adjust volume control P3 slowly until the potential difference between TP and H is 0 V. Similar adjustments are made with the voltmeter between TP and outputs K, M and L and adjusting balance control P4, (tone) low control P5 and (tone) high control P6 respectively. Once these adjustments have been made, the voltages between each of these outputs and ground should be about 5.4 V. The Maestro can then be boxed up.

Interlude and Maestro

Some readers may want to use the Maestro and Interlude, but not the Prelude, which is, of course, possible but a small circuit will then have to be added on the Interlude



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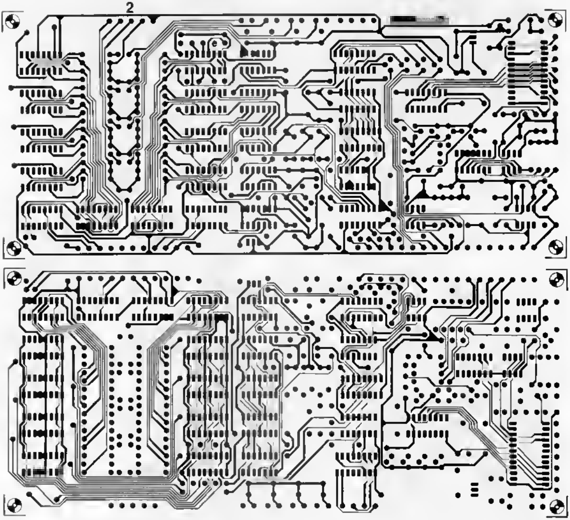


Figure 2. The printed circuit board for the receiver is double-sided with plated-through holes. Its size is an unavoidable consequence of the large number of components used.

printed cicuit board, provided that the power supply can additionally deliver 15 V at 100 mA.

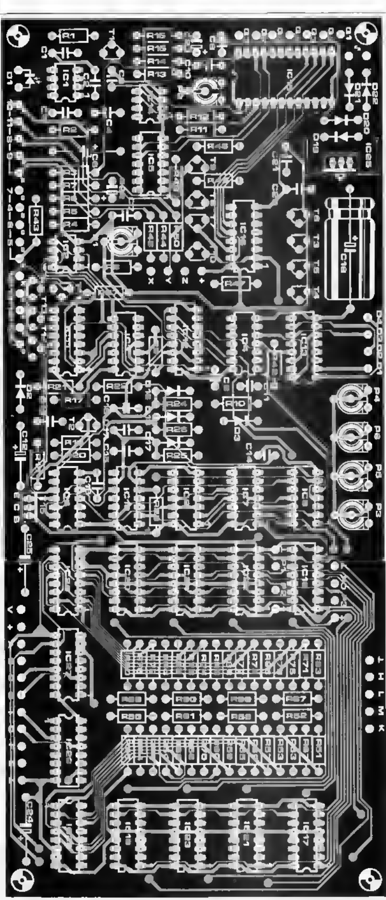
As the Interlude is a unity gain amplifier, an additional voltage gain of 10 is required to obtain an output of 1 V for an input of 100 mV. A suitable circuit for use with a symmetrical supply of ± 15 V is shown in figure 1a; if such a supply is not available, the circuit of figure 1b must be used.

The additional amplifier stage is connected between points E and F and E' and F' on the printed circuit board after resistors R23 and R23' have been removed and resistors R17, R17', R24 and R24' have been replaced by jump wires. The op-amps can be type TL 072, TL 082, RC 1458, RC 4558.

The inputs for tuner, tape and auxiliary can be connected directly to the input bus. Points D1 . . . D4, H, K, L and M are connected to the Maestro by a suitable ribbon cable.

The Interlude and Maestro can be built into one common case but that is a matter of personal choice.

That finishes the construction and presetting of the Maestro; all that remains is to enjoy it! ◼



Parts list: Receiver

Resistors

R1,R9,R10,R11,R17,
R19,R22,R23 = 100 k
R2 = 82 k
R3 = 560 Ω
R4 . . . R7,R13 . . . R16,
R27,R43,R44,
R48 . . R50 = 1 k
R8,R12 = 47 k
R18 = 560 k
R20 = 1 M
R21 = 4k7
R24 . . . R26 = 10 M
R42 = 22 k
R45 . . R47 = 10 k
R51 . . . R62 = 1 M/1%
R63 . . . R66 = 499 k/1%
R67 . . . R70 = 249 k/1%
R71 . . R74 = 200 k/1%
R75 . . . R78 = 100 k/1%
R79 . . . R82 = 49k9/1%
R83 . . . R86 = 24k8/1%
R87 . . . R90 = 15 k
P1,P2 = 100 k preset potentiometer
P3 . . . P6 = 5 k (4k7) preset potentiometer

Capacitors:

C1 = 47 n
C2,C4,C15,C21 = 100 n
C3 = 82 p
C5 = 2n2
C6 = 47 μ/25 V
C7,C10 = 22 n
C8,C14 = 22 p
C9,C11 = 100 p
C12,C24,C25 = 10 μ/16 V
C13 = 470 n
C16 . . . C18 = 220 n
C19 = 1000 μ/40 V
C20 = 330 n
C22,C23 = 1 p/16 V

Semiconductors:

D1 = BP 104
D2,D3,
D16 . . . D18 = 1N4148
D4 . . D15 = LED red
D19 . . . D22,
D_x,D_y,D_z = 1N4001
T1 = BC 560
T2 . . . T6,
T8 . . . T10 = BC 547B
T7,T11 . . . T14 = BC 557B
T15 = BD 679
IC1 = SL 480
IC2 = ML 926
IC3 = 4011
IC4 = 4072
IC5 = 4002
IC6 = 4093
IC7 = 4001
IC8,IC9 = 4025
IC10 = 40106
IC11 = 4556
IC12 = 4555
IC13 = 4042
IC14 = ML 927
IC15 = 4514
IC16 = 4043
IC17 . . . IC24 = 4510
IC25 = 7815
IC26 . . IC29 = 4052

Miscellaneous:

Tr1 = transformer,
15 V/0.8 A secondary
Heatsink for IC25
3 x relays, 12 . . . 15 V,
100 mA max.

The rapidly growing popularity of Video has resulted in an ever increasing string of requests to provida articles for the new band of Video enthusiasts. It is an even more interasting area now that the price of a good video camera is reaching mora affordabla levels. However, it is a relatively new field and good ideas and circuits taka time to formulate.
The articla here is pointed in the right direction and is eimed at readars who find an intarast in making their own video recordings. The circuit anables certain video tricks or special effects to ba used in a vidao recording and provide an extra dimansion that can make a lot of difference.

from an idea by
L. Heylen

video effect generator

box of tricks for video enthusiasts

It is not easy to describe the effects which can be obtained with this generator. It gives the pictures a more 'graphic' character as it were. But that is not the only thing. Depending upon how the generator is edjusted, the effects achieved are reminiscent of trick photograpby.

What is the idea behind this box of tricks? Well, mainly the dividing of the normally continuously variable brightness of the screen into four fixed values of brigbtness. The result is, therefore, not just a black and white picture, but additionally two grades of grey, analogous to a digitalisation of tbe brightness aod contrast.

A second feature, whicb is virtually forced as shall be seen later in the article, is the separate adjustment of brightness and colour saturation. The brightness and colour information are split in the early stages and combined again in tbe later stages of the circuit; the combining can be achieved in a proportion which is undar the control of the operator. By choosing deliberate disproportions, grotesque effects are obtained.

An important remark before technical details are gone into; the input and output of the generator are tuned to standard video signals and it is therefore possible to insert it anywhere in the video chain.

Operation

As usual, the principle of the circuit is best explained with the aid of a block diagram as thown in figure 1.

The video input signal is split into two parts: one part is passed to a colour filter and amplifier, which will be dealt with a little further on, and the othar to a four-stage comparator via a buffer. The comparator arranges the (pre-settable) splitting of the brightness into four levels. The processed signal is then passed to a mixer which re-combines the colour and brightness information.

At first sight it may appear unnecessary to filter out the colour information, only to edd it again at a later stage, but there is a good reason for this. If the colour were not filtered, the four-stage comparator would also affect the colour information. The sync signal is protected likewise for the same reason: a sync separator takes the sync signal from the buffer and applies it to a second mixer stage where it is re-combined with the rest of the signal.

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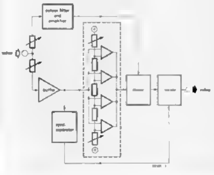

Figure 1. Block schematic diagram of the video effect generator. The information contained in a video signal is dissected into information regarding tha brightnass, information as to colour and information about the synchronisation. After the brightness information has been processed, the three bits of information are re-combined in two mixer stages.

Circuit dascription

The blocks shown in figure 1 can be recognised in the circuit diagram of figure 2: A1 is the buffer with input derived via LEVEL control P1 and its output applied to comparators K1 . . . K4. The comparators divide the originally continuously variable brightness into four fixed levels.

The sync separator is formed by comparator K5. Clamping diode D1 ensures that the output of A1 is always positive with respect to the reference voltage of comparator K5. The sync signal lies roughly in the bottom quarter of the video signal and is separated from it by K5. Diodes D2 . . . D5 and potentiometers P3 and P5 form the preset reference voltage supply for the four-stage comparator.

Transistor stage T3 is the colour filter and amplifier; its input level is set by potentiometer P2 and its output is taken to the inverting input of mixer A2. This stage filters and amplifies frequencies in the range 4.43 ± 1 MHz. The amplification is necessary to ensure retention of the information of the original signal.

The four-level output of comparators K1 . . . K4 is also applied to mixer A2 and there mixed with the colour signal from T3. The output of A2 is applied to a second mixer, T2, together with the sync signal from comparator K5.

The output of the generator is best connected

2

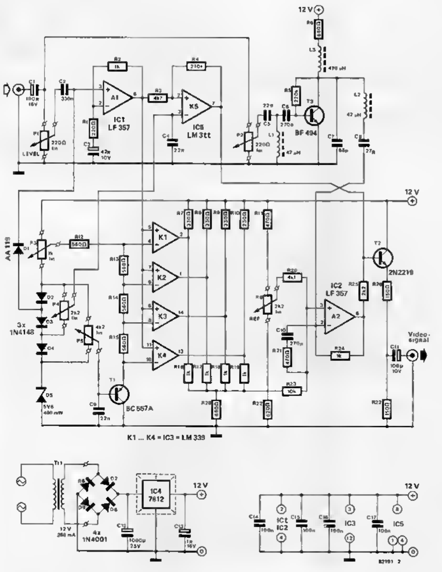

Figure 2. Circuit diagram of the video effect generator. The change of continuously variable to (four) fixed level brightness control takes place in comparators K1 . . . K4. Synchronisation signals are separated by K5, while T3 separates and amplifies the colour information. The complete video signal is reconstituted in mixers A2 and T2.

to the video input of a television receiver, but if such an input is not available, it can be fed to the aerial input via a VHF/UHF modulator.

Adjustment

The functions of the various potentiometers are;

P1 = setting of the input level (sensitivity);
P2 = setting of the colour saturation;
P3 and P5 = setting of the reference voltage for comparators K1 . . . K4;
P4 = setting of the reference voltage for comparator K5;
P6 = setting of operating point of mixer A2.

1. Set all potentiometers to their mid position.
2. Connect the generator to the television receiver and switch on the mains supply.

The input signal should preferably be a test card.

3. Adjust P4 until the picture on the television screen is still.
4. Set the reference voltage for K1 . . . K4. If four levels are not attainable, the input signal is too weak and the input sensitivity thould be increased by P1.

If the picture quality is poor, this may be due to overloading: the input level thould then be reduced by P1.

5. Increase the input signal by means of P1 and adjust P6 to thet position where the largest possible input signal can be processed without undue distortion.
6. Finally, sat the required colour saturation with P2.

NOTE: After every change of input sensitivity, it is recommended to readjust the sync level with P4.

morse and radio teletype (RTTY)

This articla gives a theoretical introduction to the RTTY decoder faatured elsewhere in this issue. It describes the principle of morse-talegraphy and RTTY in soma detail; thair advantages and disadvantages are considared carefully as are other not so well-known tachnical features. Advanced radio amataurs and listenars will find many useful hints whila others may be tempted by that fascinating hobby which brings the whola world into thair homes: listening to morse and RTTY messagas on short waves!

all about those dots, dashes and pulses

Apart from radio telephony, that is, tha spoken word, there are other 'wireless' ways of conveying a message: radio telegraphy (morse) and radio teletype (RTTY). It all started with telegraphy and it is still true today that radio communication over long distances is more reliable by morse and RTTY than by telephony: in situations where the spoken word becomes unintelligible through interference or other circumstances, telegraphic or RTTY signals can often still be received satisfactorily.

Some history

The first wireless experiments by Marconi at the turn of the century were carried out with the use of the dot-and-dash code invented by Samuel Finlay Morse in 1843 and since called after him, morse code. The idea to represent letters and numerals by a dot or a dot-and-dash code was, however, not first thought of by Samuel Morse, because messages were conveyed by tha rhythmic interruption of light and smoke signals hundreds of years before he was born. It was he, however, who first used the idea in telegraphy by wire and it was also he who devised a usable alphabet and number system in morse code (see figure 12).
Radio teletype was born from tha need for greater speed in the conveying of messages and that for decoding and typing of received messaga automatically; morse was not really suitable to meet these needs. But then, morse was intended for hand-operation, easy recognition and to be learnt fairly quickly by operators; clearly, Samuel Morse did not consider automation.
In teleprinter codes, unlike the Morse code, each combination of characters forming a letter, numeral, punctuatinn mark and so on, is of the same length as measured in units (often called bits but this can give rise to confusion with the binary digit) or in milliseconds of time.

The difference between morse telegraphy and RTTY

The main difference between morsa telegraphy and RTTY lies in the timing: morse is characterized by so-called relative timing, RTTY by absolute timing. In morse operation, the proportion between dots and dashes, between dashes and pauses, and between dots and pauses is all-important. The absolute length of the dots, dashas and pauses depend on the proficiency of the operator. Small deviations from the standard lengths do not matter, because the operator 'at the other end' recognises the pattern.
In RTTY this is completely different: the timing is fixed, in othar words, the length of the units is accurately known and does not vary. As will be seen later, this is of paramount importance for the satisfactory functioning of automatic (mechanical or electronic) decoders.
When RTTY equipment was first used, it soon became apparent that switching the carrier on and off in the rhythm of the code was far from ideal. Because the most frequently used code, even today, is based on 5 units and all combinations of these have a meaning, errors can easily occur.

Frequency shift kaying

To eliminate as many of these arrors as possible, frequency shift keying (FSK) was introduced. In this system the carrier frequency bas two values: the first (normally higher) frequency is called a mark and represents logic 1; the second (normally lower) frequency is called a space and represents logic 0. The difference between the two frequencies is called the frequency shift.
Frequency shift keying can be considered as amplitude modulation of a carrier, where the modulating signal is a square wave and the depth of modulation is 100 per cent. A square wave consists of a sinusoidal fundamental and harmonics, in which the ratio of the harmonics depends upon the duty cycla of the square wave. A symmetrical square wave has only odd harmonics. Tha frequency spectrum of a carrier amplitude modulated by a symmetrical square wave to a dapth of 100 per cent is shown in figure 1. It is immediately clear that steps have to be taken to limit the bandwidth. In practice this is achieved by connecting an

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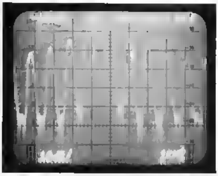

Figure 1. Frequency spectrum of a carrier amplitude-modulated by a symmetrical square wave of 1 kHz to a depth of 100 per cent.

2

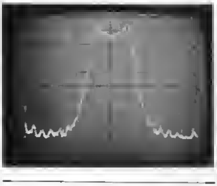

Figure 2. Frequency spectrum of a carrier frequency-modulated by a sine wave of 10 Hz at a deviation of 100 Hz.

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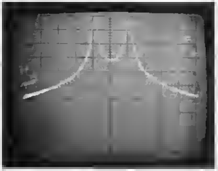


Figure 3. Frequency spectrum of a carrier frequency-modulated by a square wave of 10 Hz at a deviation of 100 Hz.

RC-filter between the key and transmitter. Transmitters with too broad a spectrum are recognisable by the key-clicks, in the rhythm of the code, just off-tune.
The spectrum of a frequency-modulated carrier is shown in figure 2. The modulating signal is a sine wave of 10 Hz and the deviation is about 100 Hz. It is evident that the greater part of the energy lies between $f_c - f_d$ and $f_c + f_d$, where f_c is the carrier frequency and f_d is the deviation. The frequency shift is twice the deviation.
What happens when the modulating signal is changed from a sine wave to a square wave can be seen in figure 3, from which it is clear that the peaks are much better defined than in figure 2. The reason for this is that the transit time from logic 1 to 0 or vice versa is very short, so that little energy is transferred in the region $f_c \pm f_d$. The slopes of the signal are, however, less steep than with sine-wave modulation, so that steps need to be taken to make the handwidth acceptable. This can be done in two ways: either by a band-pass filter or by rounding the slopes of the modulating signal.
It is seen from the above that FSK can be considered as a carrier which is frequency modulated by a square wave or as a combination of two carriers which are switched on and off sequentially. The second consideration is perfectly acceptable as long as the modulation index (the ratio of the frequency deviation to the frequency of the modulating signal) is greater than 1. This can be seen from the illustration in figures 4 . . . 6.

Demodulation of morse telegraphy and RTTY signals

The reliability of morse telegraphy is directly proportional to the proficiency of the operator. An experienced person can 'copy' a garbled message which would be incomprehensible to a novice, and in this respect an electronic circuit can be considered a novice. The human brain, with its enormous store of information, can, even when there is doubt, more often than not reach the correct conclusion. Human beings also make use of an important property of language: redundancy, which means that there is normally more information available than is necessary to come to a decision or understanding. In other words, even when some of the information is missing, the rest will still enable us to understand the original message perfectly. These human characteristics make morse telegraphy, in spite of all that has been said, the cheapest and most reliable but one method of wireless communication (the repeat request – RRQ – radio teletype system described later in this articles is more reliable than morse operation).
The block diagram of a typical morse telegraphy demodulator is shown in figure 7; it consists of a band-pass filter, an amplifier, a rectifier and a trigger. Automatic gain control (AGC) is also often incorporated. The circuit of such a demodulator presents certain difficulties. The filter should have a pass band of the order of 100 Hz and filters with such steep-sloped characteristics are fairly complicated and thus costly. The most suitable filters are built from delay elements. The delay, that is the time taken by the signal to pass through the element, is frequency dependent. At the centre frequency of such a filter each element delays the signal by one half cycle. After passing through two elements, the signal at that point is in phase with the input signal and if these are added together, there is effective amplification of the original signal. At frequencies where the two signals are 180° out of phase, adding them together would cause effective attenuation. Thus, by careful choice of the delay elements, any desired selectivity can be achieved.
The great advantage of this technique is the ability of the delay elements to block spurious signals effectively; the signal is gradually 'built up' in the filter, whereas unwanted signals are too short for any build up to take place. As the signal takes a finite

time to pass through the filter, its frequency should not change during this time, otherwise the aimed-for phase relationship will not be achieved. These filters will soon be available in digital form as integrated circuits.
For the detector a diode circuit will suffice if the filter has good selectivity, although synchronous demodulation is better because of its greater immunity to interference. Such demodulation is normally effected by a phase-locked loop (PLL) which has a dynamic characteristic of not less than 30 dB: this makes AGC superfluous.
The trigger circuit must differentiate between signals of high and low logic levels. To reduce the effects of spurious signals, the detector output should be integrated. The circuit will only trigger if the signal lasts long enough to cause a logic 1. The use of e voltage or current controlled integrator enables the integration constant to be defined by a microprocessor on the basis of the speed of the received signal.

Frequency or amplitude modulation?

RTTY was initially taken as consisting of frequency-modulated (FM) signals and was therefore demodulated in a discriminator. It was argued that this would result in an improvement of the output signal exactly es FM broadcast reception sounds mucb better, in general, than AM. Nowadays, this argument is accepted by only a small minority.
In the high frequency bands (1.6 ... 30 MHz), propagation phenomena occur which affect the path times of a transmission (one path, for instance, is reflected by the E layer of the ionosphere, another by the higher F layer). One of the effects of two waves of the same signal traveling by two different paths to the receiver is interference fading. Another effect is tbat of selective fading which occurs when some frequencies are more attenuated than others due to phase-shifting.
FM signals suffer quite badly from these effects ans this is worsened by increasing the frequency deviation, which is often done because FM theory is that the gain in signal to noise ratio is directly proportional to the frequency deviation/baud rate ratio.
Photographs taken from a spectrum analyzer show that, in most cases, it is more correct to treat FSK as e combination of two keyed carriers. The narrow bandwidth then depends only on the baud rate and no longer on the frequency deviation; at the same time it ensures greater rejection of spurious signals. An RTTY demodulator (normally called e TU – terminal unit) continues to function satisfactorily even if one of the carriers, each of which contains the same information, disappears, due to fading, for instance. The block diagram of a typical TU for FM operation is shown in figure 8. The signal is

4

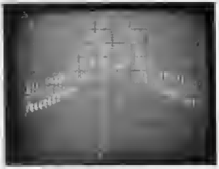


Figure 4. Frequency spectrum of a carrier frequency-modulated by a square wave of 25 Hz at a deviation of 100 Hz.

5

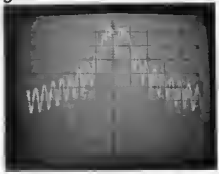


Figure 5. Frequency spectrum of a carrier frequency-modulated by a square wave of 50 Hz at a deviation of 50 hz.

6

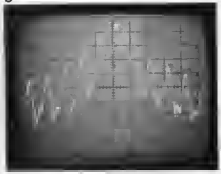


Figure 6. Frequency spectrum of a carrier frequency-modulated by a square wave of 100 Hz at a deviation of 50 Hz.

7

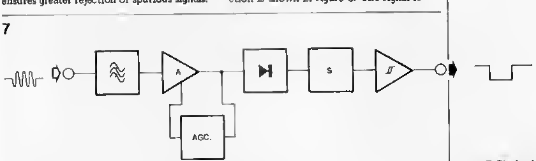


Figure 7. Block schematic diagram of a typical morse telegraphy demodulator.

8

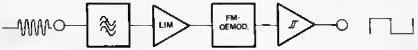


Figure 8. Block schematic diagram of a typical FSK demodulator for FM operation.

9

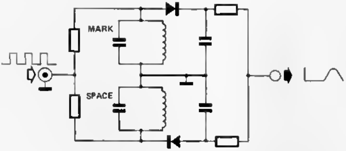


Figure 9. Circuit diagram of a frequency modulation discriminator often encountered in terminal units.

10

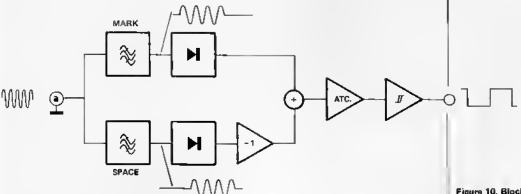


Figure 10. Block schematic diagram of a terminal unit operating as an amplitude modulation detector.

filtered, limited and then applied to a discriminator which is oftan of the 'true FM' type as shown in figure 9. A PLL would not be suitable because often there is no reliable relationship between marks and spaces, and the loop would then, of course, frequently be out of lock. A PLL is really only suitable if there is a guarantee that it will not get out of lock, for instance, when the frequency shift is small (85 Hz and 170 Hz are frequantly used values on HF) or if operation is on VHF (30 . . . 220 MHz) where propagation is predictable.
The block schematic diagram of a TU operating as an AM detector is shown in figure 10. Separate filters are used for marks and spaces and ara followed by the detectors proper. The outputs of the detectors are complementary, because when a mark is present, spaces are absent, and vice versa (see figure 11). If one of the signals disappears temporarily, the output of the adder circuit will be only half the normal value. This is, however, sufficiant to drive the automatic threshold corrector (ATC) which restores the input to the trigger circuit to its correct value. The temporary absence of a mark or

11

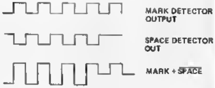


Figure 11. Idealised marks, spaces and combinations of them.

space is therefore unnoticeable at the trigger output. As the ATC is such a simple but effective circuit (a couple of diodes, resistors and capacitors) there are few tarminal units in use today without one.

Influence of the code on transmission

A code is nothing more than an agreement to process information in a certain way before conveying such information. Language is therefore a sort of code for the exchange of ideas and feelings. An important aspect of any code is redundancy. The simplest way of ensuring redundancy is repetition. This can, however, only be used if it is possible to detect whether an error has occurred. The international morse-code characters are given in figure 12, while figure 14 shows the 5-unit Baudot and the 7-unit Moore codes. Proficient operators can often detect, and rectify, errors in the received morse-coded signals, but this is not possible with the Baudot code.

The Baudot code is the first developed RTTY code; it is an asynchronous code whicb means thet the receiver is not synchronized with the transmitter by means of a clock. To make synchronization possible, the transmitter sends an additional, clock-controlled unit which is used to control the receiver clock. The onset of a character is indicated by a start unit which is of the same duration as a data unit. The start unit is always logic 0 and therefore corresponds to a space. The start unit is followed by the 5 data units. As the receiver and transmitter may not have kept in perfect unison, they must be re-synchronized after the last data unit: this is done by means of a stop unit. Older RTTY equipment worked at much lower speeds than their modern electronic counterpart and it was therefore perfectly acceptable to make the stop unit equal to 1.5 data unit. In modern equipment this has been brought down to 1 unit, so that all units (data, start, stop) are now of equal duration. This makes for much better synchronization of the clocks and therefore reduces the error rate. There are now a large number of RTTY stations whicb transmit Baudot-coded signals with only one stop unit. Asynchronous operation in which all units are of the same duration is called isosynchronous.

The baud rate is the inverse of the unit duration. For a (frequently used) baud rate of 50, the data and start units are then 20 ms and the stop units 20 or 30 ms. The baud rate itself does not give any indication of the speed with which the data are being sent. Of the 7.5 units used in Baudot (see figure 13), only five carry data and the data/unit rete is therefore $(5 \div 7.5) \times 50 = 33$ units per second.

As the possibility of an error increases with every unit, this explains why in HF traffic the Baudot code is preferred over the ARQ Moore code or ASCII (American Standard Code for Information Interchange; an 8-unit standard code for the exchange of data between machines).

One source of errors in the Baudot code lies in the so-called shift function, which is analogous to the typewriter shift from lower to upper case. The maximum number of characters attainable with 5 units is 32, which is not sufficient to cope with all the letters of the alphabet, numerals and punctuation marks. Tha shift function is therefore used to indicate when numerals and punctuation marks are coming in; when lettere are coming in again, the shift has to be reset. The troubles encountered with this method are such that press agencies process all text in lettere only: five for '5',

12

A	·—	Period .	·—·—·—
B	—···	Comma ,	——··——
C	—·—·	Colon :	———···
D	—··	Question mark, or request for repetition of a transmission not understood ?	··——··
E	·	Apostrophe '	·————·
F	··—·	Dash or hyphen -	—····—
G	——·	Fraction bar /	—··—·
H	····	Parenthesis (before and after words) ( )	—·——·—
I	··	Quotation marks (before and after words) "	·—··—·
J	·———	Equal sign =	—···—
K	—·—	Understood	···—·
L	·—··	Error	········
M	——	Cross or end-of-telegram or end-of-transmission signal	·—·—·
N	—·	Invitation to transmit	—·—
O	———	Wait	·—···
P	·——·	End of work	···—·—
Q	——·—	Starting signal (beginning every transmission)	—·—·—
R	·—·		
S	···		
T	—		
U	··—		
V	···—		
W	·——		
X	—··—		
Y	—·——		
Z	——··		
A (German)	·—·—		
Å or A (Spanish-Scandinavian)	·——·—		
CH (German-Spanish)	————		
É (French)	··—··		
Ñ (Spanish)	——·——		
Ö (German)	———·		
Ü (German)	··——		
1	·————		
2	··———		
3	···——		
4	····—		
5	·····		
6	—····		
7	——···		
8	———··		
9	————·		
0	—————		

Figure 12. The International Morse code.

13

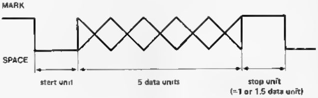


Figure 13. The composition of a Baudot character consisting of a start unit, five data units and a stop unit.

hyphen for '–', and so on. Where the alphabet in use is more extensive than our Latin-based one, these problems are even more pronounced.
A large improvement is the ARQ (Automatic RaQuest) 7-unit Moore code given in figure 14 which makes possible error detection (and eventual correction). This code which is fully synchronous (no start and stop units) gives 128 possible characters. If only those combinations are considered which give a ratio of four marks to three spaces, or vice versa, 35 characters remain available, which means that the shift function is still required. It is now, however, possible to test whether the ratio of marks to spaces is 3:4 and, if not, corrective action can be taken. In the case of one transmitter and one receiver, the transmitter is asked to repeat the part of the message where the ratio was found wanting. In the case of one transmitter and many receivers, the message is normally repeated after a certain period of time so that the original message can be compared with the repeat.
These forms of RTTY are used more and more frequently. The system where a repeat is requested is more reliable than morse operation, and it is fully automatic. The only indication of poor reception is when the buffer capacity of the receiver is exceeded. This system is gradually replacing morse communication. The system whereby message are automatically repeated after an interval of time is slowly but surely taking over from Baudot-coded traffic.

General principles of decoding

In general, the bits emanating from the demodulator are far from perfect. The deficiencies are caused by: (a) the pulse duration does not correspond to the reference time because the transmission rate has changed, and (b) spurious signals have distorted the data. The decoding algorithm must be capable of 'ignoring' these shortcomings, which is particularly difficult in morse decoders, because the unit duration in morse operation varies. The method used is to measure the bit duration, that is, to count it, and compare it with the reference time. If the measured time is greater than half the reference time, the bit is accepted as 1, if not, as 0. This method is used in the RTTY decoder described elsewhere in this issue, and also in the Elektor Baudot receiver program where it yields very good results. This further illustrates the importance of constant unit duration.
A further problem with Baudot traffic is that the start unit must be demodulated correctly. After switch-on, the receiver is ready for the transition from 1 to 0. As soon as this happens, the counting procedure starts. If during the counting procedure it should appear that for whatever reason the start unit has been 1 for more than half the reference time, a false start is assumed and the terminal reverts to stand-by. In this way, a computer will detect a false start before the start unit is finished.
In morse decoding, the microprocessor must determine and memorise the shortest bit duration at the onset of the message and then ignore, or compensate for, smaller durations. The Elektor morse decoder, as well as the RTTY decoder, have an integrator which determines the integration constant by means of an adjustable current. The setting of the current value determines the width of pulses which are to be rejected.
Synchronous systems depend on clocks for reliable operation: synchronisation is effected by means of special signals in accordance with internationally accepted regulations. The clock at both terminals is controlled by a stable, highly accurate quartz oscillator which is either thermostatically controlled or connected in a temperature-compensated circuit. Once synchronisation has been established, the two clocks are locked for a considerable time.
The decoding of RTTY signals assumes a knowledge of the baud rate: the increasing popularity of morse-telegraphy and RTTY receivers on the market is promting many stations to use non-standard baud rates. Commonly encountered rates in the HF bands are 45/50/57/100 bauds per second.

14

5-Unit Baudot Code 1	2	3	4	5	LETTERS	FIGURES: International	W.U.	Military	TWX	Weather	ARQ 7-Unit Moore Code 1	2	3	4	5	6	7
O	O	–	–	–	A	–	–	–	–	↑	–	–	O	O	–	O	–
O	–	–	O	O	B	?	?	?	5/8	⊕	–	–	O	O	–	–	O
–	O	O	O	–	C	:	:	:	1/8	O	O	–	–	O	O	–	–
O	–	–	O	–	D	Idf	$	$	$	↗	–	–	O	O	O	–	–
O	–	–	–	–	E	3	3	3	3	3	–	O	O	O	–	–	–
O	–	O	O	–	F	Opt		!	1/4	→	–	–	O	–	–	O	O
–	O	–	O	O	G	Opt	&	&	&	↘	O	O	–	–	–	–	O
–	–	O	–	O	H	Opt	#	Stop	Stop	↓	O	–	O	–	–	O	–
–	O	O	–	–	I	8	8	8	8	8	O	O	O	–	–	–	–
O	O	–	O	–	J	Bell	Bell	'	,	↙	–	O	–	–	–	O	O
O	O	O	O	–	K	(	(	(	1/2	←	–	–	–	O	–	O	O
–	O	–	–	O	L	)	)	)	3/4	↖	O	O	–	–	–	O	–
–	–	O	O	O	M	.	.	.	.	.	O	–	O	–	–	–	O
–	–	O	O	–	N	,	,	,	7/8	Φ	O	–	O	–	O	–	–
–	–	–	O	O	O	9	9	9	9	9	O	–	–	–	O	O	–
–	O	O	–	O	P	0	0	Ø	0	Ø	O	–	–	O	–	O	–
O	O	O	–	O	Q	1	1	1	1	1	–	–	–	O	O	–	O
–	O	–	O	–	R	4	4	4	4	4	O	O	–	–	O	–	–
O	–	O	–	–	S	'	'	Bell	Bell	Bell	–	O	–	O	–	O	–
–	–	–	–	O	T	5	5	5	5	5	O	–	–	–	O	–	O
O	O	O	–	–	U	7	7	7	7	7	–	O	O	–	–	O	–
–	O	O	O	O	V	=	;	;	3/8	Φ	O	–	–	O	–	–	O
O	O	–	–	O	W	2	2	2	2	2	–	O	–	–	O	–	O
O	–	O	O	O	X	/	/	/	/	/	–	–	O	–	O	O	–
O	–	O	–	O	Y	6	6	6	6	6	–	–	O	–	O	–	O
O	–	–	–	O	Z	+	"	"	"	+	–	O	O	–	–	–	O
–	–	–	O	–	Carriage Return						O	–	–	–	–	O	O
–	O	–	–	–	Line Feed						O	–	O	O	–	–	–
O	O	O	O	O	Letters						–	–	–	O	O	O	–
O	O	–	O	O	Figures						–	O	–	–	O	O	–
–	–	O	–	–	Word Space						O	O	–	O	–	–	–
–	–	–	–	–	Blank						–	–	–	–	O	O	O
					———					RQ Signal	–	O	O	–	O	–	–
					———					Idle Alpha	–	O	–	O	–	–	O
					———					Idle Beta	–	O	–	O	O	–	–

Opt = Optional

Idl. = Identification / Answer Back / Who Are You

Figure 14. Teleprinter codes and typical character assignments.

applicator

Mass produced digits, numbers and characters

While searching for a display for the Morse Decoder featured in the May issue, we came across an elegant display system that can be driven directly by a computer and yet uses just one IC.
The display consists of 16 characters each having 16 segments and is fluorescent — a change from the usual LED display. It is controlled by an 'Alphanumeric Display Controller' from Rockwell, the 10937. The fluorescent display and the ADC together form an ideal 16 digit display with the very minimum of components, a fact well illustrated by the circuit diagram in figure 1. In comparison, a similar circuit using discrete components would require 34 transistors and 68 resistors (or 4 . . . 8 buffer ICs).
An even greater disadvantage would be the 34 I/O lines needed between the circuit and the controlling computer — a vast difference from the two (yes, just two) required with the circuit here! One line is required for Clock and the other for Data, what could be more simple? Even with the most basic host computer system (say a 6502, 6532 and 2716), digits and other characters can be displayed with the greatest of ease. Data is transferred from the host computer in serial format. It is initiated by a few control words followed by the ASCII data. Each bit must be clocked in.
In order to obtain a 'running' display, all 16 characters must be stepped along by the microprocessor. The layout of the segments of each character is shown in figure 1. As an example, the letter K is displayed when segments h, g, o, j and l are switched on. The 10937 ADC controls the 16 segments of each of the 16 characters (plus the decimal points and comma tails when needed) by means of Time Division Multiplexing (TDM). Driver stages for all of the segments are included in the IC and the only external components to be added are the pull-down resistors R1 to R34.
Data (8 bit format) at the input of the IC (pin 21) is loaded into an internal display buffer. The segment decoder then translates the contents of the buffer into the segment code for the display. Each data-byte (8 bits) starts with a control bit. If this is logic '0' the remaining seven bits correspond to the ASCII code as shown. If the control bit is logic '1' the remaining bits will be control data.
When in use, the sequence of events

1

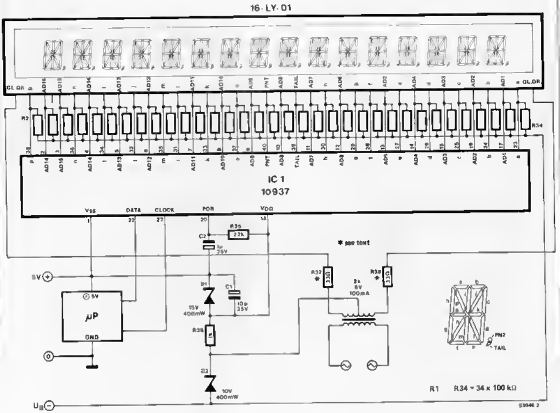


Figure 1. Only one IC is needed to control the display of 16 characters with 16 segments. The ASCII data is entered in serial format from the host computer system. There are only three interconnecting lines, the clock, data and +5 V. It is important that the computer earth is not connected to the circuit.

is as follows. Initially the IC is placed in a 'Power on Reset' condition vie C2 and R35.

- The digit driver outputs AO1 . . . . AD16, all the segment driver outputs and PNT and TAIL ara floating (in the off state).
- The LOAD DUTY CYCLE on time is set to 0.
- The LOAD DIGIT CNTR is set to 16.
- The LOAD BUFFER PTR is set to 15.

The data code for tha first ASCII character can now be entered. Sixteen data words will fill the internal data memory (display data buffer). Before each deta word is entered, the contents of the internal program counter (display buffer pointer) is automatically incremented by 1. This does not apply to the decimal point and comma. These are therefore always associated with the previous charac·ter. If a character is to be generated outside of the normal sequence and all 16 characters are in use, the con·trol word LOAD BUFFER PTR must first be entered. This is not necessary if less than 16 character positions are in use (LOAD OIGIT CNTR is less than 0). The display data buffer is filled to the given number of character positions used (via LOAD DIGIT CNTR).

At this point it will be as well to clarify the functions of the input control data words.

- Tha LOAD DUTY CYCLE, as the name suggests, controls the display duty cycle. This means in effect that the displays can be varied in brightness or turned off altogether. The maximum 'on' time period for each character is 31 clock cycles. This followed by a 1 cycle (typ. 10 µs) 'inter-digit off' time to eneble differentiation betwean two cherecters.
- Tha LOAD DIGIT COUNTER will normally only be used during the initialisation routine to defina tha number of character positions that are to be controlled. If the total is 16 a zero will be antered. If less than 16 enter the number desired.
- The LOAD BUFFER POINTER enables the possibility of mod·ifying e specific character in the display. The internal OISPLAY DATA BUFFER is set to the desired character by entaring the decimal value minus 2 of the character position to be modified. That means that to point to character 6 of the display a value of 4 must be entered. The situation gets even more compli·cated when it is necessary to point to

Display·Deta	ASCII-Cherecter	Display·Deta	ASCII-Charecter
01000000	@	00100000	
01000001	A	00100001	!
01000010	B	00100010	"
01000011	C	00100011	#
01000100	D	00100100	$
01000101	E	00100101	%
01000110	F	00100110	&
0100011t	G	00100111	'
01001000	H	00101000	(
01001001	I	00101001	)
01001010	J	00101010	*
01001011	K	00101011	+
01001100	L	00101100	,
01001101	M	00101101	–
01001t10	N	00101110	.
01001111	O	00101111	/
01010000	P	00110000	0
01010001	O	00110001	1
01010010	R	00110010	2
01010011	S	00110011	3
01010100	T	00110100	4
01010101	U	00110101	5
01010110	V	00110110	6
01010111	W	00110111	7
01011000	X	00111000	B
01011001	Y	00111001	9
01011010	Z	00111010	:
01011011	[	00111011	:
01011100	\	00111100	<
01011101	]	00111101	=
01011110	Λ	00111110	>
01011111	—	00111111	?

Control·Bit   Control·Bit

Teble 1. The coding of the ASCII characters ere listed here. The eigth bit determines whether the code is e control word (1) or an ASCII data word (0).

Teble 2

control word	code
LOAD BUFFER PTR (position of the cherecter to be chenged)	1010XXXX
LOAD DIGIT CNTR (number of digit position)	1100YYYY
LOAD DUTY CYCLE (on/off, brigthness, timing)	111ZZZZZ control bit

XXXX gives the position of the cherecter (4 bit word)
YYYY gives the number of digit positions (4 bit word)
ZZZZZ gives the number of clock periods for which a specific digit is on (5 bit word)

Tabla 2. The coding of the date control words ere given here.

applicator

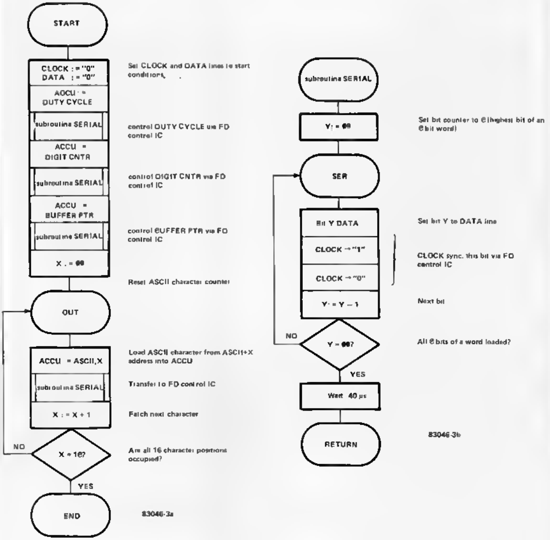


Table 3. With the aid of this flow chart programs can be written to enable ASCII characters to be displayed.

character 1 of the display because $1 - 2 = -1$! In this case, a further calculation is required: 16 (the total number of characters) minus 1 (the -1 of the previous calculation) equals 15. So, in order to point to character 1 the value 15 (hex F) must be entered.

If it is desired, when programming the ASCII characters, to deviate from the normal 'power on reset' conditions, it will be necessary to enter data in the following manner.

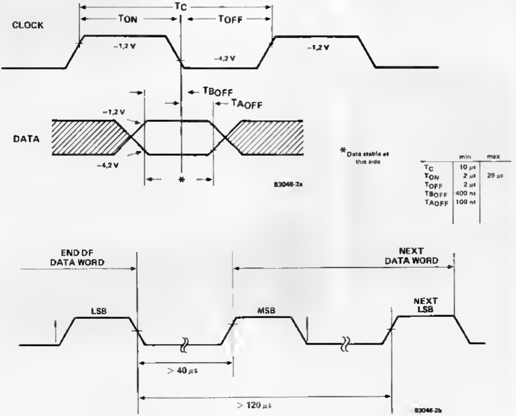
Enter LOAD DUTY CYCLE
Enter LOAD DIGIT CNTR
Enter LOAD BUFFER PTR
Enter the ASCII characters in succession.

Control words can be entered in any sequence. The order of entry is of no concern to the 10937. The coding of the control words will be found in table 2.

A word about timing. Between the end of one data word and the beginning of the next there must be a delay of at least 40 µs. The total time period for entering each data must be at least 120 µs. The timing relationship between signals at the data input and the clock is shown in figure 2.

A point to bear in mind about the hardware. Only the data, clock and +5 V lines are fed from the computer. It is important that the earth connection of the host computer is not connected to the display circuit. The values of resistors R37 and R38 applicator

2



	min	max
T_C	10 μs	
T_{ON}	2 μs	20 μs
T_{OFF}	2 μs	
T_{BOFF}	400 ns	
T_{AOFF}	100 ns	

Figure 2. The timing relationship between pins 21 and 22 of the 10937 are illustrated in the waveforms here.

can be found in the following manner. Before the display is wired in, a 100 Ω 1 watt resistor is connected between the two wires leading to the GL DR points of the display.. The voltage across this resistor is measured and should be about 7.2 V_{rms}. This should result in a value of 33 Ω for resistors R37 and R38 when a 2 x 6 V transformer is used. Variations in the transformer secondary voltage can be taken care of by altering the values of R37 and R38.

If desired a manual reset can be incorporated in the circuit by a push button in series with a 100 Ω resistor across capacitor C2.

To finalise, a few points of note about the software. With the aid of the flow chart in table 3, a program can be writted that will transfer the ASCII characters of table 1 onto the display. Remember that the first character entered will be at the right hand end of the display and the last entered will be at the left. Any spaces that occur (if less than 16 digits are used) will be on the left of the display.

Literature:
Rockwell data sheet — 10937 Alpha Numeric Display Controller.
Futaba 16-LY-01 display and Rockwell 10937 available from: Regisbrook Limited, 215 Kings Road, Reading RG1 4LS.
Telephone 0734 665955.

IC1	driver-voltage	U_B
10937P-20	20 V	−15 V
10937P-30	30 V	−25 V
10937P-35	35 V	−30 V
10937P-40	40 V	−35 V

Input voltage

(relative to +5 V)

	min.	max
"1"	+0,3 V	−1,2 V
"0"	−4,2 V	U_B

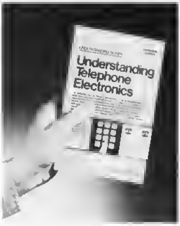
Current consumption: 40 mA max.

Table 4. Supply voltages and the logic levels for the variations of the 10937 IC. These are measured with respect to the +5 V provided by the host computer.

market

Understand telephones

Telephone communication, a century old, is now – with digitisation – moving into its second major phase of development. Helping engineers and others to understand the latest changes is a new book published by Texas Instruments. It is the twelfth title in TI's 'Understanding . . .' series.



'Understanding Telephone Electronics' follows the series' practice by taking the reader step by step from the simplest explanation of telephonic principles through to an intermediate level of telecomms learning. The book covers the technologies incorporated in dialling, ringing, transmission, signalling, switching, digital techniques, modems and cordless telephones. At the end of each chapter is a summary quiz, making the book ideal for self-paced individual learning. It is available at £3.95 per copy (plus £1.50 per order to cover p+p).

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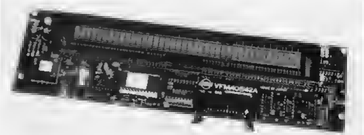

Regisbrook Limited,
Studio House,
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Telephone: 0734 665955 (2693 M)

Acoustic resonators

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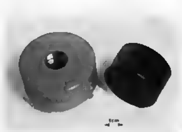

The PKM29-3AO is designed for external excitation (9 V p-p at 15 mA to deliver that rated output mentioned above).

The smaller of the two resonators shown in the photograph, the PKB8-4AO is a self-excited sounder, resonant at 2.7 kHz: which is close to the ear's fundamental resonance, and at the peak of perceived 'loudness'. The unit can be powered from 3 to 20 V, and delivers more than 75 dB at a distance of 1 metre. To put this in context, it would be difficult to hold a conversation within approximately 10 feet of the alerter, when powered from a 9 V source.

Ambit International,
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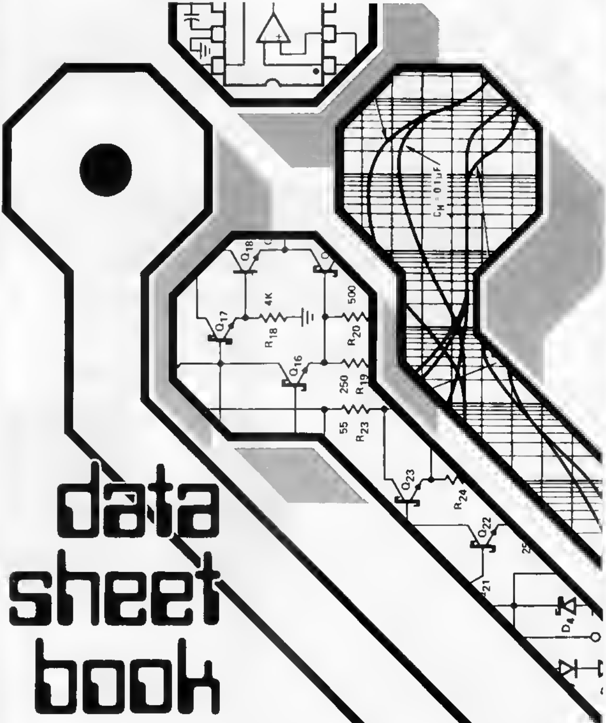

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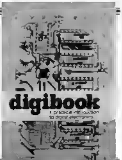

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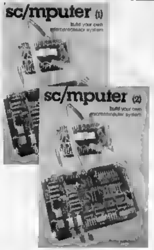

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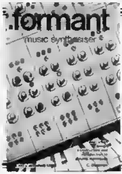

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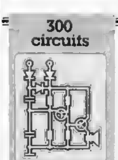

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