AS HI-FI TAKES A GIANT STEP FORWARD WE ASK — HAS THE LP HAD ITS CHIPS?

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CENTRAL HEATING CONTROLLER
SOUNDS GENERATOR FOR ZX81
BURGLAR ALARM PANIC BUTTON
AND MANY MORE!
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All this for just 60p. Order As XA02C (Maplin Project Book Volume 1 No 2). Price 60pNV

Copies of issue 3 are also available for just 60p and include the following projects:

**ZX81 Keyboard.** A full size, full travel 43-key keyboard with the electronics to make graphic symbols, function mode and shift lock, single key selections. The two-colour legend for the keys is the same as the ZX81 keyboard. The keyboard plugs directly into the sockets in the ZX81 and a special adaptor is supplied to run the keyboard from the ZX81 power supply, so there's no soldering in the ZX81 at all. This full-size keyboard gives you fast, reliable entry — use it once and you won't be able to do without it again!

**Stereo 25W MOSFET Amp.** Supplied as a complete kit including wooden cabinet and printed and punched chassis, this superb 25W rms per channel amplifier has inputs for magnetic pick-up, tape deck, tuner and auxilliary. The kit is extremely easy to build, all but 5 components mounting directly on the pcb. There are only 7 interconnecting wires in all and when completed, no setting-up is required. With its superb frequency response, low noise, low distortion and the grandeur of MOSFET sound, the amplifier is second-to-none at the price.

**Radar Doppler Intruder Detector.** Home Office type-approved microwave unit gives coverage adjustable from about 2m to 20m. May be used on its own, or with our Home Security System.

**Model Train Controller Remote Control Facilities.** Full details of infra-red, radio or wired remote control units for our Digital Multi-Train Controller.

Issue 3 also included features on the VIC20 Colour Computer, Working with Op-Amps Part 2, Making Your Own PCB's and our regular feature series: Basically BASIC, Starting Point, news of the Atari computer and video game and lots more.

All this for just 60p. Order As XA03D (Maplin Magazine Volume 1 No 3). Price 60pNV
A NEW CATALOGUE FOR 1983

At the same time that this magazine hits the news stands our new catalogue for 1983 will be available. It will be on sale in all branches of W.H. Smith from about 17th November for just £1.25. For 392 pages this represents a page-for-page price increase of just 2½% over two years. Considering that inflation topped 15% a year during that period, we're sure you'll agree that the Maplin catalogue is still incredible value for money.

Consequently in this issue of the magazine, the price list in the centre has been re-ordered for use with the new catalogue. If you don't have a copy yet, you can still use the price list with your old catalogue by looking under the appropriate section heading. If the item you are looking for is no longer in the list then it has probably been discontinued as only a few items have been moved from one section to another.

In the new year our dial-up service will be available allowing you to access our computer stock file. In the meantime a service is available that will allow you to test out the modem project. Just dial (0702) 552941 and you will be able to access our computer. The computer is usually available from 9 a.m. to 7 p.m. Mondays to Fridays. For our trade customers we are introducing a new service that will provide quantity prices if required. If you want to buy the quantity (shown in brackets in the price list) or more then we can offer very competitive prices. And the more you buy, the better the price will be. Take advantage of our quantity price discounts now. Just write to or phone our sales desk.

We've got dozens of exciting new projects lined up for 1983 as well. The most popular project from our first year was the ZX81 Keyboard and our other computer add-on projects were also extremely well-received. We will therefore have lots of new projects on this theme through 1983. In addition we have lots of other novel projects under development and we're sure you'll find your new subscription well worth the money.

November 1982 to February 1983 Vol. 2 No. 5

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December 1982 Maplin Magazine
THE MAPLIN MODEM

This modem will enable a home computer or VDU to communicate with other computers using CCITT standard tones, over the telephone. This means that you will be able to exchange programs with other people and in particular have direct access to the Maplin computer to order components etc. A modem works by converting the data input of marks and spaces, to two different audio frequencies. These audio tones are transmitted down the phone line to the other end where they are converted back to a digital signal by the modem.

So that data can be sent in both directions, four different frequencies are used, two for each direction. In order that two modems can communicate, one must be switched to the originate mode, which transmits 980 and 1180 Hz, and the other must be switched to the answer mode and transmits 1650 and 1850 Hz. Each modem receives the alternate pair of frequencies to those which it transmits.

The lower frequency is the mark condition in each case and it is usual for the terminal that makes the call to be switched to the originate mode. To prevent interference between the two directions of communication, filters are needed to pass the required frequencies in each direction. Although the frequency shift is only 200Hz, the required bandwidth of these filters depends upon the baud rate. At a baud rate of 300 baud and sending alternate marks and spaces, the first sidebands occur +/-150Hz from the carrier which is located midway between the mark and space frequencies. Therefore the minimum bandwidth for the filters is 300Hz.

Unfortunately a signal passing through a filter is delayed in time. All frequency components of the signal should be delayed equally, or jumbling and smearing of the data occurs. This is known as intersymbol or interbit interference. Minimising the delay distortion minimises the interbit interference. This is relatively easy over the centre 2/3 of the passband, but keeping the delay constant near the band edges is difficult, if not impossible to achieve. For this reason the bandwidth is widened. To maintain minimum delay at 300 baud requires an overall bandwidth of 400Hz. The overall performance of the modem is mainly dependent on the response of the filters, particularly the receive BPF (band pass filter).

Circuit

Two specialised IC's are used in this modem, the first is the 4412VP which is used to generate the required frequencies from a 1 MHz crystal. This IC is capable of transmitting American or CCITT standard frequencies, but pin 14 is earthed for the CCITT standard. The IC is switched between originate and answer by earthing pin 10 for the originate mode. The following pins are permanently earthed. Pin 15 which enables internal pull up resistors, reset pin 5, and pin 13 to inhibit a 2100 Hz tone which is normally transmitted for disabling line echo suppressors. Pin 12 is a carrier disable pin, no tone is transmitted.

by Harold Godwin

Figure 1. Modem block diagram
transmitted when this is earthed, but this facility is not used at present. Data is input to the IC on pin 11 and the audio tone is output on pin 9. The modulator output is an approximated stepped sinewave of 8 amplitude levels. Although each step is optimised so that the waveform has a maximum amount of signal energy at the fundamental frequency, a large number of harmonics are produced. For this reason, and to limit the transmitted bandwidth, the output is buffered by TR1 and passed through the transmit filter. The transmit filter, consisting if IC2 and associated components, is switched between originate and answer frequencies by TR3, 4, and TR1 switches the 4412VP.

There are two methods of connecting a modem to the phone system: acoustic coupling or direct electrical connection. Acoustic coupling has the advantage of being electrically isolated and easy to connect. However, there are problems, one is trying to exclude room noise, particularly if operating in a noisy environment. Another is the fact that the transmit tones will be heard in the telephone receiver considerably louder than the tones that are trying to be received. Although the receive filter would reduce this, there is a problem when operating in the originate mode. When transmitting a mark frequency of 980Hz, harmonics of 1950Hz will be heard in the telephone receiver considerably louder than the tones that are trying to be received.

The receive filter consists of IC4, 5 and associated components. It is switched between the originate and answer frequencies by TR5 to TR8. IC6 is an 8 pole Chebyshev filter and provides 35db of attenuation of the alternate channel. The overall gain of the filter is about 20db (less when receiving 1550 to 1950Hz). Close tolerance components are required for the filters and the resistor values are made up from two resistors in the majority of cases. IC6 is used as a variable gain amplifier to adjust for different receive levels. The output signal is rectified by D3 and used to control TR9 which acts as a variable impedance, adjusting the proportion of the output signal fed back to pin2. D4 and D5 limit the signal fed to IC7 to about 1.5V p to p.

Phase locked loop

Originally it was planned to use the demodulator section of the 4412VP to decode the received tones. Unfortunately the demodulator has been optimised for 200 baud when receiving CCITT tones, so in order to work at 300 baud it was decided to use an XR2211. This IC is a phase locked loop system especially designed for data communication. Referring to the block diagram for this IC, the input signal applied to pin 2 is amplified, limited and fed to the loop phase detector and quadrature detector. The output from the loop phase detector, at pin 11, is a DC voltage proportional to the phase difference between the VCO (voltage controlled oscillator) and the input signal. This voltage is filtered by C18, R46 and applied to pin 12 to control the VCO frequency. This locks the VCO onto the input signal and the control voltage at pin 11 is dependant on the incoming frequency over the tracking range of the VCO.

The control voltage is filtered by R45, C23 and compared with an internal reference voltage. As the input frequency changes the control voltage above and below the reference voltage, the data output on pin 7 changes. The reference voltage is decoupled by C22 on pin 10, and C19, R47, R48, RV1, RV2 determine the free running frequency of the VCO, which is set midway between the mark and space frequencies. The VCO frequency is switched between originate and answer mode by TR10.

The quadrature phase detector compares the VCO and the input frequency and outputs a voltage when the VCO is locked to the input frequency. This voltage is filtered and drives the lock detect outputs. IC8 is a monostable which drives the lock detect LED and is gated with the data output from IC7. This allows data to be received only while the VCO is in lock and prevents spurious data filling the screen when there is no input signal.

**Figure 2.** XR2211 block diagram

December 1982 Maplin Magazine
S1 switches the modem between originate and answer modes, and S2 switches between full-duplex, half-duplex and test positions. Full-duplex working allows data to be sent in both directions at the same time. Normally S1 is set to echo so that the senders terminal switches to originate and answer modes, and S2 is set to monitor exactly what was received at the far end. Normally this means that the data received at the far end is sent back to the senders terminal so that it can monitor what was received at the far end. If the data is not echoed back, the modem may be switched to half-duplex. This connects the transmit data via IC9a to the receive direction so that the transmitted data is displayed as well as that received. Obviously data cannot be sent in both directions at the same time as garbled information would be displayed. Note also that a mark condition must be received from the other end to allow the local data to be received via IC9b. The test position switches the BPF and IC7 to receive the same frequencies that are being transmitted locally. This allows the modem to be checked in local via the duplex line. This position could also be used to monitor a simplex transmission, when no signal is being received from the other end. D10 and D11 monitor the receive and transmit data respectively and are lit for a mark condition. IC10 drives the TTL output and TR11 to TR13 convert TTL levels to RS232 interface voltages of ±12V. At the transmit side D7 and D8 limit the RS232 voltages and IC9d gives TTL level out. The strap must be connected if the RS232 input is used, otherwise IC10 pin 11 is the TTL input. The power supplies of +5V, +12V and -12V are supplied by the three low power regulators and associated components. R1 reduces the power dissipation in the +5V regulator.

Construction

There are two PCB's to be assembled, the main modem board and the power supply unit. These are printed with the component overlay to make assembly easier. Starting with the modem board, the resistors should be fitted first. It is suggested that the values are checked against the circuit diagram, as a wrong value in the filters would affect the response and would be difficult to find. Next the capacitors should be fitted, checking that C15, C21 and C33 are the correct way round. It is recommended that IC holders are used and these are fitted next, but the IC's not yet inserted. The leads to the 1MHz crystal are bent so that the crystal lies flat against the PCB. The transistors and diodes are fitted next, checking that they are the correct type and the correct orientation. This leaves just the potentiometers, fuseholder and wire links to be fitted as shown on the legend. The power supply board is assembled in the same way, following the PCB legend.

A suitable case should be chosen from the wide range available that can take the two PCB's and transformers. The front panel should be drilled for the four LED's and switches. The front panel circuit diagram should be mounted on the front panel or at the back as desired. The two transformers should be mounted apart from each other to avoid mains hum. Two connecting sockets will be required to connect to the line and the computer. These are left for the constructor to choose.

The modem PCB plugs into a 24 way connector and is wired up as shown in fig. 5. Lengths of sleeving should be used over the socket connections to prevent short circuits. It is important that the feet are the correct way round, to prevent the PCB being plugged in the wrong way. When the wiring has been completed, the fuses can be inserted and the modem powered up without the IC's in. The power supply voltages should be checked to each IC socket and if correct, the modem switched off. Allow a few minutes for the capacitors to discharge and then insert the IC's and the modem can be tested.

Setting up and Using the System

The modem can be used with any computer that has a RS232 serial interface or the TTL inputs can be connected direct to a UART, if this is available, as on the Maplin VDU. Only 3 wires are needed between the computer and the modem, Tx, Rx data and 0 volts. If using the TTL inputs, these should be kept reasonably short. With S3 unoperated, connect the 2 line connections across the phone line. Normally there are 3 wires from the phone that connect to a terminal block on the wall. The line wires are the Red and the White.

The modem is most easily set up with an oscilloscope as follows. All signals are measured as peak to peak
voltage. The signal at TR1 emitter should be a stepped sinewave of 800 mv. The frequency should change if S1 is operated and if the data input is changed. Check the level at IC2B pin 7. This should be about 8V when S1 is switched to originate, and 6V for answer mode. Dial a '1' from the phone to clear dialtone, operate S3, replace the handset, and D12 should light, showing that the phone line is being held by the modem. Note that no calls can be received while S3 is operated. People ringing the number will get engaged tone. Switch to originate mode and S2 to test. Measure the signal at IC5B pin 7 and adjust RV3 for a minimum signal at this point. Check the signal level at IC3 pin 3 to be around 500mv p-p. Restore S3 to normal and D12 should darken. IC7 has to be adjusted so that the free running frequency is midway between the mark and space frequencies. The easiest method is as follows. Switch to answer mode and test position, sending alternate marks and spaces, adjust RV1 for equal mark-space ratio at IC7 pin 7. Switch to originate mode and adjust RV2 for equal mark-space ratio. Note RV1 must be adjusted before RV2, as RV2 setting is dependant on RV1. Alternate marks and spaces can be sent by sending the ASCII code for 'U' continuously. The repeat key can be used on a VDU or a short program written for the computer that puts the computer in a loop and outputs ASCII(U) to the serial port. The modem is now set up and is used as follows. With S3 normal and D12 unit, dial the number required. When the number is answered, you must decide which end will be in the originate mode and whether half or full duplex working will be used. Switch the modems accordingly and operate S3 at both ends. The handsets can now be replaced at each end and data sent in each direction. The carrier lock LED will light when the tone is received from the other end and the receive data LED shows the data received. When you have finished, S3 must be restored to normal to clear down the call. When calling a British Telecom modem with automatic answer-in, the call will be answered after a few rings and then 1650Hz will be sent. Your modem should be switched to originate and a mark sent back within about 10 seconds or else the modem at the far end will clear down and you will have to call again. Normally when your mark is received, a signing on message is sent giving instructions on using the system.

### PARTS LIST FOR MODEM MAIN PCB

#### Resistors

- All 0.4W 1% carbon unless specified.

<table>
<thead>
<tr>
<th>Resistor</th>
<th>Value</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 - R18</td>
<td>1k ohm</td>
<td>8 off</td>
</tr>
<tr>
<td>R19 - R32</td>
<td>2k ohm</td>
<td>6 off</td>
</tr>
<tr>
<td>R33 - R50</td>
<td>3k ohm</td>
<td>4 off</td>
</tr>
<tr>
<td>R51 - R60</td>
<td>4k7</td>
<td>6 off</td>
</tr>
<tr>
<td>R61 - R69</td>
<td>9k ohm</td>
<td>14 off</td>
</tr>
</tbody>
</table>

#### Capacitors

- All 0.4W 1% carbon unless specified.

<table>
<thead>
<tr>
<th>Capacitor</th>
<th>Value</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>C11 - C13</td>
<td>22uF 450V electrolytic axial</td>
<td>3 off</td>
</tr>
<tr>
<td>C14 - C16</td>
<td>33uF 63V electrolytic axial</td>
<td>3 off</td>
</tr>
<tr>
<td>C17 - C19</td>
<td>100uF 25V electrolytic axial</td>
<td>2 off</td>
</tr>
</tbody>
</table>

#### Semiconductors

- All BC parts are used.

<table>
<thead>
<tr>
<th>Semiconductor</th>
<th>Description</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1 - D8</td>
<td>1N4004, 1N4148</td>
<td>8 off</td>
</tr>
<tr>
<td>TR1 - TR10</td>
<td>2N3904, 2N3906</td>
<td>10 off</td>
</tr>
<tr>
<td>IC1 - IC7</td>
<td>4412VP, 4017, 7404</td>
<td>7 off</td>
</tr>
</tbody>
</table>

#### Miscellaneous

- All 0.4W 1% carbon unless specified.

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1</td>
<td>1MHz MP crystal</td>
<td>1 pc</td>
</tr>
<tr>
<td>Y1</td>
<td>4412 VP</td>
<td>1 pc</td>
</tr>
</tbody>
</table>

### POWER SUPPLY

#### Resistors

- All 0.4W 1% carbon unless specified.

<table>
<thead>
<tr>
<th>Resistor</th>
<th>Value</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 - R7</td>
<td>100k ohm</td>
<td>10 off</td>
</tr>
<tr>
<td>R8 - R10</td>
<td>220k ohm</td>
<td>2 off</td>
</tr>
<tr>
<td>R11 - R12</td>
<td>330k ohm</td>
<td>1 off</td>
</tr>
</tbody>
</table>

#### Capacitors

- All 0.4W 1% carbon unless specified.

<table>
<thead>
<tr>
<th>Capacitor</th>
<th>Value</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 - C10</td>
<td>10nF ceramic disc</td>
<td>10 off</td>
</tr>
</tbody>
</table>

### ADDITIONAL PARTS REQUIRED

- All BC parts are used.

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Switch (Sub. Min Toggle A)</td>
<td>1 pc</td>
</tr>
<tr>
<td>S2</td>
<td>Switch rotary 36</td>
<td>1 pc</td>
</tr>
<tr>
<td>S3</td>
<td>Switch (Sub. Min. Toggle D)</td>
<td>1 pc</td>
</tr>
<tr>
<td>S4</td>
<td>Switch dual rocker neon</td>
<td>1 pc</td>
</tr>
</tbody>
</table>

- All 0.4W 1% carbon unless specified.

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>Fuse 20mm 250mA</td>
<td>1 pc</td>
</tr>
</tbody>
</table>

A complete kit of parts is available for this project. Order As AW99H (Modem Kit). Price £39.95.
This is an explanation of a very simple circuit change for 555 or 7555 timers that improves the precision and stability of variable control over frequency ranges up to 4:1, by adding one extra resistor.

The circuit can be adjusted to work over higher ratios but low-end drift grows exponentially; a need for a wide range of control can be satisfied economically by using this circuit in a 2:1 range to clock a binary counter IC with stage switching with no loss in precision. This extension also allows very low frequencies to be generated without hard-to-obtain or less stable large components, so that the maximum to minimum ratio is very closely and the ratio controls the device.

Resistors: these drift, but they drift together and a need for a wide range of control ratios. There are ways to reduce drift will exceed that of all the other parts; the scale is linear in period, not frequency, and gets very cramped at one end for high control ratios. There are ways to reduce these problems, but the only way to achieve precision is to use a high-cost potentiometer, and a good one will cost more than a crystal.

Another approach is to use the device “control” terminal (pin 5), which lets an external voltage force the 2/3Vcc reference down for a faster cycle or up towards Vcc for a slower one. This works, but for stability a lot of power is needed from the external voltage source. The internal resistors are of silicon, with a ±50% production spread, a worse temperature drift than carbon pots., and a quite high voltage variation. An external resistor chain has to “swamp” these variations by having less than one-tenth the resistance of the internal chain for a start. If the external system includes a 20%-grade pot., its variations need another factor of at least five in waste current. With nominal IC chain totals of 15Kohm and 150K (555 and low-current 7555), a design has to start at 300 or 3000 ohms, and less for any real stability. However, the terminal is useful for very wide but not very steady control. Figure 2 shows a fully-padded circuit, which can be simplified with a high-grade pot.

In this “control” mode, capacitor C is charged towards Vcc as in the original circuit but the upper trip level is varied. This principle can be inverted, keeping the trip point at 2/3 but altering the charging level at source to something less than Vcc. If a 70% source were used, C would take several time-constants to reach 67% instead of less than one. There is a control limit at a source of 67%; below this the cycle never completes, and closes to it drift and noise become problems. The inverted circuit works quite well for small ranges of control, and is shown in Figure 3.

The ra/rt column is a design aid; the whole of the table assumes Rb is very low compared with Ra. If it is not, stability is not affected, but the frequency ratios are changed and need to be worked out for the actual values, or found on plug-board. If a need for a long pulse makes Rc too close to 2Ra, it is better to use a dual IC package with one half as a fixed monostable triggered by the variable half with low Rb.

The design calculations are just as for fixed frequency use except for Rc.

(1) Set Fmax and the wanted control ratio.

(2) The original design formula is turned over into the form

C x RT = Fmax Hz,Mohm,microfarads

1.46

Continued on page 15
Compact Disc is due to be launched by Philips and several other manufacturers in March 1983 along with about 200 different discs mostly from the Philips group labels. Philips got together with the Japanese electronics giant, Sony, some years ago and the two companies then worked together to create the final format. Philips have now licensed several other manufacturers to make players for Compact Disc and this has ensured that there is only one digital disc system so that you will be able to play any disc on any player. Fortunately we shall not see the crazy proliferation of formats that has bugged the infant video industry - VHS, Betamax and the two Philips formats, to say nothing of Laservision.

The new system is clearly a major breakthrough in sound reproduction as Table 1 shows. Not only does it give almost perfect sound reproduction, but the disc itself is extremely hard wearing. It can be handled quite freely without being damaged at all unlike the microgroove LP which seemed to acquire extra pops and clicks every time you looked at it, let alone touched it. In fact, you could drill a small hole through a Compact Disc (up to about a tenth of an inch (2.4mm) diameter and when played again, there would be no audible difference. Since the discs will...
cost about £8 to £10 each, only a little more than the cost of a good quality classical LP, not many people will be in a hurry to try this out, but it does serve to illustrate just how impervious to damage the Compact Disc is.

Immunity to ordinary handling is achieved by coating the surface on which the data are stored with a layer of transparent plastic. How immunity is given to gaps in the data stream caused by opaque dust, scratches or even holes in the disc we will describe later.

Pocket-sized Discs

The disc itself is relatively small, about 4½ inches (120mm) diameter and comes in a 5 inch square plastic pack with a hinged lid. “Sleeve” notes will be printed on a removable piece of card in the lid of the box. At first almost all the discs available will come from Philips companies: Polydor, Mercury, Deutsche Grammophon, Barclay, Casablanca, London, Archiv, Fontana, RSO, Polystar, Decca and of course Philips. The major American record companies are refusing to pay Philips the royalty they are requesting on each disc made, but since it is only 3 cents (about 1.75 pence) and there is considerable pressure from the world’s top recording artists to have their material available on Compact Disc, there will doubtless be a compromise sooner or later and within a couple of years we should see most LPs available on Compact Disc as well, as soon as they are released.

The disc will hold one hour of audio information on one side. At the present time, the label covers the other side, but it could be used to hold a second hour of recording though the space left for a label (a 17 millimetre (¾ inch) wide band around the hole in the middle) is rather small! The disc could also hold quadraphonic or surround sound information encoded into four channels, though a different player would be needed.

The surround sound player would, however, still be able to play existing stereo Compact Discs in stereo, while surround sound discs would have a message encoded into the data which would tell the surround-sound player to switch into four-channel mode.

First Models

The first generation of players to come on the market can be broadly divided into two types. The Japanese models which use an analogue filter in the output and the European models which, in the main, use a more sophisticated digital filter. The use of a digital filter, since it is physically far smaller than an analogue filter, has enabled Philips to make the smallest player on the market. Coded the CD100, this player will sell for about £400. It will also be available under the Marantz name, since Marantz are wholly owned by Philips. It measures just 320mm wide by 75mm high by 255mm deep (12½ x 3 x 10 inches).

Philips claim that the digital filter
gives superior results to the analogue filter and is more stable and reliable. We will take a look at exactly how the filters work later.

All the players will enable you to select the order in which you want the tracks played, or allow you to pick your favourite track and have it play instantaneously (a boon for deejays) and repeat the selection as many times as you wish.

LEDs on the player, light to show which track is playing and a button allows you to skip to the next track if you don't like the one that's playing. There is a fast search mode, either reverse or forward which will help you find your favourite passage, on for example a classical record, where there may not be separate tracks as such. A pause control is also provided.

Subcoded Messages

Some players will display the elapsed time on a track or how much time is left till the end of the disc. Some companies are planning to market players which when linked to a TV set will display the name of the track playing, or the text of the song, or any other information, the disc manufacturer wishes you to see. Or the information may be displayed on LED's, on the player itself.

But most of that is for the future. At the beginning all the players will be fairly similar in the features they offer. The main differences will be in the styling and here there are 3 main choices. There will be top-loaders, front-loaders where the disc is placed in a tray that pops out, and vertical players.

Once you've got your player home, you'll be able to plug it directly into the
The disc spins in an anticlockwise direction as viewed from the side read by the laser.

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radio or aux input on your amplifier. And then... perfection, or very nearly. At last you will be able to hear the full dynamic range of a symphony orchestra or your favourite pop group. No longer will the sound of a full orchestra be compressed lest the tracks on the LP get so wide they run into one another, or the sound of a single violin be enhanced by close-miking to ensure that the sound exceeds the inherent noise level of the LP material. Now you can hear it in your own home exactly as the composer and conductor meant it to be. From an inky black silence right up to the majesty of an orchestra at full crescendo, that is if your neighbours and your loudspeakers can take it.

Latest Technology

So how is all this magic possible on a disc 120mm diameter and just 1.2mm thick (4% inches by less than a twentiyth of an inch). In the broadest sense it is made possible thanks to the recent advances in digital and laser technology and the incredible scales of integration now possible in single ICs.

The first step is to turn the analogue signals to be recorded into digital signals and there are already quite a number of recording studios which use digital techniques. The digitising system used is called pulse code modulation (PCM). The incoming analogue signal is sampled about once every 22 microseconds and the voltage level detected at that instant, compared against a library consisting of 65,536 levels. Each level has a different 16-bit code and the code for the level nearest against a library consisting of 65,536 levels. Each level has a different 16-bit code and the code for the level nearest the voltage described by the signal will be heard as noise. The best signal to noise ratio possible is equal to 6n + 1.8 dB where n is the number of bits. So in our case the signal to noise ratio will be (6 x 16) + 1.8 or 97.8dB, an order of magnitude better than the best (though rarely achieved) signal to noise ratio possible with an LP.

High Speed Data

The two stereo channels are now combined into one data stream, each 32 bits comprising one left and one right channel sample for the same instant. Thus channel separation is virtually total since each group of 16 bits is completely independent of any other group. This data stream comprising 1.4112 million bits per second is however not suitable as it stands to put onto the disc for several reasons.

The data will be put onto the disc by a laser that will burn a tiny pit about 0.2 micrometres (um) deep and 0.6 um diameter (about 24 millionths of an inch) for each binary zero into the surface of a very thin layer of aluminium embedded in the plastic.

The data will be read by shining a very fine infra-red light beam onto the disc. The pits will scatter the light in all directions whilst the flat aluminium between the pits will reflect the light like a mirror. An infra-red detecting diode will register zero if no light is received (from the pits) and one, when the light is reflected back.

8 To 14 Modulation

The data are recorded in a spiral starting about 25mm from the centre of the disc and continuing to a point about 59mm from the centre. Since there is no contact between the disc and the reading system, the servo-controlled reader can only keep on the correct track if successive zeros are closer together than the pitch of the track. The distance between each track is 1.6 um so if there were two or more ones together the servo would find it difficult to decided where the track continued and could easily continue on the wrong track after a long sequence of ones.

A second reason why the data cannot be put onto the disc as it is, is that after a long sequence of ones the optical detector will have been flooded for a long time and may not turn off fast enough to detect the first zero following a sequence of ones. The detector will read the data at the high speed required much more reliably if the total spectral power is kept low.

The third reason is that since the size of a data bit anywhere on the disc is the same, there are fewer bits in one revolution at the centre of the disc than at the outside. So the disc must spin faster at the beginning (the centre) than at the end when data is being read from the outer tracks. When reading data at the centre the disc spins at about 500 rpm and at the outside about 200 rpm. In order to get the rotation speed
exactly right, it must be possible to detect the bit rate from the data. It turns out that all these requirements are met if there are at least two zeros between any successive ones and never more than ten zeros at one time. There are 16,384 different patterns of 14 bits of which 277 meet the requirements of not less than two zeros between each successive 'one'. Of those, 21 have more than ten consecutive zeros, leaving exactly 256 that meet all the requirements. This is a very convenient number, since there are 256 different patterns of eight bits as well.

The data streams from the 16-bit converters are split into 8-bit sections and each 8-bit byte is converted into a 14-bit word using a look-up table stored in ROM. Three merging bits are added at the end of each 14-bit word so that words can be joined together without violating the two to ten zeros constraint. These bits contain no information and are skipped by the decoder.

Making The Frames

The data are now arranged into frames each starting with a 24-bit synchronisation pattern and containing twelve 16-bit data words (24 14-bit words after encoding) representing 6 stereo samples, four 16-bit error correction parity words (eight 14-bit words after encoding) and one 8-bit control and display word (one 14-bit word after encoding). With three merging bits between each of the 33 14-bit words, one after the sync pattern and one at the end there are a total of 588 bits in each frame.

The eight bit control and display words can contain information, for instance to mark the pause between tracks to implement search and repeat functions, or to indicate remaining or elapsed playing time, titles or composers etc.

![Diagram of Compact Disc decoder](image-url)

Before the data are put into frames the audio data are rearranged in time. This interleaving coupled with the parity words forms a powerful error correction system that can correct a loss of up to 3,500 successive bits and compensate by interpolation, a loss of 12,000 successive bits. The principle of
this system, known as a Cross Interleave Reed-Solomon Code (CIRC) is shown in Figure 1.

In la three consecutive words are missing making it difficult or even impossible to replace the missing words and be certain they are correct. In 1b, however, after de-interleaving, the missing words are spread out in time and there are now only single errors which can be easily corrected. This then is the form the data take that are recorded onto the disc (see Figure 2). It is now the job of the Compact Disc player to recover the data from the disc and reconstruct the original stereo audio signals.

Reading The Data

The player contains an Aluminium Gallium Arsenide solid-state laser diode which emits infra-red light at a wavelength of 780nm, just outside the visible spectrum. The light passes through a half-silvered mirror and then a lens which focusses the beam onto the disc. When a digital "one" occurs in the data, the light is reflected back along the transmission beam, but deflected at right-angles when it hits the half-silvered mirror. The deflected beam then strikes a photodiode which registers the pulse of light. This whole optical system is carried on a servo controlled arm which gradually moves across the disc from the inside to the outside.

The high frequency (hf) data stream is recovered from the disc at the rate of 4.3218 million bits per second. The output from the photodiode is first amplified and filtered then passed to the input of the demodulator IC, SAA7010. See Figure 3. The incoming signal is first squared-up by a level detector and Schmitt trigger and then passed to a phase locked loop which regenerates the bit clock. The voltage controlled oscillator of the phase locked loop operates at 8.6436 MHz, twice the incoming data rate, from which a 4.3218MHz master clock for all internal timing is derived.

The incoming data are clocked into a shift register within the SAA7010 until the unique synchronisation pattern is detected. Each subsequent 14-bit word is then held in a latch and converted back to the corresponding 8-bit word by a logic array. The first 8-bit word contains the control and display information and is passed to the microcomputer which can deal with the data in whatever way a particular manufacturer desires as explained earlier. The next thirty-two 8-bit words are passed to the error correction IC, SAA7020.

Before going on to this IC, we will just mention the hf detector shown in Figure 3. When the amplitude of the hf signal is small, for example, during loss of data, the hf detector switches off the phase and frequency detectors in the SAA7010 and this prevents the phase locked loop locking onto noise which would otherwise have caused clock jitter.

Data entering the SAA7020 are stored in a shift register and a first-in-first-out (FIFO) register. The FIFO acts as a jitter reduction circuit and since it can compensate for up to ±2.25 frames, totally eliminates wow and flutter in the system. The data rate at the output of the SAA7020 is determined solely by the clock signal from a crystal oscillator. Any difference between this frequency and the frequency derived from the detected bit rate, generates an error signal which controls the speed of the motor driving the disc.

Reed-Solomon Decoders

The data are now de-interleaved by storing the 32 words of one frame in a 2K by 8 RAM along with the 28 output words of the first Reed-Solomon decoder. This decoder can correct one erroneous word, but if more than one...
word is shown by the first four parity words to be incorrect then the 28 words (the first four parity words now being discarded) are written back to the RAM unchanged, and a flag is set which marks the 28 words of this frame as unreliable. If the data was correct or corrected, the 28 output words are written back to the RAM but the flag is not set. The output words of the first decoder are further de-interleaved by means of the RAM and fed to a second Reed-Solomon decoder. This decoder can correct up to two erroneous words and the correct or corrected frame of 24 words (the second four parity words now being discarded) is written back to the RAM. If the data are still incorrect a second flag is set and the uncorrected word returned to the RAM.

After 30 stereo samples have been stored in the RAM the first sample is output from the SAA7020 in a 16-bit burst followed by an 8-bit interval then a second 16-bit burst and so on. If a sample is incorrect a flag is passed with it. If two consecutive errors are detected a flag is sent in the 8-bit interval as soon as it is detected, that is 30 samples before it is actually passed on to the interpolation and muting IC, SAA7000.

**Muting Bad Data**

Serial data from the SAA7020 are entered into a shift register and the left and right channels then descrambled. If there are no unreliable data flags then the data pass into the SAA7000 unchanged. If a single unreliable sample is flagged then the SAA7000 reinstates the missing sample by linear interpolation. If a flag arrives in one of the 8-bit intervals, the SAA7000 immediately starts to reduce the value of the samples so that they will produce a zero volume audio output after 30 samples. As soon as the flag stops appearing in the 8-bit intervals, the SAA7000 starts to increase the value of the samples until they return to their true value after 30 samples. This system ensures that incorrect samples are never heard and is gradual so that clicks are not heard in the output.

Since muting will not occur until 12,000 consecutive bits are lost, this should not be a common occurrence and even then should be of such a short duration that it will be scarcely noticeable. For example, 24,000 consecutive bits lost will cause muting for less than one hundredth of a second.

The output of the SAA7000 is 16-bit words for right and left channels exactly as they were when they were original encoded by the 16-bit analogue to digital converters (DAC) and the resulting analogue signs filtered using a complicated analogue filter. This filter can cause phase distortion in the audio signal and will reduce the slew rate. In addition, 16-bit DAC's and the complex filter are both expensive.

In most of the European players and in all Philips models a more sophisticated system is used which does not suffer from any of the problems mentioned above. A relatively cheap 14-bit DAC is used, yet the signal-to-noise ratio is only about 1dB worse than the 16-bit system (97dB instead of 97.8dB). It has only a simple low-cost analogue filter which does not affect the phase response of signals under 20kHz and does not reduce the slew rate. In addition, it virtually eliminates intermodulation distortion.

In this system the outputs of the SAA7000 are fed to a digital oversampling filter, SAA7030. The two 16-bit data streams (left and right) are fed into shift registers which quadruple the sampling frequency from 44.1kHz up to 176.4kHz. Quadrupling the sampling frequency also quadruples the effective audio bandwidth, from 22kHz up to 88kHz and the noise is spread out with it. See Figure 4. Since 75% of the noise is now above the audio band, it can be suppressed by filtering.

The 16-bit words entering this digital filter are output as 28-bit words and stored in an accumulator. The most significant 14-bits are then output to a 16-bit DAC. The SAA7030 contains two identical filters, one for each stereo channel and there are two identical 16-bit DAC's, again, one for each channel.

**Simple Filters**

A 14-bit DAC will give a signal-to-noise ratio of about 84dB. Oversampling and digital filtering add about 6dB to that figure. In addition the SAA7030 contains a noise shaper which redistributes the quantisation noise so that more noise occurs in the 22kHz to 88kHz region than in the audible region. This noise shaper adds a further 7dB to the signal-to-noise ratio giving a total of 97dB, almost the same as for a 16-bit system.

The 14-bit digital samples now arrive at a rate of 176.4kHz at the DAC, TDA1540. The input data are used to activate 14 switches which determine the output current. This output current is held between conversions by a flip-flop in the DAC. The hold function results in an output response which has a null at 176.4kHz where the first harmonic of the sampling frequency would otherwise have occurred.

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Thus with reference to Figure 5(c), it is clear to see how a very simple analogue filter can now be used to filter off any remaining frequency components outside the audio band. On the other hand Figure 5(a) shows that a very high order filter will be needed to filter out the spectral lobe stretching from 22kHz to 66kHz, generating all the problems inherent in high order filters as previously described. Also since the sampling frequency is so close to the audio band some intermodulation distortion will occur in the audio band. In the oversampled system, intermodulation products are well outside the audio band.

In the current output of the TDA1540 is converted to a voltage by an NE5532 dual op-amp. This op-amp is also used as the filter which is a third order low-pass Bessel filter with a cut-off frequency of 30kHz. A Bessel filter is used as it has a linear phase response. The output of the filter is a 1V rms max. voltage which can be connected to any hi-fi amplifier.

The End Of The LP

When Compact Disc is launched most of the potential purchasers will be those who already have expensive hi-fi systems. For them £400 is comparable with the cost of a top quality cartridge, tone-arm and turntable. And the superb quality was promised originally by enthusiastic people have been striving for over the years. But there is already signs of discontent in the hi-fi magazines, with die-hards questioning the quality of Compact Disc. In the meantime the rest of us can just sit back at last and listen to the music itself uninterrupted by the pops, clicks and bangs of those dreadful LP's!

IMPROVED TIMER CONTROL

Continued from page 7

and the time constant found. $R_T$ is the effective timing resistance of $R_A$ and $R_C$ in parallel. 

(3) Pick a trial value of $C$, and find $R_T$ to match it. As a guide, keep $C$ low and $R$ high within reason: $C$ under 1 nF makes things important, $R$ over about 470K may present problems of selection from a limited standard range. If both $C$ and $R$ look too high at low frequencies, consider using a fast oscillator and divider: this could be more stable, smaller and cheaper with no waiting for special-value parts.

(4) Use the table to get $R_A$ from $R_T$, and then work out $R_C$ as well. These are not directly usable values: there are called "design centre values", before allowing for adjustment of tolerances.

(5) Tolerancing:-

- $R_T$: ±% of $R_A$ and $R_C$ in parallel.
- $V_{CC}$ effect ±0.25% for 0.25V regulator offset
- $C$: ±1% adjustment range.
- $R$: ±1% worst-case sum ±74.25%.

There is no need to use 1% parts: other grades can be just as stable, but they alter the tolerance sum.

Take away the tolerance allowance from the design centre $R_A$ and $R_C$, and compare this result with available preferred values. If close, just continue; if far away, either:

- (a) try a different $C$.
- (b) use the next lower value and add the difference to the adjuster design.

(6) Use this adjusted $R_A$ and $R_C$ as a starting point.

or (c) try a sum of two fixed resistors: a small extra one need not be of 1% grade for 1% results.

When settled, allow twice the tolerance fraction of $R_A$ as the necessary range of adjustment, adding on any rounding-up if $R_A$ has been reduced much to a standard value. (6) Check the required adjuster range against standard values, remembering the adjuster may be ±20% itself. With a design using wide-spec. parts, the adjuster may end up very large, and selecting a fixed resistor on test for part of the adjustment will improve stability.

So far this is exactly what is done for a fixed-frequency oscillator with the standard circuit.

(7) $R_C$ needs an adjustment allowance first of all equal to $R_A$'s, and then an extra 5-6% for worst-case IC tolerances. With 1% parts, this means taking 10% from the design centre $R_C$, and allowing for up to 20% adjustment range.

One of the resistor adjustments can be replaced by capacitor adjustment, but often a full range of parts is not available.

When built, setting-up is easy enough: adjust $R_A$ at $F_{MAX}$, then $R_C$ at $F_{MIN}$, and repeat to overcome a slight interaction.

There are no special layout problems: six IC's and PCBs have worked out short antennas to suspect points. Take "reset" (pin 4) to $V_{CC}$ if not in use; for the 555, 100nF and 10nF supply and "control" de-coupling. The 7555 does not need supply decoupling, and usually control will behave without it. If the control pot. is remote, prepare to decouple the DC end of $R_C$.

For interest, $R_{TOL}$ is ±50 ppm per degree C.

$V_{CC}$ negligible, 78L05

$C$ - 150 pF/degree (polystyrene)

$R$ ± 100 ppm/deg C

and it is very unlikely drift will exceed 0.1% for a 5 degree case temperature change.

This is about as good as can be had from an RC oscillator with no oven or special components.

For interest, $R$ in the circuit can be replaced by two fixed resistors: their junction with $R_C$ is then a good linear FM input terminal for a 20% voltage swing. A dual IC can be used for sweep — with care not to upset its timing — or frequency shift keying. A simple D-to-A converter allows other codings.

They 4:1 circuit makes a very useful metronome with a range of 70-280 pulses per minute: good as clockwork and easier to set, with more range.
PANIC BUTTON

by Dave Goodman

- For use with the Maplin Home Security System
- Will trigger External Horn even if system is disarmed
- Can be reset with existing alarm unit keyswitch

This project has been designed specifically in response to the many requests we have had for a 'Panic Button' addition to our Home Security System.

The requirement is for a button placed close to the front or back doors, inside the home, or even by the bedside. In any emergency pressing the button would trigger the alarm, setting off sirens, lamps, etc., and hopefully attracting attention and dis- suading potential burglars. The Panic Button PCB caters for up to four switches, which should prove adequate for most applications, and complete instructions are given for connection to the Burglar Alarm PCB.

Circuit Description

With reference to figure 1, two diodes, D1 and D2, are wired to the spare change-over contacts on the Burglar Alarm keyswitch (figure 3). Either of these diodes will always be forward biased, allowing D3 only to conduct when the contact changes over. The keyswitch contacts are break-before-make, so that during switching a positive pulse appears at D3, which will, in turn, trigger the monostable IC1b and IC1c. This lengthened trigger pulse forward biases D4 and resets the latch IC1d and IC1e.

The output from IC1d is held low by R9 and a high output from IC1e. This may be thought of as a loop. IC1a and

Figure 1. Circuit diagram

Figure 2. PCB layout and legend
IC1f are input buffers for the panic buttons. These are arranged into two switch groups, with provision for two switches per group, allowing up to four switches to be connected. D5, D6, C2, and C3 slow the switching action to avoid contact bounce problems, and give protection from false triggering from RF voltages and spikes induced along connecting cable runs. D8, D9, C4 and C5 perform the same function for the other group.

Both buffer inputs are held high, by R6 and R8, and D7 and D10 will be reverse biased. Pressing button 1 will take IC1a input low and D7 will conduct. IC1e output will go low and IC1d output will switch high. TR1 will then conduct and remain in this state, due to the latching action of IC1d and e, even when button 1 is released. TR1 collector and emitter are wired across the external horn pins on our Burglar Alarm PCB (figure 4), and will now trigger the external horn. If the burglar alarm is in 'set' mode this too will be triggered. To reset the panic button and/or the main alarm/external horn keyswitch S9, as shown in figures 3 and 4.

Connect three wires from the Panic Button PCB to the Burglar Alarm PCB as follows:

- Panic Button PCB to Burglar Alarm PCB pin 1 +5V pin 4 to pin 30 pin 5 pin 29 also connect pins 10, 11, and 12 to keyswitch S9, as shown in figures 3 and 4.

- Re-apply power to the alarm system and turn key-switch S9 to SET. After any time out period the alarm should not trigger. If it does you may have left the panic button switched on. If you are using microswitch (mounted on PSU) you may have left pin 5 disconnected.

- The System In Use

Mount the PCB in the burglar alarm cabinet and connect the wiring as shown in figures 3 and 4.

The type of switches used for the panic buttons will depend on personal preference, but switches ideal for this purpose appear in the parts list. A make-when-pressed action is required, and up to four buttons can be used.

Some points to remember are:

1. Connect the external horn circuitry to the panic PCB, and NOT to the burglar alarm PCB. This is done previously.
2. The normal burglar alarm functions have not changed in any way.
3. The panic facility will function whether the burglar alarm is set or not. The only difference between the two modes is that although both internal and external horns sound in the ARMED mode, only the external horn will sound in the DISARMED mode.
4. Either type of external horn PCB will function with this project.

They fit all sixteen veropins and solder those too. Cut all excess leads and check for dry joints and short circuits. Reconnect power, sirens, etc., and turn the keyswitch to SET. Short circuit pins 15 and 16 on the panic PCB. Both internal and external horns should sound. Turn key to DISARM. Remove short from pins 15 and 16 and short pins 8 and 9. The time only the external horn should sound, and it should continue sounding until the short is removed. Turn the keyswitch to SET and then back to DISARM to reset the external horn. Tests are now complete and the system is ready for use.

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Testing

Refer to figure 4 before attempting to connect the PCB to your alarm unit, first switching off mains and removing batteries, if fitted. This will cause the external horn to trigger, so disconnect the external wiring from pins 29 and 30 (if used), and reconnect the wire ends to a 4.5V battery. If the horn still sounds, reverse battery connections to these wires and the horn will stop. Of course, the batteries may be removed from the external horn cabinet, but this may prove to be inconvenient in practice.

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3. The panic facility will function whether the burglar alarm is set or not. The only difference between the two modes is that although both internal and external horns sound in the ARMED mode, only the external horn will sound in the DISARMED mode.
4. Either type of external horn PCB will function with this project.
Filtering is the act of separating what is wanted from what is unwanted. In electronics this usually means some form of separation on the basis of signal frequency. In the simplest case, signals are divided into two 'bands' known as 'low frequencies' and 'high frequencies', separated quite arbitrarily by the 'cut-off' frequency. The fact that capacitive reactance depends upon frequency is often used to obtain such separation. This idea leads to simple filters of the 'inverted-L' type, known as 'low-pass' and 'high-pass' filters; these, together with their characteristics, are shown in Figure 1.

The characteristics of these simple filters show that, soon after the cut-off frequency is reached, the filter cuts off with a constant slope which is never greater than -6dB/octave (i.e. -20dB/decade). This is a basic limitation where a high degree of separation is required. Also, there is no gain at all at the wanted frequencies. These filters are said to be 'passive'. By using the op-amp with its high gain and differential inputs, filters can be designed to have real gain and high degrees of rejection of the unwanted frequencies: these are known as 'active' filters.

The Op-amp as an Active Filter

To see how the op-amp can be used as the basis for an active filter, consider a now familiar circuit, the inverter. This is shown in Figure 2, where the circuit is drawn twice (a) and (b), each case illustrating how either the input component or the feedback component can be represented by a 'block' which could contain literally anything. For example, if these components are a resistor R1 and another resistor R2 respectively, the circuit is then just an inverting amplifier with a gain of R2/R1. The gain being quite independent of frequency, at least within the limitations of the op-amp itself. But, if either branch contains frequency-conscious components, then the situation will be entirely different. The gain of the amplifier will vary with frequency and in such a way that it is under the designer's control by his choice of network components, either at the input or in the feedback path or both. Thus, a number of different configurations for active filters are possible, based on this idea.

The Twin-tee Selective Amplifier

One example of a frequency-conscious network is the twin-tee filter. This has the characteristic that at a particular frequency, given by $f = \frac{1}{2\pi RC}$, its impedance is very high. If the impedance of the network is called $Z_2$, and it is used in the feedback path, then it will give a gain of $Z_2/R_1$ (if the input circuit is a simple resistor of value R1); this gain will be a maximum at the frequency quoted above. The circuit is obviously selective and in fact behaves rather like a high-Q resonant circuit, but at low frequencies instead of radio frequencies. The frequency that it selects depends upon the values of R and C used in the twin-tee network. A value of gain, $R_2/Z_1$, the feedback network being a simple resistor $R_2$. This gain is a minimum at a frequency given by the formula already quoted, as is fairly obvious. A possible circuit is shown in Figure 4, additional components being provided so that the gain 'off the centre frequency' is defined by $R_2/R_1$ (giving unity gain in this case) as well as giving some degree of control over the shape of the rejection curve. For example, increasing the value of $R_2$ increases the gain away from the centre frequency but does so at the expense of the sharpness of the curve. At the centre frequency, the situation is more complex because then $R_3$ comes into play as well; it also has some effect on the sharpness of cut-off, but if its value is made too large, use of RV to obtain maximum rejection of the centre frequency is more difficult. It is a point worth experimenting with. For the values given in Figure 4 and a design frequency of 400 Hz, a sketch of the characteristic with RV adjusted as well as possible is also shown.

For both of these twin-tee filters, note that the sharpness of cut-off is considerably greater than that of the simple filters mentioned earlier.
The Wien Acceptor Amplifier

An acceptor amplifier is a useful circuit in that it allows analysis of a complex signal i.e., one containing a number of harmonics, which can then be separated into constituent parts and each measured individually. An obvious example of this is the measurement of harmonic distortion in audio signals. If the fundamental frequency and harmonics of a distorted signal are selected separately by a filter, each can be measured by an electronic voltmeter to give information about the percentage of the various components in the signal. Obviously, such a filter must be variable and the twin-tee is not particularly useful in this application because of the need to vary three components at once. For this reason, the Wien network is a better proposition and a static and transposing it, R2 is found to be 10k, which is perfectly reasonable. It is obvious as the only unknown and by substituting values for the numerator e.g. R1 = 10k; R2 = 100k, C = 1x10^-9 = (R1 x R3 x C1 x C2)/R2. As a starting point, let L be equal to some arbitrary value and then evaluate C for the cut-off frequency of 500Hz; if C turns out to have a ridiculous value then choose another cut-off frequency of 5kHz; if C turns out to be 632k. If C turns out to be 632k.

Low-pass and High-pass Filters

Both the circuits of Figure 6 and Figure 7 are known as 'second order' filters because they double up on the use of the previously mentioned inverted-L filter sections. As a result, the ultimate cut-off slope is 12dB/octave instead of being only 6dB/octave. The circuits are arranged to give unity gain over the passband but substantial attenuation outside the passband. The filter elements for Figure 6 and Figure 7 are R and C and, for the single inverted-L section, the cut-off frequency is determined when \( R=1/(2\pi fC) \) which, by transposition, means that the cut-off frequency is \( f=1/(2\pi RC) \). However, the use of two identical sections means that the attenuation is actually -6dB at this frequency so that the true -3dB frequency is rather different than given by the above formula for a single section. For example, in Figure 6, the cut-off frequency for a single section works out at 339Hz but the actual value obtained for the second order circuit is nearer 200Hz. Similarly for the circuit of Figure 7 while the cut-off frequency for a single section works out at 3.386kHz, the actual cut-off frequency for the second order circuit was found to be about 5kHz.

An Alternative Approach

So far each active filter presented has consisted of a well-known passive filter used in conjunction with an op-amp, the filter type being quite clearly identifiable e.g. as in the Wien circuit. Now a completely different approach will be demonstrated which shows even more clearly the clever tricks that can be played with the aid of op-amps. The starting point is the idea that induc- tors and capacitors can be 'simulated' by any circuit that produces a 'lagging' or 'leading' phase angle between applied voltage and the resulting current respectively. To illustrate the first case, Figure 8 shows how two op-amps can be connected to produce a 'gyrator' circuit or simulated inductor. This apparent inductor appears between the terminals shown and the major advantage is that a costly, heavy and bulky component is replaced by a handful of small, cheap ones; also the inductance value is readily changed. Thus, any real filter that contains an inductor could contain a gyrator circuit instead. However, inductors in LCR filters are often in series with the signal and the gyrator simulates an inductor which has one terminal earthed, a slight disadvantage.

This circuit simulates a capacitor but, and harmonics of a distorted signal are selected separately by a filter, each can be measured by an electronic voltmeter to give information about the percentage of the various components in the signal. Obviously, such a filter must be variable and the twin-tee is not particularly useful in this application because of the need to vary three components at once. For this reason, the Wien network is a better proposition and a selective amplifier based on this approach is shown in Figure 5. The Wien network is a better proposition and a selective amplifier based on this approach is shown in Figure 5. The circuit uses positive feedback from the output to the non-inverting input, and negative feedback from the output to the inverting input. The amount of positive feedback can be controlled by RV3 and is independent of frequency. On the other hand, the negative feedback is provided by the Wien network and therefore depends upon frequency. If RV3 is adjusted correctly, both types of feedback cancel out at one particular frequency, given by \( f=1/(2\pi RC) \), and the gain of the circuit is very high. At all frequencies above and below this value the negative feedback predominates and the gain is low. With the values of R and C given in Figure 5 the circuit can be tuned to accept any frequency in the range 1.6 - 12.5kHz. Switching values of C would allow several ranges to be covered.

Low-pass FDNR Filter

Figure 10 shows a T-filter using high value series inductors. Such components are inconvenient because of cost, weight, size, etc., and the use of an FDNR-based filter allows them to be eliminated. Suppose that the filter to be cut off at 500Hz, the values of the passive components being found from the following two simple formulae.

1. \( \text{Cut-off frequency} = 1/(\sqrt{2LC}) \)
2. \( R = 2LC \)

As a starting point, let L be equal to some arbitrary value and then evaluate C for the cut-off frequency of 500Hz; if C turns out to have a ridiculous value then choose another value of L and try again. Suppose L is 200H, then the formula (1) gives a value of C of about 1nF, a perfectly reasonable value. Now R can be evaluated from formula (2) and is found to be 632k.

Thus, for the passive circuit, the values are \( L = 200H; C = 1nF \) and \( R = 632k \). These are the values that must now be transformed into the values for the synthesised circuit. Thus, for the FDNR-based circuit, \( C = 1/(632 x 10^3) = 1.6\mu F; R = 200 ohms \). The values for the FDNR circuit are related by the expression

\[ C = 1 \times 10^3 = (R1 \times R3 \times C1 \times C2)/R2 \]

Again an initial choice has to be made. Suppose that a guess is made at reasonable values for the numerator e.g. \( R1 = 10k; R3 = 100k; C1 = C2 = 100nF \), this leaves R2 as the only unknown and by substituting these values into the expression just given and transposing it to \( R = 10k \) which is perfectly reasonable. It is obvious that a certain amount of judgement and/or experience is invaluable in this sort of design. The complete circuit is shown in Figure 11.
220/240V AC INVERTER

by Dave Goodman

★ Runs small domestic appliances such as televisions, hi-fi and lights
★ Supplied from a standard 12V car battery
★ Ideal for camping and caravanning

Now that winter is well on its way, bringing the threat of power cuts, a standby power source can be extremely useful. Central heating pumps can be kept running, or the family can be entertained by connecting a television to the inverter.

The need is for a 220-240V AC (50Hz) supply at 100 Watts to be derived from a 12V car battery. The power available should be adequate for most small domestic appliances, providing that their total power requirement is less than 100W.

Circuit description

The crystal XI and IC1 produce a stable 100Hz square wave, which is further divided by IC2 to give two 50Hz waveforms, one of which is 180 degrees out-of-phase with the other.

The transistors TR1 and TR2 both drive the MOSFETs TR5-8, which alternately switch the windings of T2 to the 12V battery supply. D4 and D5 become forward biased if the battery is wrongly connected, blowing the fuse FS1. D4

Figure 1. Inverter circuit diagram.
and D7 prevent reverse voltage spikes, developed across T2 primary windings, from damaging the MOSFETs. Transformer T2 has been specially developed for use in this system, and steps up the voltage on its primary windings from 17.5V rms to 250V rms across the secondary. Because of the fast switching action that use of the MOSFETs provides, the waveform appearing at T2 secondary under load is a good square wave, whose high harmonic content may cause problems with some equipment connected to it. C7 removes many of the upper harmonics, 'rounding off the edges' of the square wave and producing a more sine wave like waveform.

To produce a high power output, T2 turns ratio is about 20:1. With reference to the primary voltage (17.5V) this would produce 350V rms with small loads connected to T2. To control this voltage T1 monitors the supply output, producing 12V AC across pins 5 and 7 for 250V input. This voltage increases to 15V AC for 350V input, and is rectified by BR1 to produce a small DC biasing voltage at TR4 gate. TR4 acts as a voltage controlled resistor in this circuit, and the drain to source resistance decreases in proportion to a positive value voltage applied to its' gate. RV2 and associated resistors determine the bias voltage to TR4. With

![Figure 2. Legend and artwork](image1)

![Figure 3. Chassis connection](image2)

![Figure 4. Heatsink and MOSFET assembly](image3)
neon lamp N1 indicates that a high voltage is present on SKT1.

**PCB assembly**

Refer to the parts list and figure 2. Fit R1 to R14 and diodes D1 to D3. Insert BR1. The bridge will have either a plus sign or one lead longer than the other three. In either case this must go into the hole next to the plus sign. Fit RV1 and RV2, followed by transistors TR1 to 4. TR4 has a metal plate on top, and TR1 and 2 cases have a small pip on the side which must line up with the legend. Fit C1 to 6, C3, C4, and C6 are polarised, and you must ensure correct orientation. Fit IC1 and IC2 sockets, and crystal X1. Now solder all components in, and cut all spare leads. Fit veropins P1 to 7 from the track side, then solder in. Mount T1 with two 6BA x 3/16 in bolts, nuts and washers, and connect the secondary leads to pins 5 to 7. Re-check all components and look for bad joints and shorts on the track face.

**Main assembly**

If using the box recommended for this project figure 6 shows the holes to be drilled to enable all components to be mounted. Note that the two sides finished in black will be the top and front, and the plastic covered panel will be the rear (with the plastic facing inwards and the metal facing outwards).

The plain aluminium sheet is the base, and once it is drilled the PCB can be mounted using four 6BA x 3/16 in. nuts, bolts, washers, and four 6BA x 1/8 in spacers. T1 end of the board should be innermost. Next, fit the eight way connecting strip using three 6BA x 1 in bolts, nuts and washers (figures 3 and 5). This lies across the base from front to back. Use two 6BA nuts and a 6BA solder tag fitted to the centre bolt for the chassis connection to the battery negative.

Mount T2 to the left side of the base panel. Use four 2BA x 3/16 in bolts, nuts and washers. This completes the base panel assembly.

Drill the black top panel (figure 6). Mount the 13A socket pattress using two 2BA x 3/16 in CSK bolts, nuts and washers. Neon N1 fits into hole D, and the 1/16 in fuseholder fits into hole E. This completes the top panel assembly.

Next, mount TR5 and 6 to a pre-drilled heatsink. Use a suitable silicon grease for good heatsink conduction. No mounting kit is required here. The FETs will only fit one way round (figure 4). Use four 4BA x 3/16 in bolts and nuts with 4BA washers fitted under the heads of three bolts and a 4BA solder tag under the fourth. The fourth bolt is at the bottom of the drawing the tag fits on the heatsink side. Use 20 swg copper wire to join Drain pin to Drain pin and Gate pin to Gate pin. Diode D6 mounts under the heat sink, with the cathode (bar end) connected to Drain and the anode connected to the solder tag. Repeat this assembly for TR7 and 8. These two heatsinks will eventually join TR5 and 6 Gate bus bar to PCB pin 3, and repeat for TR7 and 8 to PCB pin 3.

Keep these last two cable runs as short as possible. Use two lengths (300mm each) of black 20A rated cable, and pass through each of the two holes in the back panel beneath each heatsink. Place the heatsinks onto the back panel and fit with six 2BA x 3/16 in bolts, nuts and washers. Solder one end of each cable onto the solder tag fitted on each heatsink. The other ends of the cable go into the two centre connecting strips. Fit two short lengths of 20A cable into the same strips and solder their other ends to the 6BA solder tag chassis connection (figure 5).

Assemble the back panel and base panel along with the two side plates and three extrusions. Leave the top and front open for now. Complete the rest of the wiring as shown. Use red 20A cable to and from the fuse FS1 and 20A black and 20A red cables with crocodile clips to the battery.

Capacitor C7 may be fitted directly into the connector strip providing that systoflex sleeving is placed over both bare leads. The same applies to diodes D4 and 5. The cathodes (bar ends) go to positive and the anodes go to negative.

**Wiring assembly**

Figure 5 shows the wiring arrangements. The centre (pink) wire of T2 primary fits directly into the tag strip, whilst the other two (black) primary wires go through the back panel holes and solder onto the Drain common bus bars (one wire to each bus bar), as shown in figure 5. Use 5A rated cable to join TR5 and 6 Gate bus bar to PCB pin 4, and repeat for TR7 and 8 to PCB pin 3.

Assemble the back panel and base panel along with the two side plates and three extrusions. Leave the top and front open for now. Complete the rest of the wiring as shown. Use red 20A cable to and from the fuse FS1 and 20A black and 20A red cables with crocodile clips to the battery.

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Maplin Magazine December 1982
Testing

Set RV1 fully clockwise and RV2 to half-way. Insert a 5A fuse into the holder. Remember you are dealing with 250V AC and that you should treat this with the same respect you would have for normal mains supply. Connect the battery. If you have an ammeter capable of reading up to 15A DC connect this in series with the battery positive and red connecting lead. Neon N1 should come on and the transformer may quietly buzz. The supply current should be approximately 500mA with no load connected.

Connect a voltmeter set to read 250V AC across the 13A mains socket. The reading will drop down to 230/240V, 250V (RV2) and the A.V.C. (RV1). Connect a 15W lamp into SK1. Turn RV1 fully clockwise and RV2 to halfway. Insert a 5A fuse into the holder. If you have an ammeter capable of reading up to 15A DC connect this in series with the battery positive and red connecting lead. Neon N1 should come on and the transformer may quietly buzz. The supply current should be approximately 500mA with no load connected.

Remove the battery supply and plug a 15W lamp into SK1. Turn RV1 fully clockwise again and reconnect the battery. Both neon and lamp will flicker. Turn RV2 anti-clockwise until there is a reading of 250V AC on the meter. Now turn RV1 anti-clockwise until the neon N1 may flash. Turn RV1 fully clockwise again and reconnect the battery supply. The reading of 250V AC on the meter. Now turn RV2 fully clockwise. The transformer may need to be connected in series with T2 primary centre-tap to produce a waveform suitable for operating such appliances. This will be a matter for experimentation, and outside the scope of this article.

Finally, slot the top panel in place, followed by the blank black front panel. Fit the metal extrusion into both panels followed by the blank black front panel. The assembly is now complete.

The prototype has been used successfully on televisions, spot lamps, hi-fi, tuner, cassette recorders, soldering irons and AC induction motors, although the latter requires high battery current. Some time switches or synchronous motors may not run correctly on this system, and a high current choke may need to be connected in series with T2 primary centre-tap to produce a waveform suitable for operating such appliances. This will be a matter for experimentation, and outside the scope of this article.

INVERTER PCB PARTS LIST

<table>
<thead>
<tr>
<th>Resistor All 0.4W 1% Metal Film</th>
<th>Value</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>2M2</td>
<td>1 off</td>
</tr>
<tr>
<td>R2,3.9,10</td>
<td>10k</td>
<td>3 off</td>
</tr>
<tr>
<td>R4,6,12,15</td>
<td>47k</td>
<td>2 off</td>
</tr>
<tr>
<td>R5,7,13</td>
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<td>3 off</td>
</tr>
<tr>
<td>R8</td>
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<td>100k</td>
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<td>RV1</td>
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</tr>
<tr>
<td>RV2</td>
<td>10k Hor-sub min Preset</td>
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</table>

Capacitors

<table>
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<tr>
<th>Value</th>
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</tr>
</thead>
<tbody>
<tr>
<td>C1,2</td>
<td>4.7µF Ceramic</td>
</tr>
<tr>
<td>C3</td>
<td>10µF, 25V, P. C.</td>
</tr>
<tr>
<td>C4</td>
<td>10µF, 35V P. C.</td>
</tr>
<tr>
<td>C5</td>
<td>100mF Mica Disc</td>
</tr>
<tr>
<td>C6</td>
<td>1µF, 63V, P. C.</td>
</tr>
<tr>
<td>TR5</td>
<td>470nF 16µ Cap</td>
</tr>
</tbody>
</table>

Semiconductors

D1-14                       | 1N4001, 1N4007, 1N4007 | 2 off |
D2.3                       | 1N448, 1N448, 1N448 | 2 off |
TR1.2                     | BC177, BC177, BC177 | 2 off |
TR3.4                     | BC558, BC558, BC558 | 2 off |
TR4.5                     | 1N0100, 1N0100, 1N0100 | 2 off |
IC1.6                     | 4060BE, 4060BE, 4060BE | 2 off |
G2.9                     | 4013BE, 4013BE, 4013BE | 2 off |

Miscellaneous

BR1.2                     | W005, W005, W005 | 1 off |
X1.2                     | Crystal 3,2768 MHz, FB797, FB797 | 1 off |
T1.2                     | 6-6-6 Sub-mini Transformer, FB797, FB797 | 1 off |
14 Pin DIL Smt             | BL18U, BL18U, BL18U | 1 off |
16 Pin DIL Smt             | BL18U, BL18U, BL18U | 1 off |
Vernip 2141                | FL212, FL212, FL212 | 1 off |
Inverter PCB               | GB12N, GB12N, GB12N | 1 off |

A complete kit of all parts except the case is available for this project. Order As LW95D (Inverter Kit). Price £49.95. The case suggested for this project is the NM3, shown on page 71 of our 1983 catalogue. Order As YK43W.
The devices that will be discussed here are unijunction transistors (UJTs), junction field effect transistors (JFets), VMOS transistors, and silicon controlled rectifiers (SCRs).

UJTs

Unijunction transistors used to be quite popular, but are not often used in new designs due to the availability of inexpensive integrated circuits such as the 555 timer device which give more predictable results and greater versatility. Unlike other forms of transistor a UJT cannot be used as an amplifier, and these devices are in fact normally only used as the basis of relaxation oscillators. A UJT is analogous to two resistors and a silicon diode connected in the manner shown in Figure 1. The total resistance through the resistors is several kilohms and the upper resistor is normally somewhat lower in value than the lower one. A UJT is used in the oscillator configuration shown in Figure 2, and this provides three output waveforms (which are shown in the diagram). A UJT is a three terminal device like ordinary bipolar types, but the terminals have different names, these being base 1, base 2 and emitter. In the circuit of Figure 2 there is initially an extremely high input impedance at the base 1 and base 2 terminals falls substantially. C1 largely and rapidly discharges into the emitter of Tr1 until the charge voltage is no longer high enough to sustain the regenerative action, and the device then reverts to its original state. C1 then starts to charge again, and this process continues with a nonlinear sawtooth waveform being produced across C1. This signal is at a fairly high impedance, especially if R1 has a high value. As C1 discharges, positive pulses are produced at the base 1 terminal and negative pulses are generated at the base 2 terminal. These are both at a low impedance.

It is important to realise that you cannot produce a UJT by simply connecting two resistors and a diode in the configuration shown in Figure 1. A UJT actually consists of a bar of silicon which forms the two resistances, with a single semiconductor junction on the bar to form the diode. It is from this single junction that the name unijunction is obtained. Two resistors and a diode connected in the manner shown in Figure 1 will not produce the regenerative action required to trigger the UJT to the on state. R1 should not have a value of less than about 10k or it will supply enough current to hold Tr1 in the on state and oscillation will be blocked. Similarly, if R1 is made more than about 1 megohm in value it will not supply enough current to trigger Tr1 properly, and oscillation will not take place. Another point to bear in mind is that R2 and R3 must be very low in value or they will prevent the circuit from operating.

JFets

The three terminals of a JFet are called the gate, drain, and source, and these roughly correspond to the base, collector, and emitter of bipolar transistors. JFets are depletion mode devices, and they require bias circuits that are subsequently different to those employed with bipolar transistors. However, like bipolar transistors they can be used in three amplifying modes which are

Figure 2. A UJT relaxation oscillator and output waveforms.

Figure 3. A simple JFET common source amplifier.

by R. Penfold

Introducing the fundamentals of electronics for the constructor.

UJTs, FETs and SCRs

In this final article in the "Starting Point" series we will consider some of the semiconductor devices which have not been covered by previous articles in the series. The equivalent bipolar configurations are the common emitter, common collector (or emitter follower), and common base modes. Whereas ordinary transistors are normally switched off and require a forward bias to enable them to be used as amplifiers, JFets are normally in the on state and require a reverse bias in order to partially switch them off so that they can act as linear amplifiers. In Figure 3 the gate of Tr1 is biased to the negative supply potential by R1, while R2, the drain to source.
The opposite direction for a P channel type.

An important difference between bipolar a field effect devices is that the latter have a very high input impedance and consume very little input current. The input impedance of a JFET is typically about one thousand megohms at low frequencies (the input capacitance gives reduced input impedance at high frequencies), and some field effect devices have an input impedance of over a million megohms. The gain of a field effect transistor is not therefore specified as a transconductance current gain since such a figure would be of little practical value, but instead it is the transconductance that is specified. This relates the change in input voltage to the change in output current, and in data sheets "gm" is the abbreviation often used for transconductance.

Transconductance is usually specified in milli-mhos, and this unit is equal to one volt change in input potential giving a change in output current of 1 milliamp. Transconductance is sometimes specified in micro-mhos, and this unit is equal to a one volt change in input potential giving a current change of just a few millimicroamps. Most JFET devices have a gm of about 250 mhos, which means that a 4 volt change in the input potential gives a 1 amp change in output current! High power types have gm values in excess of 1000.

VMOS transistors can be used in the output stages of audio power amplifiers and other high power linear applications, and their freedom from secondary breakdown and thermal runaway plus their excellent high frequency response make them in many respects ideal for such applications. They are also useful for switching applications such as the simple pulse type motor speed controller circuit of Figure 4. VMOS transistor Tr1 can be driven direct from the output of the 555 timer I.C. without the need for any current limiting resistor since Tr1 is in series with the device being damaged in consequence.

Power MOSFETs are another type of high power field effect devices. They are primarily intended for use in very high quality audio power amplifiers, and designs of this type have been featured in previous issues of this magazine.

S.C.R.s

Silicon controlled rectifiers or "thyristors" as they are popularly known, are switching devices and cannot be used for linear amplification. These are analogous to the circuit shown in Figure 4.

Initially both transistors will not receive any base current and will be switched off, but if a forward bias of about 0.6 volts is applied to the gate terminal the npn transistor will begin to conduct and supply a base current to the pnp transistor. This device then supplies a base current to the npn transistor, and a regenerative action results in both transistors switching hard on. They

![Figure 4](image-url)  
**Figure 4.** A motor speed controller using a VMOS transistor.

VMOS devices

Until recently there were no field effect power devices available to the amateur user, and there were in fact no really practical power f.e.t.s. at all. Power JFETs are now produced, but are difficult to use and are not available to amateur users. There are other types of power f.e.t. though, and the most common type is the VMOS transistor.

These are enhancement mode devices, and are similar to bipolar transistors in that the device is cut off with a gate bias voltage of zero, and does not begin to conduct until a gate potential of about 0.8 to 2 volts is reached. Like all field effect devices, the input impedance of VMOS transistors is very high and they are voltage rather than current operated. They have transconductance figures which are much higher than those of JFETs, and they obviously need to be since they are powered from a base voltage. No attempt need to be made to control output currents of a few amps with an input voltage change of just a few volts. Most VMOS devices have a gm of about 250 mhos, which means that a 4 volt change in the input potential gives a 1 amp change in output current! High power types have gm values in excess of 1000.

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![Figure 6](image-url)  
**Figure 6.** A simple bistable circuit using an SCR.

remain in this state even if the forward gate bias is removed, and the device conducts between the anode and cathode terminals with a voltage drop of about one volt or so between the two.

The simple bistable circuit of Figure 6 demonstrates the basic properties of an S.C.R. Power will not be supplied to the load until PB1 is operated and a gate current is fed to CSR1 through current limiting resistor R1. The C106D device specified for CSR1 is a sensitive device which requires a gate trigger current of no more than 0.2mA, but most thyristors require a trigger current of as much as 20 or 30mA. When PB1 is released CSR1 remains switched on provided the current through the load is high enough, and the hold-on current for the C106D is no more than 3mA. Again this is lower than the figure for most types, and a hold-on current of about 20 to 35mA is more common. Apart from a few special types it is not possible to switch off a thyristor by reverse biasing the gate, and the only way to switch off the device is to take the anode to cathode current below the hold-on level. In this circuit this is achieved by momentarily operating PB2 so that the current flow is briefly diverted from CSR1.

A triac is similar to a thyristor, but it will operate with gate and load voltages of either polarity (they can even be of opposite polarity). Triacs are mainly used to control A.C. loads in applications such as lamp dimmers and drill speed controllers.
CB Transceiver

Dear Sir,

After receiving the last issue of your magazine, I feel a strong desire to voice my complaint regarding the quality of the software backup that comes with the BBC Micro computer. I purchased my computer from your store and was given the promise of a software backup from your company, Maplin. However, I have never received the promised backup.

I am very disappointed with the service I have received from your company. I feel that I have been misled by the advertisement that was given to me when I purchased the computer. I believe that the company should be held accountable for their failure to provide the promised service.

I would like to hear from other customers who have experienced similar issues with the software backup service. Have you had any luck contacting Maplin to resolve this problem?

Yours sincerely,

[Signature]

Additions To 25W MOSFET Amp

Dear Sir,

Congratulations to Dave Goodman on designing the Superb 25W MOSFET Amp. However, I have a couple of questions about the design.

Firstly, why were DIN input sockets used, as few people write for the BBC just for Atari. And they've already added to the price of the BBC Micro suitable for business use. They write for the BBC Micro suitable for business use, and they've already added to the price of the BBC Micro suitable for business use.

Secondly, why wasn't a source monitor switch provided as this enables quick comparison between the music source and the recording. Also having this switch prevents oscillation when the record control is depressed on the tape deck while having the input switched to tape.

I realise these additions would have meant extra wiring and components not mounted on the PCB, but surely the revenue generated in convenience would make it worthwhile. Thank you for an otherwise good project.

Yours sincerely,

[Signature]

Universal Timer Builder

Dear Sir,

Thank you for the third issue of your magazine in which you include a request for letters, so we hereby oblige! First I agree with most of your customers/teachers that your delivery service is very good, which, as well as the BBC Micro, is what we expect from magazines for the wide variety of subjects dealt with.

Recently I completed E. T. Grimley Evans's Universal Timer. It is relatively easy to make simple phono to DIN adaptors, but much more difficult to fit phono sockets on the back panel and wire them to the circuit board. Each phono socket makes one connection whereas a DIN can make four or five, and you take up more space and require more complex sockets with screw-heads to keep the phono socket's shield intact. The extra space used would have made it difficult to fit the remote control unit.

Extra facilities could have been provided of course, but a source/monitor switch is just one of many. Any of them would have added to the cost and complexity, and these we wished to avoid.

Suggestions For New Stock

Dear Sirs,

I might suggest a few additions to your excellent range of electronic components:

1. 4mm plugs with 4mm cross-hole (1 believe they are called "Bunch Plugs")

2. I.C.s CA 3130 and CA 3140 in DIL 14 pin packages.

3. Resistor arrays with ceramic resistors. Circuits for electronic multi-meters often specify them.

4. [List of other suggestions]

While writing, I would like to thank you for replacing the faulty "scope probe sp promptly a month ago.

Yours sincerely,

[Signature]
CIRCUIT MAKER

Simple NiCad charger
J. R. Smith, Paignton, Devon

Most commercial NiCad chargers have connections for the A to D range of cells, but do not include PP3 type batteries. This circuit will charge from 1 to 6 standard 1.2V NiCads or one PP3 type in ten hours. If more than one cell is being charged then they should be connected in series, and the charging connection is made between positive and negative pins at IC1 input.

Switch S1 selects the appropriate range for the cell to be charged, and this must be chosen before applying mains power.

Resistors R1 to 8 determine the current flowing through IC1, which is a constant voltage regulator. The total current flowing through the NiCad will therefore be resistor (load) current and IC1 drive current (3 to 4mA). Bolt the IC onto a suitable heatsink when charging C or D type cells.

Simplified car lights reminder
J. M. Dunnett, Prestatyn, Clwyd

This circuit uses less components than the one published in Issue 1.
With the ignition off, the base of the transistor is held sufficiently low via R1 and R2 to cause it to conduct. If the lights are also on, 12V from the lighting circuit will pass through the conducting transistor and activate the buzzer.

If the ignition is switched on, the transistor base is taken high, it no longer conducts, and the alarm ceases. The switch and LED are optional and are intended to cater for situations where the lights have to be left on with the ignition off.

ATARI VIDEO GAME

NEW CARTRIDGES FOR ATARI VIDEO GAME

Over the next three months, five new cartridges will be released by Atari for the Video Game Console.

Star Raiders
At last the most popular of Atari’s Computer games becomes available for the Video Game. A vicious star battle in the glory of 3D, this game will be even more popular than Pac-Man or Space Invaders. The cartridge comes complete with its own keypad controller. For one player only, a joystick controller is also required.

Order As BC53H (VCS Star Raiders) Price £29.95

ET - The Extra-Terrestrial
ET needs your help! The lovable little alien is stranded on the planet Earth, and just like in the movie, he needs an interplanetary phone to contact his friends for rescue. Help him find the parts he needs. Call Elliott to guard him and help ET return to the planet he loves. Contains 3 games, played with a joystick controller.

Order As BC54J (VCS ET) Price £29.95

Volleyball
Superb graphics on this the first of Atari’s new series of Sports Games offering a high degree of realism.

Order As BC55K (Volleyball) Price £29.95

Also Coming
Due for release in January 1983 are Raiders Of the Lost Ark and Frog Pond.

Order As AC76H (Raiders Of Lost Ark) Price £29.95
Order As BC56L (Frog Pond) Price £29.95

December 1982 Maplin Magazine
**PRICE LIST**

All prices shown in this price list are valid from 15th November 1982 to 12th February 1983

Please note new telephone number for Sales Only (0702) 552911

Prices shown in this list include VAT at 15% where applicable. Items marked NV are rated at 0% and the price shown applies both to inland and export orders. Overseas customers should add up the total cost of all items, except those marked NV and deduct 13% to arrive at the total price excluding VAT. Alternatively multiplying the total price (except NV items) by 0.87 will give the total price excluding VAT. Please add extra for carriage on all overseas orders. Carriage will be charged at cost.

Although postage charges to customers living in the Republic of Ireland and in the UK, but not on the UK mainland, are the same as to mainland addresses we regret that we must levy an additional charge of £5 on each order containing any items marked “Delivery by Carrier”.

Will customers from the Republic of Ireland please add 40p and then 35% to the cost of their order now that the Irish pound is not equivalent to sterling, to cover the rate difference and negotiation fees. We will refund any difference; please state cheque or credit note. Alternatively if you pay by bank draft drawn in pounds sterling on a London bank, then you need add nothing extra. Bank drafts drawn in pounds sterling on a London bank should be readily available from your local bank.

All prices are for the unit quantity shown in the catalogue (unless shown otherwise on this list) i.e. each, per pack, per metre etc. All prices include postage and packing. There is a 50p handling charge which must be paid on all orders having a total value of under £5.00.

The price list is intended for use with our 1983 catalogue and applies to all mail orders. Prices in our shop are generally lower on heavy items as mail order prices include postage and packing costs.

Copies of manufacturers’ data sheets are available for most IC’s - price 40p each.

Prices charged will be those ruling on the day of despatch.

### TRADE QUANTITIES

The letter in brackets after the price indicates the minimum quantity of that item you can buy and qualify for a trade price. If you buy less than the quantity shown then the price is that shown. If you want to buy the quantity shown or more of that item, then please contact us for a trade price. If no trade quantity is shown, then the price shown is the best price we can offer regardless of the quantity.

Trade quantities shown for wires or cables of any type is in metres, not reels or parts of metres. Trade quantities for nuts, bolts, washers, Hiatts etc. refers to the number of packs, i.e. to qualify for a trade price on Tag 2BA for example (trade quantity 500). You will need to order 500 packs which is equal to 5000 tags.

Most items in the price list have a letter in brackets after the price which indicates the trade quantity as follows:

- **A** Trade quantity 5
- **B** Trade quantity 10
- **C** Trade quantity 25
- **D** Trade quantity 50
- **E** Trade quantity 100
- **F** Trade quantity 250
- **G** Trade quantity 500
- **H** Trade quantity 1000

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**Trade Quantities**

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- **Price**: The price includes VAT at 17.5% and is in UK Pounds (£). VAT is added to the prices shown.
- **Units**: All units are in UK Pounds (£) unless otherwise stated.

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The letter in brackets after the price indicates the minimum quantity of that item you can buy and qualify for a trade price. See table at start of price list. If you buy less than the quantity shown then the price is that shown. If you want to buy the quantity shown or more of that item, then please contact us for a trade price. If no trade quantity is shown, then the price shown is the best price we can offer regardless of the quantity.

Trade quantities shown for wires or cables of any type is in metres, not reels or parts of metres. Trade quantities for nuts, bolts, washers, Hiatts etc. refers to the number of packs, i.e. to qualify for a trade price on Tag 28A for example (trade quantity 500), you will need to order 500 packs which is equal to 5000 tags.
TRADE QUANTITIES

The letter in brackets after the price indicates the minimum quantity of that item you can buy and qualify for a trade price. See table at start of price list. If you buy less than the quantity shown then the price is the standard price. See table at start of price list. If you buy less than the quantity shown then the price is the standard price.

Trade quantities shown for wires or cables of any size is in metres, not reels or parts of metres. Trade quantities for nuts, bolts, washers, Hiats etc. refers to a number of packs, i.e. to qualify for a trade price on Tag 28A for example (trade quantity 500), you will need to order 500 packs which is equal to 5000 tags.

December 1982 Maclaren Magazine
SPECIAL OFFERS

FOUR FABULOUS SPECIAL OFFERS FOR CHRISTMAS

PACK OF 200 1N4148
This is the most popular of all the diodes, used in thousands of different circuits and ideal for fast logic applications. This is an incredible offer at half our usual price.
Usual price £8 for 200. Save £4
Order As SP95D
(Pk of 200 1N4148)
Price £4.00

AM/FM RADIO
A good quality medium wave and VHF pocket radio with telescopic aerial, earphone and carrying strap. (Needs four HP7 cells, not supplied.)
Incredible Price only £3.95
Saving £1 on our usual price.
Order As SP97F (AM/FM Radio)
Price £3.95

ELECTRONICS FOR ALL KIT

Now's the time to pick up this fantastic bargain. Our enormously popular 'Electronics For All' kit is available to you at a huge discount. We'd like to clear up our remaining stocks prior to making some more for next Christmas. So hurry — this offer is strictly while stocks last.
With this kit, you and your children can get started in this fascinating hobby. You will build projects using the latest micro-chips and you will learn to use the actual components (it's not all in little plastic boxes like most other kits). But you can still use the components over and over again. It is completely safe for children as there is no soldering and there are no dangerous voltages.
Even if you've never touched a transistor before, the superb book contained in the kit will show you exactly how to build the projects. You will build a two-waveband radio, a two-octave organ and lots more interesting projects. Even a nine-year-old, following the simple instructions, should be able to get every project working first time. The kit is superbly packaged in a full colour box.
Order now and save £15 off our previous price!
Order As SP96E (Electronics For All) Price £14.95

CANON ULTRA-SLIM TIME/DATE/ALARM/STOPWATCH CALCULATOR

A special end-of-catalogue offer that is strictly while stocks last!
An ultra-slim 8-digit calculator with memory that also incorporates a quartz-crystal and functions: as a clock with hours, minutes, day and date displayed; as an alarm clock which beeps discreetly when a preset time is reached and as a stopwatch with hours, minutes, seconds and tenths of seconds displayed. It will fit easily into an inside pocket or handbag as it is less than 4mm thick. The device has a liquid crystal display and battery life will be about one year. The day, date, time display is normally operating continuously and after use as a calculator, if not returned to clock mode manually, it will return automatically after 10 to 20 minutes.

Specification

Timepiece
Quartz crystal frequency: 30,720Hz
Accuracy: Better than ±30 seconds per month (at 25°C)
Display:
Date, day of week, hours, minutes, flashing seconds indicator, AM/PM.
Alarm: Electronic beep signal. Display shows when alarm is set.
Stopwatch
Measuring unit: 1/10 second
Measuring range:
To 9 hours, 59 minutes, 59.9 seconds
Standard: Lap time displayed while count continues; Stop count and restart; Two sets of times with simultaneous start.
Calculator and General
Display:
8-digit liquid crystal with minus, overflow and memory signs.
Types of calculation:
Addition, subtraction, multiplication, division, percentages, square roots, chain multiplication and division, constants, powers, add-on and discount calculations, reciprocals, sum and difference of products and quotients, calculations requiring memory.
Power source:
One lithium battery (LF1/2V) (3V DC 0.6mW)
Battery life: 1 year (with intermittent calculator use)
Size: 94 x 56 x 2.9mm
Weight: 36gms (including battery)

Supplied complete with batteries, wallet and instruction booklet.
Save £2 on our previous price!
Order As SP98G (Canon LC61T) Price £13.95

Maplin Magazine December 1989
THE ONE'S THAT GOT AWAY

We regret that the following items were inadvertently omitted from the 1983 Maplin catalogue. They appeared in the 1981/2 edition, and will be reinstated in 1984. Prices can be found in our current price list under the relevant section heading. We apologise for any inconvenience that this causes.

GUITAR STRINGS

Order As LB60Q (Guitar Strings Steel)

December 1982

(total 8 strings).

Pack contains an extra 1st and 2nd string electric and acoustic guitars, round wound.

INSTRUMENT CASE HANDLE

Mild steel handles fine chromed (on nickel on copper). Two sizes available: Fixing hole centres 3/4 in. (9.52mm, SMALL) or 6in (152.4mm LARGE).

Order As FX00A (Inst Handle Small)
Order As FX01B (Inst Handle Large)
Order As FX02C (Ferrule)

CIGARETTE LIGHTER EXTENSION LEAD

An extension lead with plug at one end to fit the cigarette lighter socket in a car and socket at other end to accept cigarette lighter plug. Approx. 1.7m of lead.

Order As YB68Y (Car Lighter Ext. Lead)

INTEREST FREE CREDIT EXTENDED

( APR = 0%)

Following the incredible success of our Interest Free Credit scheme in its first months of operation, we are pleased to announce its indefinite extension.

So if you have an order containing over £120 of computer hardware, then buy it on credit — interest free. Here's how it works.

In our shops

1. Phone the branch of your choice and give them your order (must include at least £120 worth of computer hardware). We will also have to ask you some personal financial questions in order to fill up our credit application form.

2. We will phone you back within 48 hours to let you know whether your application has been approved.

3. Any time after this, you may visit the shop to collect the goods. You must bring with you some form of identification (e.g. driving licence, credit card) and sign the form that we will filled in on your behalf. A deposit of 10% will be required.

4. A further 10% will be payable every month for a further 9 months equalling the total cash price for the goods.

By mail-order

1. Send your order to us (which must include at least £120 worth of computer hardware) and mark clearly on it "Interest Free Credit Terms" Enclose 10% of the value of the goods with your order.

2. We will send you by return of post, a credit application form.

3. Complete the form and post it in the stamped addressed envelope supplied.

4. When approved we immediately despatch your goods to you.

5. One month after goods despatched the first 10% payment becomes due, and thereafter a further 10% is due monthly for a further 8 months, equaling the total cash price for the goods.

Example

A VIC20 computer could be yours for just £16.99 down and £17 per month for nine months.

Interest free credit terms are only available in the U.K., not in Northern Ireland, Isle of Man and Channel Islands.

OUR COMPUTER WOULD LIKE TO TALK TO YOU

We hope to launch a brand new service in early 1983, allowing you, through your Modem, to talk directly to the Maplin computer. You will be able to access our stock file to check stock levels, then place your order, using any of the credit cards that we accept to pay for it. A few seconds later your order will be printed out, then collected and posted to you.

However, until we can make this available, you will still be able to call our computer on 0702 552941, and a message on our computer will tell you if your Modem is working correctly. If your computer is not operational, you will hear only a ringing tone. This part of the service will be ready for use in late November.

CORRIGENDA

ISSUE 1


Page 6. Fig. 8. Dimns. given for 'B' holes on Front View are incorrect, mount PCB in 'A' holes and drill through fixing holes for correct positions.

ISSUE 3

Page 3. Fig. 2. SK2 Pin numbers are incorrect, from left to right they should read 1, 2, 4, 6, 8, 7, 5, 3. Note the PCB is correct.

ISSUE 4

Page 5. Digi-tel Motherboard oct. There are 4 Diodes shown below R1 to 11 without oct references, their designations are D31 to 34, working from top to bottom: Pin 15 on Skts 1-4 goes to IC's 7, 8, 9 & 10 Pin 2 not 15 as shown; Veropin 48 should be connected to collector of TR2 not to IC4 Pin 10; Veropin S5 has been omitted and joins to IC19 Pin 11.

Page 41. Frequency Counter: Fig. 2, R47 value is 10M.

Page 42. Fig. 3, on IC7 Pin 10 goes to D13.

Page 43. Fig. 6, R65 value is 1k; R71 & R72 have been added thus:-

Page 44. Fig. 7, for better performance IC14 has been changed to SP8680, but please note that the circuit and PCB require no modification to order code (QY18U) is also unchanged. Some early kits may still contain the 11C90, however.

Page 45. Main Parts List: Add R71 to 470R (Qty 8), Add R65 to 1k (Qty 8), Delete R47 from 1M (Qty 1), Delete R65 from 47k (Qty 1), Add R47 value 10M, Add R72 value 330R, Delete 1N4148 Qty should be 24.

Page 57. ZX81 I/O Port: Fig. 1, IC1 Pin 9 goes to A10.
EXTERNAL HORN
PROGRAMMABLE
TIMER
by Dave Goodman

* Three timing settings from 2 minutes to 2½ hours
* Switch over from sounder to flashing beacon when time is up
* Directly replaces the previous external horn PCB
* Two wire control with tampering detection

New recommendations concerning the use of burglar alarm sounders have recently been introduced, and apply only to sirens or bells fitted outside protected premises, not to those used internally, unless they are likely to be audible outside. The ruling comes under the noise pollution title, and requires that alarm sound indicators cease to function after a seventeen minute running period from switch-on. Presumably the alarm would, or should, have been raised within this time, and the appropriate authorities notified, making further ear-blasting and nerve-shattering decibels unnecessary. So that it is not forgotten that the alarm system has been activated a flashing lamp or beacon can be switched on which will flash away until reset. Perhaps eye pollution will become a problem in the future!

Specification

A timer project has been designed for use with the Home Security System (see March issue) which will directly replace the previous External Horn PCB. Any type of siren, bell, or sounder requiring 12V at no more than 1A DC can be used, and in addition a lamp or beacon rated at 12V and less than 1A DC can be switched on after a preset time-out period has elapsed. One of three timing periods (see table 1) ranging from 2 minutes to 2½ hours can be programmed by removing or adding two wire links as required.

A 12V battery supply is needed to power this system, and batteries, siren, and PCB will all fit into an external horn cabinet. Unfortunately, this PCB is larger than the previous one, and the mounting holes in the cabinet lid will not align with it, so a further two 6BA holes are required. The lamp may be fitted to the cabinet, or wherever it will be readily visible.

Circuit Description

R1 terminates a two wire loop connection from the mother board in the main alarm. Removal of R1 from the circuit, either by shorting or open

Figure 1. Circuit diagram.
circuiting the loop, will trigger the main alarm (described in the March issue). TR1 is an N-type J-FET device, and requires a negative potential between gate and source to prevent drain current flow. With Pin 1 or 2 disconnected, R3 holds TR1 gate to ground, allowing drain current to flow. C1, R2 and D1 help prevent RF and voltage spikes, that may be introduced along the length of connecting cable used, false triggering the timer. Now, with TR1 conducting, the voltage drop across R4 and R5 is sufficient to allow TR2 to conduct, and connect the battery positive rail, via D4, to the supply rail. R13 monitors the positive supply rail, and TR3 immediately conducts, switching RLA, and allowing the siren connected between pins 5 and 6 to operate for a period of time (generated by IC1 and 2).

IC1 is a programmable timer, with an internal clock and four dividing stages. Clock frequency is set by R10, R11 and C3 to 16.5kHz, which is divided down by one of three stages set by links from the positive rail to pins 12 and 13 (Table 1). The Q output at pin 8 requires further dividing, and is applied to a 12 stage ripple counter, IC2. C4 and R12 apply a reset pulse to IC2, ensuring that all twelve dividing stages will

PROGRAMMABLE TIMER PARTS LIST

<table>
<thead>
<tr>
<th>Resistors</th>
<th>All 0.4W 1% metal film unless specified.</th>
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</thead>
<tbody>
<tr>
<td>R1, 4, 11</td>
<td>1k off</td>
</tr>
<tr>
<td>R2</td>
<td>22k (M220K)</td>
</tr>
<tr>
<td>R3</td>
<td>3.9k (M39K)</td>
</tr>
<tr>
<td>R5, 13, 15</td>
<td>10k off</td>
</tr>
<tr>
<td>R6, 14, 16</td>
<td>4.7k (M47K)</td>
</tr>
<tr>
<td>R7, 2, 3</td>
<td>10k off</td>
</tr>
<tr>
<td>R10</td>
<td>47k (M47K)</td>
</tr>
<tr>
<td>C1, 4</td>
<td>100µF Disc Ceramic (B103D)</td>
</tr>
<tr>
<td>C2</td>
<td>100µF 25V axial electrolytic (FB49D)</td>
</tr>
<tr>
<td>C3</td>
<td>750µF 1% polystyrene (EHC55K)</td>
</tr>
<tr>
<td>C4</td>
<td>1µF 30V Tantalum (WE600K)</td>
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</table>

<table>
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<th>Semiconductors</th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D1, 4</td>
<td>1N4148</td>
<td>2 off</td>
</tr>
<tr>
<td>D2, 3</td>
<td>1N4001</td>
<td>3 off</td>
</tr>
<tr>
<td>D4, 5, 6</td>
<td>1N4001</td>
<td>3 off</td>
</tr>
<tr>
<td>TR1</td>
<td>2N3989</td>
<td>2 off</td>
</tr>
<tr>
<td>TR2</td>
<td>BC377</td>
<td>2 off</td>
</tr>
<tr>
<td>TR3, 4</td>
<td>BC357</td>
<td>2 off</td>
</tr>
<tr>
<td>IC1</td>
<td>4541BE</td>
<td>2 off</td>
</tr>
<tr>
<td>IC2</td>
<td>4040BE</td>
<td>2 off</td>
</tr>
</tbody>
</table>

| Miscellaneous | | |
| RLA, B        | Ultra-min relay SPDT (Y195K) |
|               | vertron 2141 | 1 Pk (ML21K) |
|               | 14 pin DIL skt (SL18U) |
|               | 16 pin DIL skt (SL19W) |
|               | Programmable timer P.C.B. (LARM) |
|               | 12V, 50mA Beacon (YC39K) |

Printed below are the parts needed for the External Horn Case, if required:

| H2, 6V lantern battery | 2 off |
|                        | (X140D) |

A kit of parts is available for this project. It does not include the Beacon which must be ordered separately if required, nor does it include any of the parts listed below.

Order As LW98G (Programmable Timer Kit) Price £6.95

December 1982 Maplin Magazine
WIRES AND WHEREFORS

by Christopher Roper

On first sight, a casual glance through the local electronic retailers' catalogue usually reveals a bewildering assortment of wires and cables which are available to the amateur enthusiast. With such a wide choice, difficulty may be experienced in choosing the right wire for the job in hand, but armed with a few facts it is relatively simple to decide on the appropriate cable. Having said this it should be borne in mind that the average length of wire is itself something of a technological feat; as I hope this article will show.

Cables and wires usually fall into one of several groups, dictated by their usage; e.g. power cables, signal cables etc., although there is often some overlapping between groups. Consider cables in general. Looking through the appropriate catalogue pages usually reveals several descriptive facts and figures relating to number of strands per core, current ratings, voltage ratings and, in the case of screened cables and some multicore cables, a figure for capacitance is usually given. The figure quoted for the number of strands is given in two parts, e.g. 7/0.2 or 16/0.2. The first number gives the number of strands within the core and the second number gives the diameter of each strand in millimeters. Therefore a wire which is listed as being 7/0.2, has seven strands each of which has a diameter of 0.2mm.

The maximum voltage rating is the maximum potential that can be applied across the conductor's insulation without it breaking down due to electrical stress. For obvious reasons this rating should not be exceeded. The current rating is the maximum current that the conductor should be allowed to carry, but although this should never be exceeded it is often necessary to derate this value under certain conditions. The factors which determine the current capacity of a conductor, apart from its cross sectional area and the type of insulation surrounding it, are its proximity to other current carrying conductors, the ambient air temperature and the type of equipment that it is built into.

The amount of heat generated by current flowing in the conductor, should not be allowed to exceed the temperature rating of the insulation and as the number of individually insulated conductors which are loomed together, is increased, the heat dissipation is decreased. Further restriction of the cables, such as within an enclosed chassis, will further lower the heat dissipation. When dealing with the above situations it is often necessary to have some form of guide as to the amount by which the current capacity of the cables should be derated. For example, a loom consisting of thirty or more individual conductors may need to have the current rating of each conductor derated by as much as 50%. These considerations can become important when dealing with projects such as hi fi amplifiers and the like, which draw appreciable amounts of current.

Screened Cables

Current flowing in a wire can cause other problems, apart from those already mentioned. Consider for example, screened cables. These are usually used when outside interference sources can be troublesome. The cable screen is usually connected to zero volts or ground and helps to minimise interference induced signals, as well as helping to contain the transmitted signal. Capacitive effects within screened cables dictate to some extent their usage. The inner insulation of the cable acts as the dielectric of a capacitor, with the screen and the inner conductor acting as the capacitor plates. The capacitive effects which are produced can result in a finite time delay being imposed on the transmitted signal. In general terms a cable with a lower capacitance is more suitable for audio and radio frequencies, bearing in mind that the measure of capacitance in both cases is in pico farads i.e. 100-300pf/m.

Capacitive effects can also cause problems between two individually insulated conductors, which are in close proximity, when one or both are carrying alternating currents; under certain circumstances it is possible for signals being carried in one lead to become superimposed on those being carried in the other lead. The use of screened cables in this situation will help to minimise the effect, although this is not always the answer, especially when dealing with power supply leads. In this case it is best to avoid running power supply cables and signal leads within the same loom.

High Frequency Cables

Certain conductors are designed specifically to carry very high frequencies. On first sight it might seem that a conductor with virtually zero resistance will carry high frequency signals as efficiently as it will carry low frequency signals, but this is not the case. The effective resistance of a conductor increases with frequency, and at high frequencies its resistance may be many times greater than its low frequency resistance. As the signal frequency increases, the signal current tends to flow more within the surface layers of the conductor and less within its central core, giving rise to the phenomenon known as 'skin effect'. The explanation for skin effect is fairly straightforward, when one considers the effect on a conductor which is within its own associated magnetic field.

A current flowing in a conductor produces lines of magnetic flux which actually exist within the conductor itself and there is a greater concentration of flux lines nearer the centre of the conductor than at the surface layers. From this it follows that in a multi strand conductor, the individual conductors in.
ductor nearest the centre of the bundle has induced within it a greater back e.m.f. (electromotive force) than one nearer the outside. This greater induced e.m.f. results in a greater inductive reactance which is effectively an increase in its resistance. At low frequencies this inductive reactance is negligible, but at much higher frequencies it can become troublesome.

The most commonly used cable for high frequency work, i.e. VHF and UHF is Co-ax. This is similar to the screened cables usually with a centre stranded section of conductor with silver. The silver has a lower resistance than the copper, which offsets the inductive reactance.[1] Copper wires in a polythene insulation covered with a braided screen. However, the spacing between the core and screen is accurately defined which produces capacitances usually around 50-60 pF/m, i.e. much less than screened cables and also maintains a more consistent impedance level.

A less common method of overcoming high frequency problems is to plate the conductor with silver. The silver has a lower resistance than the copper, which offsets the inductive reactance.[2] Capacitances usually around 50-60 pF/m, i.e. much less than screened cables and also maintains a more consistent impedance level.

For specific purposes where a large number of conductors are required all carrying high frequency signals. Litz wire (Litzendraht) can be used. This type of cable has individually insulated strands which are wound around its neighbours in such a way that each occupies the centre of the bundle in succession. This type of wire comprises 3, 9 or 27 strands which are all plated together in this manner.

**Which Wire?**

The majority of cables and wires that are available, are based on perhaps half a dozen different designs. At the bottom of the table are the relatively simple single corded, multi-strand conductors such as 10/0.1mm and 7/0.2mm, which, for their respective sizes, have useful current carrying capacities. They are ideal for most projects and as general hook-up wire.

**Ribbon Cable**

A logical development of this type of wire is ribbon cable. Ribbon cable is usually comprised of ten or twenty individually insulated and colour coded conductors which are bound together longways so as to form a ribbon of cable. It may be split into any number of ways and any single conductor may be branched off at any point. It is useful where space is limited as it lies flat against any chassis. Some types of ribbon cable are designed so as to be fitted with multipin plugs which fit neatly into standard IC sockets. This is useful for compact interconnections between circuit boards.

A further development of ribbon cable is interboard jumper cable. This is similar to ribbon cable but is designed specifically for interconnecting circuit boards.

For low to medium power applications, 16/0.2mm is a good general sized wire with a current carrying capacity of about 3 amps. This, alongside with 7/0.2mm is a useful choice for the amateur workbench. For myself, these two wire sizes form the bulk of my stock and although the amount on the wire rack is dependent on the types of projects being built, it is useful to have several metres of each colour.

**Screened**

There are many types of screened cable, ranging from single corded to multi-cored, and from single screened to multi-screened. As mentioned before capacitive problems with these types of cables, tends to make the appropriate choice more difficult. As a general guide for the spares box, a few metres each of single core, twin corded and four core should be useful; but this will obviously depend again on the individual requirements.

**Mains Cables**

The choice of cable suitable for making external mains connections to equipment is one that requires special attention. Whilst overloading the internal wiring of equipment may lead to the rapid demise of its component parts in a puff of smoke, overloading a mains cable can have consequences which cannot be overstressed. The wires and cables already mentioned should never be connected to the mains directly, with the possible exception of 16/0.2mm in certain cases, and then only within the equipment itself. To comply with British Standards mains cables must have two separate insulation layers. Apart from acting as an insulator, it must be capable of withstanding a certain amount of general abuse, and in many cases, the equipment that the cable is fitted to, has a bearing on the type of insulation that is used. For most applications PVC or rubber insulated mains cable of suitable current rating, is probably sufficient, but where there is a possibility of accidental contact with hot appliances, e.g. irons, toasters, fires, etc., it is advisable to use one of the cotton covered heat resistant type.

---

The beacon listed in the parts list gives a very bright flash once a second, but only draws 50mA, so battery life is extended. It is not necessary to make connection to a siren or lamp at this stage, as both RLA and B give an audible click when operated. Remove the wire from pin 1 and you should hear RLA click on. If you have placed a link in LKB you will have to wait two minutes before RLB clicks on. The next step is to connect both siren and lamp to repeat the tests after remaking the connection to pin 1. Ensure correct polarity of the four connecting wires, red is positive and black negative (figure 3). The system is now ready for use.

**Usage**

Fit the timer PCB into your external horn cabinet. If you already have an external horn PCB it must now be discarded as this new system completely replaces the old unit. Two new holes are needed, but the existing spacers, nuts, and bolts can be used for mounting. If you do not possess our external horn cabinet, see parts list for details. Connect the batteries and siren, you will need a length of two-wire cable for connection to the lamp if fitted externally. Connect up to the Burglar Alarm and the system is complete.

---

**EXTERNAL HORN PROGRAMMABLE TIMER**

Continued from page 41

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 mins</td>
<td>Link B</td>
</tr>
<tr>
<td>2hrs 30mins</td>
<td>Links A &amp; B</td>
</tr>
<tr>
<td>17 mins</td>
<td>No Links</td>
</tr>
</tbody>
</table>

**Table 1: Program Table**

**Assembly**

Refer to figure 2 and the parts list for building this project. You may commence construction by bending and inserting resistors R1 to 16 and diodes D1 to 6. Note that D1 is a zener diode, and different from the others. Fit capacitors C1 to 5, you will see that C2 and C5 are polarised, and must be fitted the correct way round. Finally, fit transistors TR1 to 4, and relays RLA and B, both IC holders, and all the Vero pins. Solder all the components into place, clean, and inspect the track for shorts and dry joints. When you are completely satisfied with your handiwork, proceed with testing before putting into use.

**Testing**

Preliminary checks can be made with a meter set to resistance range. Measure between pins 3 and 4 (supply rails), there should not be a short circuit here. Measure between one of the supply rail pins of LKA or LKB and pin 4, again there should not be a short circuit. Wire the PCB to the burglar alarm holder, plug into the mains and connect to a suitable 12V battery supply. Two 6V lantern type or three 4.5V batteries are recommended for use with the project, because quite high currents can be drawn by bells or sirens.

**Usage**

Fit the timer PCB into your external horn cabinet. If you already have an external horn PCB it must now be discarded as this new system completely replaces the old unit. Two new holes are needed, but the existing spacers, nuts, and bolts can be used for mounting. If you do not possess our external horn cabinet, see parts list for details. Connect the batteries and siren, you will need a length of two-wire cable for connection to the lamp if fitted externally. Connect up to the Burglar Alarm and the system is complete.

December 1982 Maplin Magazine
DIGITAL CENTRAL HEATING CONTROLLER

* Works with either gas or oil-fired central heating
* Designed to work reliably and without adjustment over long periods of time
* Eliminates wasteful standing losses within the boiler
* Saves you money

by Chris Bearman

Ever rising fuel costs are tending to make most of us seek ways in which to reduce our energy consumption, particularly in the home. Many firms offer us their wares with the promise of lower fuel bills in the future, usually these take the form of some type of insulation, be it draught exclusion, wall and loft insulation or double glazing. One area which has its fair share of economy suggestions is the central heating system. At present there are thermostatic radiator valves, and zone control valves to name but two.

The digital central heating controller was designed with two basic views in mind. First, to help to make the system more economical, and second, to make the controls more convenient to operate. The controller was designed around a basic gas fired central heating system, but it could work just as well with an oil fired boiler. The controller directly activates two motor valves, a pump and a boiler. The 'primary' water route through the boiler should be pumped to allow the controller to operate correctly. Some types of heating system use what is called a 'gravity primary' which does not require a pump to heat the water in the hot water cylinder. This type of system probably has no motor valves in it either and so would need a few alterations to allow it to work successfully with the controller. An example of a suitable system is shown in Figure 1. This diagram is obviously much simplified, and can of course be altered in many ways to suit the particular application.

Circuit description

It can be seen from the circuits (Figures 2, 3 and 4) that there are two sets of control buttons. One set is mounted on the control box (usually near to the pump and motor valves) and the other set is at a convenient remote location. In a two storey house the water cylinder is found upstairs, so the controller would be near to this, the remote control set is probably best mounted in the kitchen.

The remote switches S1-4 activate the LEDs in the opto-coupler D14, hence giving isolation to the logic inputs. Either the outputs of the couplers, or the operation of switches S5-9, act on the inputs of the latches in IC1. These inputs may also be acted on by the operation of the timer circuitry, IC2.
When Pin 2 of water latch IC1 is taken low, the two 'water on' indicators are activated, one on the control box and the other on the remote panel. If the cylinder thermostat shows the water temperature to be below the set level, the output of IC3 will go high, enabling TR4 and so operating the water valve via RLC. Once open, the inbuilt switch in the valve will take pin 11 of IC4 low, enabling input 3 of IC6. Pin 6 of IC6 then activates both the pump and the boiler via IC4, transistor TR2, and relay RLA. It can be seen that two thermistor sensors are attached to inputs 12 and 13 of Op Amp IC7. One of these is attached to the hot water pipe leaving the water cylinder, and the other is attached to the cylinder itself. These form the 'Water Used' circuitry. The preset RV1 is adjusted so that when the hot water pipe has cooled down, (in relation to the cylinder) i.e. no hot water has been run off for some time, the output on pin 14 will go high. This disables the reset lines of the counters IC8 and IC9. When the water in the cylinder is up to temperature IC4 pin 4 will go low thus forcing pin 7 of latch IC1 to go high. Clock pulses from the slow clock IC10 will now reach the input of the counter IC8. When no hot water is used for some time, the output of IC7 pin 14 will go high, thus allowing the counters to time out. After a period of about half an hour or so, assuming that the 'water' button is not depressed again, and that no hot water is used, pin 11 of IC9 will go high thus clearing down the water latch IC1; at this point the 'water' indicator will go out.

Heating may be turned on by pressing either of the two 'H' buttons. It may also be set to come on 'timed'. The buttons act upon input Pin 15 of the heating latch IC1 and cause output 13 to go high. This output is taken to Pin 2 of the 'OR' gate IC11. The other input of the 'OR' is from the frost-stat circuitry, IC7.

Both the frost-stat and the room thermostat share the same thermistor sited to control the temperature of the heating in the house. The output of the thermistor is taken to pins 2 and 6 of the 3403 (IC7). One of the Op-amps is

Figure 2. Circuit diagram.
adjusted by an external knob on the control-box (RV3) for the desired room temperature. The other is adjusted by a pre-set (RV2) to the desired lower-level temperature which will activate the heating. It will be noticed that the heating does not have to be on for this to operate, hence the premises may be left unoccupied with no fear of frozen pipes during a cold spell.

The output of the 'heating timed' circuitry is taken to Pin 5 of the next 'OR' gate (IC11) and so to the 74LS11 (IC12), on Pin 11. If the other inputs 10 and 9 are high, the output on Pin 8 will activate the heating motor valve via TR3 and relay RLB. Input 10 of the 74LS11 is taken from Pin 1 IC7 which is acting as the room thermostat. The other input, Pin 9, is fed from the output of latch IC1.

The 'B' button is found only on the control box and is used to give a priority to water heating when the central heating is also being used, for instance when a bath is needed. Switch S9 (B) causes the water latch to operate via Pin 3 of IC1. Pins 11 and 12 of IC1 are also taken low, thus causing the output IC4 pin 8 to go low. This has the effect of shutting down the heating on a temporary basis (as it does when the roomstat is up to temperature). It is restored eventually when the cylinder thermostat reaches the desired temperature, so taking Pin 10 of the latch low and reactivating the heating.

It will be noticed that the system design eliminates 'standing losses' with the boiler, which occur in the majority of central heating systems. This is when the boiler 'short cycles' by itself on it's own thermostat even when no heat is required by the radiators or the hot water.

System power

The electronics are supplied with the necessary +5 volts from a 723 voltage regulator, IC13, and a series pass transistor TR6. A separate feed is taken off the bridge rectifier to a simple regulator TR5, D4, to give around 12 volts for the operation of the relays. This supply is isolated to a degree by means of the choke L1 and the capacitor C4. The +5 volts is protected from over-voltages by an ordinary cro-bar circuit, D3 and CSR1. Three fuses are used to give protection to the low voltage supplies, these are FS1, FS2 and FS3.

It is preferable to run a separate lead from the mains plug to the relay contacts which supply the voltages to the external devices, this is to reduce the likelihood of mains-originated interference problems. If mains interference poses a serious problem (this all depends on the other devices using the ring main supplying the controller) then the best solution will probably be found in a small mains filter.

When constructing the controller, the logic must be assembled away from the mains transformer and the relays. Transistors TR5 and TR6 must be mounted on adequate heatsinking; TR2, TR3 and TR4, each need only be fitted with a small cooling fin. The cable

Figure 3. Circuit diagram.
from the remote controls should not be run alongside of any mains cabling to reduce the possibility of any noise being induced onto the supply rails.

Setting up

It will be noticed that at various places in the circuitry, indicators have been fitted. These are invaluable for setting up the unit, and are of future use when adjustments to the settings are required.

Before first powering up the unit, the +5V adjustment should be set to its midway position, along with all of the other pre-sets. Now apply power to the unit and adjust RV4 to give +5 Volts. To calibrate the room thermostat, an ordinary thermometer is required. Set the thermometer up close to where the room-stat may be used to sense the temperature in the water cylinder. It should be possible to add further points to the scale by dividing the distance between the two points by the number of degrees rise in the room temperature.

An immersion heater type thermostat may be used to sense the temperature in the water cylinder. It should be firmly attached in an upright position to the top or the not water cylinder (inside of the insulating jacket) and set to the temperature required by means of the adjusting control at the top. To adjust the ‘water used’ pre-set RV1, it will be first necessary to bring the water in the cylinder up to temperature by depressing the ‘W’ button. Check for correct operation of the motor valve, the circuitry and indicators, and when up to temperature note the position of the pre-set RV1 which causes the time out enable indicator LED 3 to extinguish. Run out half a sinkful of hot water and note the new setting of the pre-set. The final position will be somewhere between the two of these marks. Initially set the pre-set two thirds of the way back to the first mark and observe that if no further hot water is used, the indicator comes on after a period of five to fifteen minutes. The longer it takes for the indicator to come on after the last water was used, the longer before the start of the timeout.

The frost-stat is the most difficult to adjust in that the temperature of the thermostat has to be reduced to around five degrees C. The setting may be obtained by adjusting it two thirds of the way down the scale and waiting for the colder weather. Two settings at the lower end of the scale should enable a similar calibration to be carried out as was done with the room-stat.

*Note that a lot of the components have been very conservatively rated, this being felt necessary to ensure that the unit will run cool and reliably as it is likely to be left switched on for very long periods of time.

### CENTRAL HEATING CONTROLLER

#### PARTS LIST

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<td>D14</td>
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#### Miscellaneous

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<tr>
<td>PS1</td>
<td>Fuse 500mA anti-surge</td>
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<tr>
<td>PS3</td>
<td>Fuse 50mA anti-surge</td>
</tr>
<tr>
<td>PS4</td>
<td>Fuse 50mA anti-surge</td>
</tr>
<tr>
<td>RL1,2,3</td>
<td>5A mains relay</td>
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<tr>
<td>R1,2</td>
<td>2 pole changeover relay</td>
</tr>
<tr>
<td>S1,9</td>
<td>SP make push button switch</td>
</tr>
<tr>
<td>S10,11</td>
<td>SP make min toggle/slide switch</td>
</tr>
</tbody>
</table>

### December 1982  Maplin Magazine 47
The first part of this series took a broad view of the historical development of the communications satellite. This is an area of rapid change, with new satellites continually being put into orbit, and some old ones coming back down to Earth! Since the beginning of this year, 9 Russian Cosmos and 1 Ekran satellite have been launched from Plesetsk and Baikonur. These include military navigation and surveillance satellites and one direct-broadcast satellite put into a geostationary orbit. The Americans have not been idle either, with an RCA Satcom 4 and a Western Union Westar 4 being launched into a geostationary position from Cape Canaveral. Of the ones that come down, virtually all burn up in the Earth's atmosphere on re-entry, so there is little danger of being hit by falling satellite debris. Such a fate for the satellite is not inevitable, but depends on the altitude and shape of the orbit. If the altitude is much below 500km., then the drag due to the outermost parts of the atmosphere gradually takes effect and the orbit decays, becoming lower and slower, until the satellite finally burns up in the denser parts of the atmosphere. Some satellites have small rocket motors which are used to carry out manoeuvres in space, either to alter the angle of the orbit or adjust the altitude. Usually, any data produced by satellites is beamed back to Earth by radio, but some of the Russian surveillance satellites are able to dump photographic material in re-entry canisters just before they burn up. This method is used by their low flying 'photosats', which often streak across the target area at altitudes as low as 160km. Such orbits decay very quickly and these satellites have to be replaced about every fortnight.

Those satellites placed in a geostationary orbit, 36,000km. out in space, may last for many years before they finally fail; such failures are usually due to faults developing in the satellite because of the extremely harsh conditions of outer space. The satellites are subjected to the full intensity of the sun's rays on one side and the bitter cold of space on the shaded side. In order to even out the temperatures and keep the internal electronics within reasonable limits, the satellite is given a slow spin to spread out the heating effect. Also, reflective metal foil is used to deflect some of the sun's heat, or electrical heaters used to maintain the stability of particularly sensitive parts of the craft. Part of the telemetry from the satellite monitors the various components and the craft may be manoeuvred to ensure a proper temperature balance. Despite these precautions, some satellites still fail due to impact by micro-meteorites. These are small pieces of interstellar debris, some no larger than a pin-head, which travel through space at colossal speeds and can punch a hole through the satellite. Especially vulnerable are the solar arrays, which offer a large target area; if critical parts of these are damaged then the satellite is deprived of

Figure 1. GOES modular assembly.
Amateur satellite. of the world which are easier using an satellite-eye-view. This is by WEFAX, or weather facsimile. By suitably which these images are transmitted is as insight into the mechanisms which drive the atmosphere. The most important parts of such a satellite are the imaging sensors, of which GOES carries two, the Visible and Infra-red Spin Scan Radiometer, (VISSR), and the Visible and Infra-red Spin Scan Radiometer Atmospheric Sounder, (VAS), which is a more sophisticated version of the VISSR. The VAS telescope and operation are shown in Figure 2. Imaging is achieved by scanning a focussed spot over the Earth. Light from the surface enters the telescope at right angles to its optical axis via the flat scan mirror, which is provided with an angular positioned stepping mechanism. The scanned pattern, after processing, resembles a conventional TV picture. Fast scan lines are achieved by rotation of the spinning satellite and the lines are moved by the stepped

GOES weather satellites

The internal construction of a satellite will naturally depend on the job it is intended to do; they range in complexity from that of Echo 1, simply a large balloon launched by NASA for bouncing off radio signals, to those like GOES (Geostationary Operational Environmental Satellite). This satellite is operated by the American National Oceanic and Atmospheric Administration (NOAA). Figure 1 shows the various parts of this particular satellite, which is used mainly for investigations into the physics of the Earth's atmosphere. The most important part of such a satellite are the imaging sensors, of which GOES carries two, the Visible and Infra-red Spin Scan Radiometer, (VISSR), and the Visible and Infra-red Spin Scan Radiometer Atmospheric Sounder, (VAS), which is a more sophisticated version of the VISSR. The VAS telescope and operation are shown in Figure 2. Imaging is achieved by scanning a focussed spot over the Earth. Light from the surface enters the telescope at right angles to its optical axis via the flat scan mirror, which is provided with an angular positioned stepping mechanism. The scanned pattern, after processing, resembles a conventional TV picture. Fast scan lines are achieved by rotation of the spinning satellite and the lines are moved by the stepped

Figure 2. VAS telescope optics.

mirror to scan north-south. The data from these sensors can be used for detecting the amount of water vapour in the atmosphere and producing temperature profiles, as well as visible-light and infra-red pictures. All of this information is used by meteorologists to help predict weather patterns and gain some insight into the mechanisms which drive the atmospheric weather machine. One way in which these images are transmitted is as WEFAX, or weather facsimile. By suitably decoding such transmissions it is possible to feed them into a facsimile copier and obtain pictures of the visible field of view. This is by no means a straight-forward task, but there are ways of obtaining a 'satellites-eye-view' of the world which are easier using an Amateur satellite.

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TV of the future

The direct broadcast satellites are rather different in their mode of operation, being used primarily to re-transmit signals beamed at them from ground stations. They contain a number of devices called transponders, which receive the incoming up-link signal, amplify it, and then re-transmit it back towards Earth, usually on a different frequency. By the use of specially designed transmitting antennae the down-link signal may be directed to a particular area within the satellite's field of view, called the 'footprint'. Although nowhere near as powerful as ground-based broadcast stations, which often have transmitter powers measured in hundreds of kilo-watts, their unique vantage point in space is more than sufficient compensation. The usual problems associated with terrestrial radio communication, such as limited range, obstruction by high ground or buildings, reflections which cause ghosting in TV pictures or interference between the ground wave and the sky wave which introduces multi-path distortion, simply do not exist with satellite reception. Thus it is not necessary to have high-powered transmitters with omni-directional antennae, and there are no areas of weak signal due to hills and valleys. The only disadvantage is that special high frequency receiving dish antennae and tuners are needed, and these are quite expensive at the moment, although with improvements in this area of semi-conductor technology and equipment design they may be expected to become much cheaper. Also, by using a sufficiently high down-link frequency, and 12 GHz is likely for L-sat, the proposed European D-B satellite, a receiving dish of less than a metre diameter may be used. It is likely that an interim solution will be to set up neighbourhood schemes, where one large dish and frequency converter could be used to satisfy a number of normal, domestic TV receivers.

Amateur satellites

For those interested in becoming involved in satellite communications, possibly the easiest and most rewarding way is through Amateur satellites. Many readers will be aware of the existence of Radio Amateurs, whose activities provide a worldwide service and who operate on nationally and internationally agreed frequency bands. As a group they have been responsible for many advances in the understanding of radio, such as the nature of the propagation of radio waves. One of their latest ventures has been to become involved in producing a number of satellites for Amateur use, and the whole activity from design through to launch has been co-ordinated by AMSAT. This is a group comprised of Radio Amateurs who are interested in satellites and their use in the field of amateur radio communication. Although the organisation originated in America, there is a very well established branch in this country, called AMSAT-UK. The satellites they operate, known as OSCARs, are used to facilitate radio communication between all parts of the world. Although not as complex as commercial satellites, for an amateur group to have put a number of such satellites up aloft is no mean feat. The usual mode of operation is as a transponder, mentioned earlier. Here, though, the frequencies are in the more manageable HF and VHF bands. The up-link is on 145 MHz and the down-link on 29 MHz, and to make the best use of the limited power available transmissions are on SSB (Single Side Band). The Russians, never ones to be left out, launched several of their own amateur satellites at the end of last year.
SOUND GENERATOR for the ZX 81

by Dave Goodman

- 3 Programmable Tone Generators
- Noise Generator with 3 Pitch Levels
- Separate Attenuators for Noise and Tone Generators
- Entry from PEEK and POKE in BASIC
- Connects Directly into the Expansion Port Socket (or into the motherboard)
- Single Address Access

This sound generator is a worthy addition to our ZX81 hardware projects. Almost infinite possibilities for sound and noise effects that can be added to your own program for greater realism.

Circuit Description

ICs 1, 2, and 3 are connected to the computer address lines A1 to A15. This means that all addresses up to 65534 may be presented, so a decoder is required to examine all lines, but only to respond to a particular address. The address code used here is 16370, which lies between the 16360 and 16380 used in our I/O port project. A0 is not used, so a further address of 16371 exists.

A negative going address decode pulse appears at the output of IC2, and is used to latch data into IC4 and enable IC6. To avoid corruption of data into IC6 the output of IC4 must be latched to the data code before IC6 is enabled.

Buffers IC5a and b delay the enable pulse just enough to allow IC4 to latch before enabling IC6. IC6 pin 4 READY line controls the duration of the WRITE ENABLE (pin 5) and CHIP ENABLE pulse for correct circuit operation, via IC5c. R1 and C1 smooth the +5V supply, to keep noise spikes down to a minimum, and audio output is taken from IC6 pin 7, via low pass filter R3 and C2, to the output pins 1 and 2. IC5d buffers the 3.22MHz clock, and prevents lengthy track runs from crashing the ZX81.

Most important is D1. You may be aware that because of incomplete address decoding, the ZX81 ROM is repeated between address 8193 and 16383, which is an unused area between ROM and system variables. These addresses can be POKEd providing that the ROM is deselected at that time, and D1 conducts when A13 is high, freeing this area for use.

Assembly and Construction

Insert all track pins and both vero pins. Fit all six DIL sockets, R1, 2, and 3 and C2. Fit disc ceramics C3 to C7 and C1 and C8 noting the polarity markings. Insert all ICs the correct way round, then clean the PCB and make the final inspection for short circuits and dry joints.

Testing and Use

If you do not possess a motherboard you will require a 2 x 23 way socket to solder onto the PCB edge connector, otherwise plug into your motherboard. The signal is insufficient to drive a loudspeaker direct, as it is only 300mV in amplitude, so you will need an external amplifier and speaker connected to pins 1 (signal) and 2 (screen). Switch on the ZX81 and a cacophony of noise should be heard. Run the following test program:

```
10 REM TEST PROGRAM
15 LET A = 16370
20 INPUT B
25 POKE A, B
30 GOTO 10
```

Press RUN then NEWLINE and input the following codes followed by NEWLINE after each code: 159 191 223 255 (you should hear the tones disappearing one by one until all the signals are off) 144 128 64. A low frequency tone of approximately 98Hz (G2) Maplin Magazine December 1982
steps, code 1 being the highest frequency that covers 98Hz (G2) up to 6.3kHz (G8) in 64 attenuation codes. The first code given is 144 and attenuation levels are in 15 x 2dB steps down to 1 so 64 maximum volume, e.g. Tone generator 1 = 95 to 98Hz. Any number between 1 and 64 may now be entered and the appropriate tone should be audible. Refer to the following listing for access codes and settings.

To input data into tone generator 1 only, first enter the required volume level from the access code, 128, again, and then a frequency code. The frequency range covers 98Hz (G2) up to 6.3kHz (G8) in 64 steps, code 1 being the highest frequency and code 64 being the lowest, so enter 64. The entered codes are now 144, 128, 64, which is tone generator 1 producing an output of 98Hz at full volume. As a Tone Generator access code was entered after the attenuator, the frequency can be changed as desired, but if an attenuator code is now entered, 144 to 159 in this example, the frequency can only be altered by entering the access code, 128, again, and then a frequency code.

Keep in mind that when a register is accessed it will remain 'on line' awaiting further update input codes. Access to Tone Generators 2 and 3 is in the same manner, except that the codes are different. If you enter 144, 128, and 64 to set up a tone in Generator 1, then enter 176, 160 and 32. Two tones will now be heard, with Generator 2 an octave above Generator 1. Entering a frequency code will now only alter Generator 2.

Pulse and noise effects require attenuation codes and an access code only. Once the attenuation level has been set noise and pulse codes are entered and are immediately audible.

Tone Generator 3 can be used to control either noise or pulse registers and code 231 followed by 192 allows control of white noise pitch by entering 1 to 64. Similarly, code 227 followed by 192 allows control of a 480Hz pulse tone by entering 1 to 64, and the lowest frequency possible is 6Hz.

Obviously, the best way to understand the system is to use it, therefore a few simple programs are given for assistance, shown at the end of this article. When writing music programs remember that G2 to G8 spans 73 notes and control only covers 64 notes, therefore higher frequency notes tend to become sharper in relation to the lower octaves.

Run these programs in SLOW mode:-

```
10 REM ZMD878DM
20 REM ZMD878DM
30 REM ZMD878DM
40 REM ZMD878DM
50 REM ZMD878DM
60 REM ZMD878DM
70 REM ZMD878DM
80 REM ZMD878DM
90 REM ZMD878DM
```

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<th>ACCESS CODE</th>
<th>FREQUENCY RANGE</th>
<th>ATTENUATION CODE</th>
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<tr>
<td>1</td>
<td>128</td>
<td>1 (G2) to 98 (G2)</td>
<td>144 to 159 (OFF)</td>
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<tr>
<td>2</td>
<td>192</td>
<td>High pitch</td>
<td>240 to 255 (OFF)</td>
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<tr>
<td>3</td>
<td>228</td>
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<tr>
<td>7</td>
<td>225</td>
<td>120Hz</td>
<td>240 to 255 (OFF)</td>
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This text is too long to be shown here, please view the full article for further details.
BASIC has three methods of supplying data to a program:

1. The INPUT statement — the user interacts with the computer while the program is running. Each time the program runs new data is requested and is input from the terminal.
2. The READ, DATA and RESTORE statements — the READ statement directs the program to read from a list of values built into a data block by a DATA statement. In terms of program execution time, it is much more efficient to use READ and DATA statements than INPUT statements because the user does not have to interact with the program when it is run. The RESTORE statement enables the same data to be used more than once during the execution of the program.
3. The file statements — data can be accessed from or written to a file created during the program run. The RESTORE statement enables the same data to be used more than once during the execution of the program.

Files

Since files are externally stored and program independent, their already been described. Now the BASIC statements used to create a file are considered.

Creating and Opening a File

The OPEN statement enables a new file, or an existing file, to be opened and associated with a file number which establishes a communication channel between the program and the file. Some versions of BASIC only allow one file at a time to be used by a program so it is not required to associate a file number since this will be a system default.

Usually the OPEN statement performs several functions which include naming the file, designating the operations to be performed and designating a communication channel. An example of this would be:

```
10 OPEN "string" {FOR INPUT} AS FILE # expression
```

The OPEN "string" component of this statement either references a file which already exists, in which case the file name enclosed within quotation marks is used to locate the file or names a new file. The file name is a string of alpha-numeric characters enclosed within quotation marks. Usually it must be less than a certain maximum number of characters depending on the system you are using and will be explained in the user's guide for your system.

```string```

The AS FILE # expression portion of the OPEN statement associates the file and the program with a common communication channel. This enables the file, which is stored on a peripheral device, to be associated with the current program which is in the computer's main memory area. The location associated with the file name is called a channel number and is specified in the expression part of the AS FILE # portion. This location can then be accessed by the program.

The following examples show how the OPEN statement is used:

```
20 OPEN "SUBJECT" FOR INPUT AS FILE # 1
```

This statement opens the file named SUBJECT. The FOR INPUT portion shows that the file already exists and that the data is to be read from the file. The AS FILE # portion establishes communication channel 1 as the link between the program in main memory and the file on a peripheral device.

```
30 OPEN "INFORM" AS FILE # 3
```

This statement causes BASIC to search for the file named INFORM. If the file exists it is opened and the program can access its data; if the file is not found a new file is created and assigned to the file name INFORM. The program can then write data to this file. The file is accessed by channel number 3.

```
10 OPEN "RESULTS" FOR OUTPUT AS FILE # 2
```

This statement creates a new file which is assigned to the file name RESULTS. The FOR OUTPUT portion of the statement notifies BASIC that this is a new file to which data can be written. The AS FILE # 2 portion of the OPEN statement establishes communication channel 2 as the link between the program in main memory and the file on a peripheral device.

Some versions of BASIC have different OPEN statements to open a file for reading and to open a file for writing. For example, to open a file to accept data the statement could be:

```
WOPEN "open file name" open file name
```

but to open a file to retrieve data the statement could be:

```
ROPEN "open file name"
```

This depends on the system you are using and will be explained in the user's guide for your system.

Closing a File

All files opened by a program should be closed before the program terminates execution. Unless they are closed the file may become 'corrupt', that is some of the contents may be spuriously altered or destroyed. The CLOSE statement is used to close a file and disassociate it from a communication channel. After a file has been closed it cannot be accessed until it has been re-opened.

The general format of the CLOSE statement is:

```
CLOSE channel number
```

where expression list may be one file number or a list of opened file numbers associated with commas. The part of the CLOSE statement shown within square brackets is usually optional. If no expressions are specified all files opened by the program are closed.

The following examples illustrate the use of the CLOSE statement:

```
10 CLOSE # 1:REM CLOSE FILE ASSOCIATED WITH CHANNEL 1
20 X=3
30 CLOSE 2,X,3+2:REM CLOSE FILES 2,3&5
40 CLOSE:REM CLOSE ALL FILES
```

Writing to a File

To write data to the terminal the BASIC PRINT statement is used. The PRINT statement can also be used to write data to a file. The general format is:

```
PRINT {FOR OUTPUT} AS FILE # expression list
```

where number channel number can be the communication channel number associated with a file that has been opened with the OPEN statement or zero. If zero is specified the output is to the terminal. The character preceding the channel number is usually optional. List can be any numeric or string expression or a numeric or string variable. Each item in the list must be separated with a comma or a semicolon. Also the first item in the list must be separated from the channel number by a comma.

The following short program opens a file called EXAMPLE for output and then writes the string "FIRST LINE OF FILE EXAMPLE" to the file when the program is executed.

```
10 OPEN "EXAMPLE" FOR OUTPUT AS FILE # 1
20 PRINT # 1, "FIRST LINE OF FILE EXAMPLE"
30 CLOSE # 1
40 END
```
The program consists of the following lines:

Line 10 — The REM statement serves only as a comment. The characters after REM are ignored.

Line 20 — The OPEN FOR OUTPUT statement creates a new file and assigns it the name "EUROTEMPS". The AS FILE # 1 portion establishes communication channel number 1 as the link between the program in main memory and the file on a peripheral device.

Lines 30, 70 to 120 — The READ statement on line 50 is associated with the DATA statements on lines 70 to 120. When it is executed the READ statement assigns data from the DATA statements to the variables P$, C and F. Each data line is a string followed by two numeric constants. Lines 40, 120 — The end of the data is signalled by a null string followed by two zeros. The IF THEN statement tests the string assigned to P$ to see if it is null. If the condition is true the program control is directed to the CLOSE statement. Set on line 140 which closes the file. Some versions of BASIC have file statements which test whether the end of the file has been reached. If this facility was available on your system it would not be necessary to set up a dummy data item to signify the end of file.

Line 50 — The PRINT # statement writes the variables P$, C and F to the file associated with channel 1. The data is written to the file separated by string constant commas. This is to enable the data to be retrieved using the INPUT # statement.

Line 60 — The GOTO statement repeats lines 30, 40 and 50 to write all the data contained in the DATA statements to the file.

Line 130 — The PRINT # statement writes the null string and zeros to the file.

Line 140 — The CLOSE statement closes the file EUROTEMPS and disassociates it from communication channel 1. Line 150 — The END statement signifies program completion.

To write the data to the file EUROTEMPS the program must be executed by typing RUN. After program execution is complete the data contained in the file EUROTEMPS can be made available to any BASIC program.

A program to retrieve the data contained in the file EUROTEMPS is:

10 REM DATA TO BE RETRIEVED FROM FILE EUROTEMPS AND DISPLAYED ON THE TERMINAL
20 OPEN "EUROTEMPS" FOR INPUT AS FILE # 1
30 INPUT # 1, A$, B$, C$, F
40 IF A$ = "" THEN GOTO 70
50 PRINT A$, C$, F
60 GOTO 30
70 CLOSE # 1
80 END

RUN

LONDON 18.7 65.7
AMSTERDAM 21.0 69.8
EDINBURGH 17.8 64.0
PARIS 22.8 73.0
MUNICH 22.8 73.0

The same result would be achieved by assigning the string to a string variable and then printing the string variable, i.e. line 20 could be substituted with the lines:

15 LET MS = "FIRST LINE OF FILE EXAMPLE"
20 PRINT # 1, MS

The next section shows how this data can be retrieved from the file.

Reading from a File

To input data to a program from the terminal the BASIC INPUT statement is used. The INPUT statement can also be used to retrieve data from a file to use as input to the program. The general format is:

INPUT (#) channel number, list where channel can be the communication channel number associated with a file previously opened using the OPEN statement, or zero. If zero is specified the input is from the terminal as for the program INPUT statement.

List can be a single string or numeric variable or a list of variables separated by commas. Also the first item in the list must be separated from the channel number by a comma. The # character preceding the channel number is usually optional.

The INPUT # statement line that retrieves data from a file must duplicate the format of the PRINT # statement that wrote the data. Also the type of variable used to store the retrieved data must correspond to the type of data item being retrieved. When the INPUT # statement is to request more than one data item, the data must have been written to the file separated by a string constant comma. This is because the INPUT # statement reads data in the file in the same manner as a program INPUT statement (where the data following a DATA statement is separated by commas). For example, the statement which writes the integers 1 and 2 and the string "THREE" to the file assigned to channel number 1 is:

10 PRINT # 1, 1, "", 2, "", "THREE"
The program line retrieving this data would be:

20 INPUT # 1, A, B, Z$

When this statement is executed the first data item retrieved from the file is assigned to the variable A, the next to variable B and finally the string is assigned to the string variable Z$. These variables can then be used in other BASIC statements to perform any desired operation on the data within the program.

The following programs demonstrate how data can be written to and retrieved from a file using BASIC file statements.

10 REM FILE EUROTEMPS TO BE WRITTEN TO
20 OPEN "EUROTEMPS" FOR OUTPUT AS FILE # 1
30 READ P$, C, F
40 IF P$ = "" THEN GOTO 130
50 PRINT # 1, P$, C, F
60 GOTO 30
70 DATA "LONDON", 18.7, 65.7
80 DATA "AMSTERDAM", 21.0, 69.8
90 DATA "EDINBURGH", 17.8, 64.0
100 DATA "PARIS", 22.8, 73.0
110 DATA "MUNICH", 22.8, 73.0
120 DATA "", 0, 0
130 PRINT # 1, P$, "", C, "", F
140 CLOSE # 1
150 END

The program consists of the following lines:

Line 10 — The REM statement serves only as a comment.

Line 20 — The OPEN FOR OUTPUT statement creates a new file and assigns it the name "EUROTEMPS". The AS FILE # 1 portion establishes communication channel number 1 as the link between the program in main memory and the file on a peripheral device.

Lines 30, 70 to 120 — The READ statement on line 50 is associated with the DATA statements on lines 70 to 120. When it is executed the READ statement assigns data from the DATA statements to the variables P$, C and F. Each data line is a string followed by two numeric constants. Lines 40, 120 — The end of the data is signalled by a null string followed by two zeros. The IF THEN statement tests the string assigned to P$ to see if it is null. If the condition is true the program control is directed to the CLOSE statement. Set on line 140 which closes the file. Some versions of BASIC have file statements which test whether the end of the file has been reached. If this facility was available on your system it would not be necessary to set up a dummy data item to signify the end of file.

Line 50 — The PRINT # statement writes the variables P$, C and F to the file associated with channel 1. The data is written to the file separated by string constant commas. This is to enable the data to be retrieved using the INPUT # statement.

Line 60 — The GOTO statement repeats lines 30, 40 and 50 to write all the data contained in the DATA statements to the file.

Line 130 — The PRINT # statement writes the null string and zeros to the file.

Line 140 — The CLOSE statement closes the file EUROTEMPS and disassociates it from communication channel 1. Line 150 — The END statement signifies program completion.

To write the data to the file EUROTEMPS the program must be executed by typing RUN. After program execution is complete the data contained in the file EUROTEMPS can be made available to any BASIC program.

A program to retrieve the data contained in the file EUROTEMPS is:

10 REM DATA TO BE RETRIEVED FROM FILE EUROTEMPS AND DISPLAYED ON THE TERMINAL
20 OPEN "EUROTEMPS" FOR INPUT AS FILE # 1
30 INPUT # 1, C$, F
40 IF C$ = "" THEN GOTO 70
50 PRINT C$, F
60 GOTO 30
70 CLOSE # 1
80 END

RUN

LONDON 18.7 65.7
AMSTERDAM 21.0 69.8
EDINBURGH 17.8 64.0
PARIS 22.8 73.0
MUNICH 22.8 73.0

The next section shows how this data can be retrieved from the file.
INTERFACING MICROCOMPUTERS

Using Parallel Input/Output Ports
by Roy Waters BSc., MSc., C.Eng., FIEEE.

The Function of Parallel Interface Adapters

Introduction

This article deals with how to interface projects to a microcomputer and to program the complete system.

There are two modes of transmission of data between computers and peripherals (external equipment), serial and parallel. Inside the computer all data transfers are in parallel mode, that is each bit of each data word is assigned a separate line. Serial data transfer, where only one wire is used and the data bits are transferred one after the other is done very quickly. In serial data transfer, where only one wire is used and the data bits are transferred one after the other, the data line is assigned a separate line. Serial data transfer is used in situations where relatively long distances are involved.

For our present purpose we shall consider parallel data transfers; the more usual and convenient way of connecting equipment to computer. However, it is still necessary to interpose special circuitry between external equipment and the computer data bus (i.e. the data lines, usually eight in a small computer). See Figure 1.

The Need for an Interface Adapter

Data messages from a computer data bus only last for the order of 1us, also data messages to a computer are only allowed to last for about 1us on the data bus otherwise the system would probably crash.

The functions of the interface device are therefore:

a. to capture the data from the computer in a register and retransmit it to the external circuitry "at leisure"

b. to hold data from the external source ready for the computer to "snatch it" very quickly

c. to perform these operations only when instructed to do so by the computer program.

See Figure 2.

Interface systems

The interface system, Figure 3, will comprise connections to the computer address and data buses and a few control lines. It will provide two 8-bit sets of input/output lines to connect to external equipment.

Most of the work is done by a single IC package. Such packages (or "chips") are appropriately called Peripheral Interface Adapters (PIA), Parallel Input Output (PIO) or Versatile Interface Adapters (VIA), the latter includes timers and serial I/O facilities also which we shall not need to deal with at present.

A few additional logic gates are required to enable the user to choose an address which will not conflict with other operations on his particular computer.

Most current micro computers use micro processors and support devices in the 6800, 6500 or Z-80 families. All of these families have interface packages, but generally speaking they are interchangeable i.e. they will work with other micro processors, but pin-outs and programming will vary.

The following are a selection of such interface adapters. The numbers suggest of operation and use. The 6800, 6821, Z-80 PIO, 6520, 6522 and 8154. The INS 8154 is related to the 8060 SC/MP but is frequently used with other micro processor systems.

These devices are all similar in principle of operation and use. The 6821 will be considered in particular as it is comparatively easy to understand and use.

Construction of an Interface System

Connections to the Computer

Some micro computers already have an interface adapter fitted (or a socket for one) with parallel Input/Output ports available from the board edge. If your computer has this facility you may like to skip the following constructional details and concentrate on the programming in the next section. However, that which follows will assist greatly in the understanding of interface adapters even if your computer has a different one from the type specifically dealt with here.

If your computer does not have an interface facility which is readily accessible, read on. You will learn how to construct your own interface system so that your computer may be connected and used with your own projects. Note, however, that your computer must provide the following:

1. Access to the Address Bus, the Data Bus and certain control lines (i.e. all these lines must be brought out to the board edge or to a socket to facilitate connection.)

2. A wiring or board layout diagram or clear markings on the board identifying clearly the connections.

3. A memory map.

If you are proposing to purchase a microcomputer make certain that the one you choose either has these facilities or already has an Interface Adapter (or socket for one) on board. At this stage you may not think of connecting your own circuits to the computer, proposing to use it only for programming, games, calculations or business accounts. However, if you dabble in electronics at all you will soon want to involve your computer, when you realise its potential in this context. Connecting your own circuitry is really quite simple and there is no fear of damaging the computer if appropriate instructions are followed.

Address Decoding

Interface Adapters are accessed via the
Address Bus like RAM or ROM memory and are allocated one or more specific addresses. The address bus lines are therefore connected either directly to the Interface Adapter or through an address decoder. As indicated in Figure 4 all connections are made directly from the microcomputer to the 6821 PIA except for the address lines. Most of the address lines are decoded externally, using TTL logic gates. These should be from the LS range to minimise bus loading.

One possible arrangement is indicated in Figure 5. To minimise the number of address decoder IC chips to two, utilising all three Chip Select pins on the PIA, a good choice is:

1. 74LS30 8-input NAND
2. 74LS27 Triple 3-input NOR

Using the NAND gate and two of the 3-input NOR gates provides for 14 address line inputs, eight of which must be High and six Low to enable the 6821 PIA.

The combination shown in Figure 5 gives the PIA addresses as EF80, EF81, EF82 and EF83 (four addresses are necessary to program this PIA, as we shall see later).

With these suggested TTL ICs, any address combination may be used which results in eight address lines being High (1) and six Low (0). A few examples are indicated in Table 1. From this Table note the following:

1. In each example the two least significant digits are XX, because they are always connected, not to the decoder gates, but directly to the PIA pins RS0 and RS1. The next two address lines, A2 and A3 are always designated 0, so that when programming the PIA the least significant four bits will always be 0000, 0001, 0010, 0011 in binary, that is 0, 1, 2, 3 in hexadecimal.
2. The total of 1's is always 8.
3. The total of 0's is always 6.

### Hexadecimal:

- EF80/3: 1110 1111 0100 00XX
- EF81/3: 1110 1111 0010 00XX
- EF82/3: 1110 1111 1111 00XX
- EF83/3: 1110 1111 1110 00XX

### Binary:

- EF80/3: 1110 1111 0100 00XX
- EF81/3: 1110 1111 0010 00XX
- EF82/3: 1110 1111 1111 00XX
- EF83/3: 1110 1111 1110 00XX

Table 1. Some alternative address combinations.

### Memory Map

Which address decode combination should be used? Before sticking a pin in to decide this, you must study carefully the memory map of your computer. This will almost certainly be designated in hexadecimal and will indicate the "areas" of address memory already allocated for specific functions, e.g. RAM user memory, operating system in ROM, display, etc. You must choose an address within an empty area. As almost all microprocessors used in small microcomputers have 16 address lines giving 65,536 discrete addresses there should be plenty of available addresses from which to choose.

In addition to the Address and Data bus line connections and a common Ground it will be noted that R/W and 02 connections are made to the PIA. The R/W Read, not Write signal indicates to the PIA whether the computer wishes to read from or write to the PIA, 02, the Phase Two clock signal is the timing strobe to ensure that data transfers only take place after the correct address signals have been set up and decoded.
**The Input/Output Ports**

Each individual bit pin of the two 8-bit Ports can be programmed as either an input or an output by the computer program.

These I/O Ports are all TTL compatible, that is to say they may be connected directly to drive TTL logic gates or be driven by TTL devices. For our present purpose it is sufficient to generalise and say that each Port pin may either be fed from a standard TTL gate or feed one standard TTL gate input (not necessarily 'LS' series TTL).

Since it is comparatively easy to drive any electrical circuitry from TTL and to feed any signals into TTL it follows that the computer can drive or be driven from any electrical circuitry, via the PIA.

More will be said about connections to the Ports in following articles on projects using them. However, for the present purposes of developing and testing the system and learning how to program it, it is very useful to be able to read the state of each Port line. This may be done by connecting LED's as indicated in Figure 6. The input of any standard TTL device may be connected to a Port pin and the output will sink enough current to illuminate a LED adequately using a resistor of between 270 and 330Ω. If TTL Hex inverters are used, a LED will be ON when a logic 1 (High) signal is present on the corresponding Port pin.

For test purposes, when checking Ports as inputs the pins may be connected to Ground or +5V for logic 0 or 1 respectively.

**Power Supply**

A +5V stabilised supply must be fed to the 6821 PIA and the two decoder TTL gate chips. The total current requirement will be about 110mA. There may well be enough reserve in your computer power supply. However, if indicator LED's also have to be supplied from this source a further 12mA per LED must be taken into account. In this case you are advised to connect 100nF capacitors directly across the 6821 and TTL decoder supply pins, and really it is advisable to do this anyway.

A separate stabilised power supply unit may be used and may well supply any project that is interfaced to the computer as well. There is no problem here, but remember to common the Ground of this supply to that of the computer, but do NOT connect the two +5V lines.

**Circuit Diagram**

The circuit shown in Figure 7 assumes the PIA address to be EF80/EF83. Remember the Address line connections may be changed to obtain different addresses.

**Board Layout I**

6821 PIA Only

The board, Figure 8, accommodates the circuit of Figure 7 providing two 8-bit parallel output ports.

A reset button has been included as there might be difficulty locating the computer reset connection. It will be found more convenient not to common the computer and interface RESET lines, since either may then be reset without the other. For testing and many circuit operations it may be found unnecessary to use the manual reset on the interface. The software routine of initialising the Ports virtually does this. However, it may be useful as a safety stop button, particularly if the interface is driving motors or servo-systems.

The Veroboard layout has been designed for ease and minimum construction work, and will only take an hour or two to put together. It is suggested that IC sockets be tinned copper 24 swg wire.

Connections to the Veroboard. The quickest and most convenient connections are made using 0.1in. pitch edge connectors plugged into the board edge. 1/0.6 single strand wire can usually be plugged straight into sockets on a computer board for test purposes. Ribbon cable to a plug which will marry to the computer connector is advisable as a long term arrangement.

**Board Layout II**

6821 PIA and LED Indicators

LED's can be temporarily connected to the Ports via 7404's as buffers with the aid of a socket breadboard.

As a more permanent feature, it is very useful if a lot of development work is to be done, to connect the LED's on to the PIA interface board as shown in Figure 6.

The advantages are:
1. A visual indication of the state of the Ports.
2. Additional Buffered Outputs (BO0 through BO7) capable of sinking 6mA per
output with the LED's or 16mA if the LED's are disconnected (48mA if 7416's are used).

3. A visual indication of the input signals to the Port, assuming the input circuit can sink the 1.6mA required by the 7404's.

For board and LED economy only eight LED's are shown. By making the vertical connections to the Port lines via Verobins with insulated hook-up wire, it is an easy soldering job to swap between Port A and Port B as the need arises.

### Parts List

**Interface only**

- RC1 1N7        M4K7
- C1 100n        YR75S
- IC1 6821        WQ45A
- IC2 74LS30      YF20W
- IC3 74LS27      YF18U
- DIL socket 40 pin      HO3BR
- DIL socket 14 pin      2 off BL18U
- Vero 10347      FLQ9K

or a smaller board if no extra circuits are to be used on board: FL101L (Vero 10348)

**Additional Items for the indicators**

- R2 thru R9 300R 8 off S300R
- D1 thru D8 8 off WL32X
- IC4, 5 7404 2 off QX40T
- 2141 FL21X

### Programming Interface Adapters

#### Simplified Functional Diagram

The simplest use of all Interface Adapters for parallel port input/output operations consists of programming the computer to place data on the port lines or read data from the port lines. Most of these devices have additional facilities which are useful but more complex to use. In the interests of simplicity we shall omit these facilities at present.

The simplified functional diagram, Figure 10 is relevant to all parallel I/O adapters as far as their simplest mode of operation is concerned.

The least significant 2, 3 or 4 address lines go straight to the adapter, allowing 4, 8 or 16 discrete addresses to be allocated to programming and using the adapter. Higher order address lines go via the external address decoder to the Chip Select pins. It will have been noted from Figure 4 that the 6821 has only two address pins, allowing four addresses only. These addresses and the data sent to them are decoded by the PIA and fed to four Registers on the right of the diagram.

Each 8-bit Data Direction Register, DDRA and DDRB (for Ports A and B) determines whether each corresponding bit in the 8-bit Data Registers DRA and DRB shall be an input or an output.

0 defines as an input
1 defines as an output

**Example:** If DDRA is loaded with 15 (decimal), that is OF (hex) or 0000 1111 (binary) then:

- DDRA: PA7 PA6 PA5 PA4 PA3 PA2 PA1 PA0
- DRA: 0 0 0 0 1 1 1 1

The process of defining the Data Direction is referred to as initialisation of the adapter.

The process of initialisation and writing data to a port is precisely the same as writing data to a specified memory location. Similarly reading data from a port is the same as reading data from a specified memory location.

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### Figure 9

Veroboard layout for 6821 with LED indicators.

### Figure 10

Simplified functional diagram of the Peripheral Interface Adapter.

### References

- "Microcomputer Components" — Motorola
- R6500 Hardware Manual
- R6500 Software Manual — Rockwell International
- Microcomputer Components — Motorola.
The computer may be programmed to perform these functions in machine code. Assembly Language or in a High Level Language (usually BASIC in the case of microcomputers).

It is, of course, much easier to program in BASIC. However, the BASIC interpreter MUST:

Either have the POKE and PEEK instructions to enable specified address locations to be accessed (some microprocessors use symbols instead of the words POke and Peek but the effect is the same). Or have BASIC statements enabling the user to write subroutines in machine code in order to access specified addresses.

To Program Port A as all Output lines

The following assumes that the address decoder has been connected for addresses EF80/EF83. If some other address has been wired this must be used, but note the least significant character will be the same.

For Port A to be all outputs the following locations must be addressed and loaded with data as follows, and in the sequence shown in Table 2.

Example Suppose in the table that nn=A6 (Hex)

This is 1010 0110 (binary). Then a High (nominal 5V) signal would appear on pins PA7, PA5, PA2 and PA1.

A Low signal would appear on pins PA6, PA4, PA3, PA0.

Once these first three lines in the above programming sequence have been run to initialise the Port, the operation of loading Port A with data:

Location Data
EF80 nn may be repeated for different values of nn, giving different output patterns.

Programming the PIA in 6502 Machine Code

If your computer uses a 6502 microprocessor, you are using PIA addresses EF80/EF83 and you can use Page 4 (04) of memory locations must be accessed and loaded with data as follows, and in the sequence shown in Table 2.

Example Suppose in the table that nn=A6 (Hex)

This is 1010 0110 (binary). Then a High (nominal 5V) signal would appear on pins PA7, PA5, PA2 and PA1.

A Low signal would appear on pins PA6, PA4, PA3, PA0.

Once these first three lines in the above programming sequence have been run to initialise the Port, the operation of loading Port A with data:

Location Data
EF80 nn may be repeated for different values of nn, giving different output patterns.

Programming in BASIC

Using BASIC all Hexadecimal numbers must be converted to decimal numbers first, unless your version of BASIC allows direct usage of Hexadecimal numbers (some do).

The following BASIC program will load the output binary pattern 1101 0011 (D3 in hex) on to the Port A pins.

<table>
<thead>
<tr>
<th>Location (Hex)</th>
<th>Contents (Hex)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF81</td>
<td>0</td>
<td>Next instruction to DDRA</td>
</tr>
<tr>
<td>EF80</td>
<td>FF</td>
<td>DDRA loaded 1111 1111 1111</td>
</tr>
<tr>
<td>EF81</td>
<td>FF</td>
<td>Next instruction to DRA</td>
</tr>
<tr>
<td>EF80</td>
<td>nn</td>
<td>Loads the binary pattern equivalent to nn on to Port A pins.</td>
</tr>
</tbody>
</table>

Before running this program the Port A output pins are EF80/3 and XXX=EF8.

Mix of Inputs and Outputs

To find the correct data to load into the Data Direction Register proceed as follows:

1. Decide which Port lines are to be inputs and which outputs.
2. Tabulate thus:—

<table>
<thead>
<tr>
<th>Port bit:</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input or Output:</td>
<td>in</td>
<td>out</td>
<td>in</td>
<td>in</td>
</tr>
<tr>
<td>Corresponding DDR:</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Before running this program connect the Port A output pins as follows:—

PA0,1,2,4 to 5V.

PA3,6,7 to Ground giving a binary pattern of 0001 0111 (17 (hex)) 23 (decimal))

After RUN the printout should be 23.

Check with other input patterns.

In the above program replace the last line with 90 GOTO 70
then as you change the connections the new output will appear on the screen.

Summary of Programming Instructions for the 6821 PIA

In Table 4 XXX represents the first three hexadecimal characters of the PIA address. If this has been wired as EF80/3 then XXX=EF8.

<table>
<thead>
<tr>
<th>Location Contents</th>
<th>Mnemonic, Data</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0400 A9,0</td>
<td>LDA Abs</td>
<td>EF81=0</td>
</tr>
<tr>
<td>0402 8D,81,EF</td>
<td>STA Abs</td>
<td>EF80=FF</td>
</tr>
<tr>
<td>0405 A9,FF</td>
<td>LDA Imm FF</td>
<td>EF81=FF</td>
</tr>
<tr>
<td>0407 8D,80,EF</td>
<td>STA Abs</td>
<td>EF80=FF</td>
</tr>
<tr>
<td>040A 8D,81,EF</td>
<td>STA Abs</td>
<td>EF80=FF</td>
</tr>
<tr>
<td>040D A9,D3</td>
<td>LDA Imm D3</td>
<td>EF80=D3</td>
</tr>
<tr>
<td>040F 8D,80,EF</td>
<td>STA Abs</td>
<td>EF80=FF</td>
</tr>
</tbody>
</table>

Note: For INPUT load 0

For OUTPUT load 1

Therefore, in this example instead of loading FF or 0, 4C must be loaded at the appropriate instruction.

<table>
<thead>
<tr>
<th>Port A</th>
<th>XXX1</th>
<th>0</th>
<th>All lines outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>or XXX0</td>
<td>FF</td>
<td>All lines inputs</td>
<td></td>
</tr>
<tr>
<td>or XXX1</td>
<td>FF</td>
<td>Next instruction to DRA</td>
<td></td>
</tr>
<tr>
<td>or XXX0</td>
<td>nn</td>
<td>Write data nn to Port A</td>
<td></td>
</tr>
<tr>
<td>or XXX0</td>
<td>—</td>
<td>Read data from Port A</td>
<td></td>
</tr>
<tr>
<td>Port B</td>
<td>XXX3</td>
<td>0</td>
<td>Next instruction to DDRB</td>
</tr>
<tr>
<td>Either XXX2</td>
<td>FF</td>
<td>All lines outputs</td>
<td></td>
</tr>
<tr>
<td>or XXX2</td>
<td>0</td>
<td>All lines inputs</td>
<td></td>
</tr>
<tr>
<td>or XXX3</td>
<td>FF</td>
<td>Next instruction to DRB</td>
<td></td>
</tr>
<tr>
<td>or XXX2</td>
<td>nn</td>
<td>Write data nn to Port B</td>
<td></td>
</tr>
<tr>
<td>or XXX2</td>
<td>—</td>
<td>Read data from Port B</td>
<td></td>
</tr>
</tbody>
</table>

A good check that all port lines are working correctly is to connect LED's to all lines and write a BASIC program to count input data and output data to the Port from 0 to 255.

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To initialise Port B for the above input/output pattern load the following:-

XXX3 0 Next instruction DDRB
XXX2 4C Defines inputs/outputs
XXX3 FF Next instruction DRB
XXX2 To access Port B

It is advisable to use Port B for mixing inputs and outputs. This Port has Tri-state buffers, so connections to the lines designated as outputs will not affect input readings. However, it is not very likely that lines designated as outputs will acquire a voltage of any significance from external sources so if it is necessary for both Port A and Port B to have a mix of I/O there should be no trouble.

**Basic Program to Read/Write Port B**

Suppose the following is required:-

Port B Bit: 7 6 5 4 3 2 1 0
Designation: Inputs Outputs
DDRB: 0 0 0 0 1 1 1 1
Port to output: 0 0 1 1
DDRB=0F(hex.)=15(decimal)
DRB=03(hex.)=3(decimal)

100 =61314 EF82
30 =61314 EF82
40 POKE B,0 Next instruction to DDRB
50 POKE A,15 Define I/O bits
60 POKE B,255 Next instruction to DRB
70 POKE A,3 Load 0011 in outputs
80 =PEEK A Read Port B
90 PRINT D
100 END

RUN

If the Port B input lines have input signals as follows—

PB7 PB6 PB5 PB4
0 1 0 1
then the printout would be 83 (decimal) i.e. 53 (hex.)

The PEEK statement reads all 8 bits of the Port. In this case it reads the value 3 (decimal) previously POKE'd to the 4 output bits, plus 80 (decimal) present on the input lines.

In general the PEEK statement will read the signals on the input lines plus the latest value to be POKE'd to the output lines. This is because once a signal has been POKE'd to the outputs it is held on the output lines of those bits of the Data Register programmed as outputs until it is updated.

A number POKE'd to a Port containing bits programmed as inputs will not affect these input lines.

At first reading the programming of I/O Ports may appear a little complicated. The easiest way to learn to program a PIA is to build the system, connect LEDs and signals to the Port lines and try it out.

**Figure 11. Superboard II J1 socket designations and location of sockets.**

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**Appendix A**

**For owners of Superboard II or UK101 microcomputers**

These microcomputers are readily connected to the interface system described above. However, some owners of Superboard II may feel they have insufficient information to proceed with confidence.

If the Port A input bits are connected to the 40-pin socket, designated J1 at the bottom right hand side of the board. The pin connections are shown in the diagram, Figure 11. Note that all DIL sockets and IC's on the Superboard II are “upside-down” when viewed from the keyboard and pin 1 is in the bottom right-hand corner of the socket.

Temporary connections to J1 may be made by pushing 1/0.6 solid-core wire into the sockets, but you are recommended to use a 40-pin DIL “Header socket” and use multicore ribbon cable to connect the interface system as a more permanent feature.

If 8272 data direction buffers are NOT fitted in positions U7 and U8 (16-pin sockets, lower centre of board) there is no connection between the computer Data Bus and the designated sockets on J1.

You are advised NOT to use 8272 buffers as the Superboard connections may not hold these in the Tri-state (high impedance), but in the Read Mode when quiescent. In this mode any signals applied to the external data bus connections may cause a system crash. Instead it is necessary to use jumpers to connect relevant input and output pin sockets of the U7 and U8 DIL sockets, as indicated in Figure 12. These connections may be made by using 1/0.6 solid-core wire (again note that the socket connections are “upside-down”). The connections for U7 and U8 are identical.

**Figure 12. Superboard II connections for sockets U6 and U7.**

The three most significant hex. address characters depend upon the address decoder connections and will vary from one system to another.

All sixteen of the least significant hex. character are used for programming the assembly language interface adapters other than the 6821. You will find programming details in their computer manuals. Alternatively data sheets should provide the programming information necessary, although sometimes a little difficulty for the newcomer to understand.

**Appendix B**

**Use of other Interface Adapters**

Owners of microcomputers using interface adapters other than the 6821 should find programming details in their computer manuals. Alternatively data sheets should provide the programming information necessary, although sometimes a little difficulty for the newcomer to understand.

**6522 Versatile Interface Adapter**

Information on this device is included here as a number of microcomputers use it. Some constructors may prefer to pay a little extra for an adapter having two timers and a serial interface as well as the parallel ports.

**Circuit Diagram**

It will be noted that the circuit diagram, Fig. 13, is almost identical to that of Fig. 7. The 6522 pinouts are slightly different and address lines A2 and A3 are connected directly to the VIA. In the software programming that follows these lines will be zero always, however by connecting them to the address bus the Timers and the Serial I/O may also be used.

**Programming the 6522 for Parallel I/O**

The three most significant hex. address characters depend upon the address decoder connections and will vary from one system to another.

The data pp initialises bits as outputs or inputs and location of sockets.

The data pp initialises as outputs or inputs 1 for output 0 for input in the same way as for the 6821.

**Figure 13. Circuit diagram when using the 6522 VIA.**

**Appendix C**

**Use of other Interface Adapters**

Owners of microcomputers using interface adapters other than the 6821 should find programming details in their computer manuals. Alternatively data sheets should provide the programming information necessary, although sometimes a little difficulty for the newcomer to understand.

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**Appendix C**

**Use of other Interface Adapters**

Owners of microcomputers using interface adapters other than the 6821 should find programming details in their computer manuals. Alternatively data sheets should provide the programming information necessary, although sometimes a little difficulty for the newcomer to understand.
This article describes several circuits that may be added to a layout using the digital control system described in issues 2 and 3 of Electronics (order numbers XAO2C and XAO3D). These circuits have been in use on the authors' 00 gauge outdoor layout for some time, and have been found to improve the realism and enjoyment of the railway greatly.

Train Head and Tail Lamp Control

This circuit enables the head and tail lamps to be operated automatically from the receiver unit fitted in the locomotive and controlled by the direction of travel.

This unit may be fitted to dual ended locomotives to enable the head lamps to light only in the direction of travel, or to a complete train that is to operate in both directions, for example an H.S.T. set, providing white lights at the front and red lights at the rear whichever way the train is moving.

The circuit is fed from the output of the decoder in the receiver module described in issue 2 figure 5.

When a receiver is selected by the control unit and the speed control advanced, pulses appear at one of the two outputs of the decoder, the number of pulses being dependent on the speed setting. These pulses are fed via R1 and D1 (figure 1) to C1, causing it to charge rapidly. It is prevented from discharging when the input goes low by D1 being reverse biased.

The voltage developed across C1 is used to turn TR1 on, via R2, and in so doing causes current to flow through the lamp in the collector circuit. R3 reduces the voltage to enable a 12V lamp to be used. The lamp and the LED are effectively in series across the supply, so that when TR1 is on the LED is extinguished, and when it is off the LED will light via the resistance of the bulb filament. The lamp will not light because the LED only draws about 10mA as R4 is in series with it.

Installation

Examples of installation for various applications are shown in figures 2 and 3. It will be seen that to control headlamps at both ends of a locomotive two control circuits will be needed. In the case of a complete train it is necessary to electrically couple all vehicles together. This is useful as it enables several track pick-ups to be made along the length of the train, also making carriage lighting possible.

Three wires are required to enable headlamp control. A bridge rectifier and control circuit are required at the non-driving end of the train, the pulse...
This length of Track must be greater than the longest Train.

Figure 4: Loop control schematic.

Figure 5: Loop control circuit.

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signals being fed on the third wire. A very flexible type of wire should be used between carriages, and the wire used in telephone cords has been found suitable for 00 gauge applications. Enough slack must be left to allow for negotiation of sharp curves. A single lamp may be used for the headlamps, and flexible light guide (XR56L) can be used to transfer the light to the front of the vehicle. The ends of the light guide may be shaped into a lens by holding it near a heat source and allowing the plastic to melt and form a small dome. Two LEDs may be used if required by connecting them in series, although it may be necessary to try several LEDs before installation, to ensure that they are both of the same brightness.

**Automatic Loop Control**

Loops on model railway systems present a problem due to the confliction of track polarity when entering or leaving the loop. The system described here automatically detects when a train is entering or leaving the loop and sets the polarity accordingly. The receivers used in locomotives are fed from a bridge rectifier, and are therefore not affected by the change in polarity of the track, thus there is no pause during switching.

Figure 4 shows a typical loop arrangement with the four sensors, two placed at each end of the loop. These sensors are simply made from gold plated wire and arranged so that the wheel flanges of the train make contact between one running rail and the sensor wire. This arrangement has been found very reliable in practice, and may be used in other applications where accurate train position detection is required.

Figure 5 shows the circuit of the automatic loop control and it can be seen that a positive input from any of the track sensors will cause the bistable, formed by gates 1 and 2 of the IC, to change to one state or the other, depending on the sensor activated. The inputs from the sensors are decoupled by C1 and C2, to prevent false operation due to inevitable voltage spikes found on model railway systems.

**Installation**

The system should be installed referring to figure 4 as a guide, but do not worry at this stage about the polarity of the connections to the loop section. When the sensors are in position check that operation by shorting them to the appropriate running rail with a screwdriver blade, to ensure that sensors 1 and 2 cause the relay to operate and 3 and 4 cause it to release.

The polarity can now be tested by driving a train into the loop, if the protection circuit on the controller trips as soon as the train enters the isolated section the connections to the loop must be reversed, and a further test carried out to ensure that all is now correct. It will be noted that the distance between the two inner sensors must be greater than the longest train that is likely to use the loop, to prevent both sets of sensors being activated at the same time.

**Track Circuited**

The circuit shown in figure 7 provides a means of detecting when a train is in a particular section of the track. This information may be used to provide an indication on a track layout diagram, as well as being interfaced with signalling equipment.

![Diagram](image_url)

**Figure 8: Tail lamp circuit.**

The individual sections of track which need to be equipped must be isolated at both ends on the positive rail only, and fed by the common supply from the controller via the detector circuit. A single wire feeds from each detector and is connected via a 12V bulb to the negative supply (EARTH). The lamp lights when current is drawn from the track due to TR1 (figure 7) being turned on by the volt drop across D1 and D2. The two diodes only allow a reduction of about 1.4V, and do not affect the operation of the system. It should be noted that only vehicles that draw current through their wheels will be detected by the track circuiting so it is necessary to provide track pickups at both ends of the train. This may be accomplished by winding a resistor of about 470 ohms between both wheels on an axle of the last vehicle, or a tail lamp may be provided using the circuit shown in figure 8.
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