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and computer PROJECTS

VOL. 12 NO. 12 DECEMBER 1983

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Two cassette deck operation without Expansion Interface

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Our January 1984 issue will be published on Friday, December 16. See page 825 for details.

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Everyday Electronics, December 1983
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Everyday Electronics, December 1983
QUITE SIMPLE

Small is beautiful. This adage has relevance to our hobby. Experienced constructors will agree that satisfaction derived from one's efforts is not directly proportional to the component count nor to the overall complexity of the design. A simple circuit using few, if indeed any, i.c.s can provide much enjoyment during its construction and this enjoyment is compounded when the completed project is seen to give pleasure (however simple and innocent) to others.

Computer projects apart, our complement of designs in this final issue for the year is unashamedly biased towards the simple and novel—in particular to projects having a part to play over the Christmas period. In this age of video and computer games, and other kinds of sophisticated electronic toys, it may be questioned whether interest can be aroused in so modest a device as a Magic Candle; or whether children will be attracted and excited by a flashing light display emitting merely a watt or two of illumination. But surely it will be a sad state of affairs if over-exposure to high-technology-based consumer products jades our ability to be enthralled and amused by unpretentious objects. And this applies most especially in the case of young children.

At this time, Christmas presents are uppermost in our minds and suggestions are always welcome. Well here's one. Egg-timers are not exactly a rarity, but this month's design is novel in that it generates a reasonable imitation of a clucking chicken. Perhaps a useful and amusing gift to make for ma or the wife?

ANOTHER SCHOOLS WINNER

The Environmental Data Recorder featured in this issue won for its schoolgirl and schoolboy designers the third prize in this year's Schools Electronic Design Award Competition. It provides yet another fine example of the enterprise and technical ability that exists amongst scholars in our secondary schools. Though conceived and designed with science department studies in mind, the Environmental Data Recorder is likely to find many uses amongst personal computer owners.

It is hoped that the appearance of this article will also act as a reminder—and a stimulant—to scholars throughout the UK who have produced an interesting piece of electronic equipment to enter this year's SEDAC. Schools please note that Registration should be made by November 30, 1983.

A special prize of £100, sponsored by IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 9LS, is to be awarded to the winner of the competition.
OWNERs of the TRS-80 Model I Level II Microcomputer will know that this computer has the capability of driving two cassette decks. However, with just the basic system, only one may be used, since only one I/O port is provided. On adding the expensive and now discontinued Expansion Interface, two cassette I/O ports are provided. This project provides two cassette ports for the basic system without the need for the Expansion Interface.

CIRCUIT DESCRIPTION

Before the operation of the circuit can be understood, it is necessary to understand its purpose. Those familiar with Level II Basic will know that any tape I/O command may have the suffix #1, or #2, placed after it. A #1 denotes that the next cassette I/O must go to cassette deck No. 1, while a #2 denotes that the I/O must go to cassette deck No. 2. If the Basic interpreter detects a #1, then a 00 is written to memory location 37E4H, whereas if a #2, is detected then FFH is written to this location. In both cases the actual I/O goes through port FFH, the cassette port on the rear of the Model I Console. All that has to be done then is to look at memory location 37E4H and use its state to select either cassette deck.

The circuit consists of four basic sections (see Fig. 1). There is an address decoder which monitors the address bus and when the value 37E4H is present it enables the data latch. The data latch monitors data line 0 and, when enabled, reads and stores the state of this data line.

The output of the data latch, which is an echo of its input, is presented to the relay driver and relays. The relays are used to switch the I/O port between the two cassette decks. Finally, there is a small power supply to power the whole circuit.

ADDRESS DECODER

The address decoder consists of IC1, IC2, IC3a, IC3b, and IC4. To understand its working we must consider the binary equivalent of 37E4H, which is what actually appears on the 16 address lines, see Fig. 2. As can be seen, when this location appears on the address bus, A2, 5, 6, 7, 8, 9, 10, 12 and 13 all go high, that is, they have a potential of 5V. A0, 1, 3, 4, 11, 14 and 15 all go low; they have a potential of 0V. IC1 and IC2 are the major components of the decoder and are 8-input NAND gates. When all eight inputs are high then the output goes low. A2, 5, 6, 7, 8, 9, 10 and 12 are connected to the eight inputs of IC1. See Fig. 3.

As can be seen from Fig. 2, all these address lines go high when 37E4H is addressed and so the output of IC1 will go low. A0 goes low when 37E4H is addressed and this low, along with the low from the output of IC1, is applied to the inputs of the 2-input NOR gate, IC3a. The output of this NOR gate will therefore go high and is applied to one of the inputs of the other 8-input NAND gate, IC2. A1, 3, 4, 11, 14 and 15 all go low when 37E4H is addressed and these are each inverted by one of the six inverters making up IC4. The six highs from the outputs of IC4 are applied to six of the inputs of IC2. Finally, A13, which goes high when 37E4H is addressed, is applied to the last input of IC2. Since all eight inputs of IC2 are now high, the output will go low.

We have now uniquely decoded the memory address 37E4H which appears
as a low on the output of IC2. It is now necessary to decide whether or not the computer wants to write to or read from this memory location. If this was not done, the data latch may become active at the wrong time and hence remember the wrong data.

The computer tells us when it wants to write to a memory location by sending a low on its WR output. The "bar" means that this output is true when it is low and hence is normally high.

The WR signal is connected to one of the inputs of IC3b, a 2-input NOR gate. The output of IC2 (the output of the address decoder) is connected to the other input of IC3b. Since both inputs of IC3b will be low when the computer wants to write to 37E4H, the output will go high. This output is used to control the data latch, IC5.

**DATA LATCH**

The data latch consists of a D-type flip-flop which forms half of IC5. For those unfamiliar with the operation of the D-type flip-flop, a brief description is given.

This type of flip-flop has two inputs and two outputs. One input is the D, or data, input and the other is the CLK, or clock input. The two outputs are Q and Q'.

If the CLK input is kept low then the outputs remain in a constant state no matter what signal is present at the D input. However, when the CLK input is taken high, the outputs begin to echo the signal at the D input. Q takes the same state as the D input while Q' takes the opposite state. When the CLK input goes low then whatever state is present on the D input will be latched into the flip-flop and remembered until another high CLK step.

The outputs will be kept in their respective states, whatever they were when the CLK input went low.

The D input of the flip-flop IC5 is connected to the first data line of the computer, D0. Normally this is changing state many thousand times a second as data is moved about the computer. However, since 37E4H is not being written to, the CLK input of the flip-flop will be low and so the signal at the D input will have no effect.

When 37E4H is written to, the CLK input goes high and the state of D0 is latched into the flip-flop. The timing of the computer is such that the address lines and data lines change state in synchrony and hence the data fed to the flip-flop remains constant until the CLK input goes low. The non-inverted output, Q, is fed to the relay driver.

**RELAY DRIVER**

The relay driver consists of a single transistor connected in the common emitter configuration. Its operation is that of a current amplifier, amplifying the 20mA available from the output of the data latch to the 125mA necessary to drive the relays. Diode D1 is reverse biased across the coils of the two relays. Its purpose is to conduct away the reverse e.m.f.
produced by the relays as they turn off, and hence protect the transistor.

The contacts of the two relays form four single-pole changeover switches. These are used to switch four of the five data routes from one cassette deck to the other. The only route not switched is the common motor switch connection. Note that it is necessary to switch the earth line as well as the signal paths since otherwise bad hum loops or even cassette malfunctions can occur.

As has already been described, a 00 is written to 37E4H when cassette 1 is to be used and FFH is written to this location when cassette 2 is to be used. Thus the output of the data latch will be low for cassette 1 and high for cassette 2. The relays will be off for cassette 1 and on for cassette 2.

The relay contacts are wired up so as to connect cassette 1 to the cassette port when the relays are off and to connect cassette 2 to the port when the relays are on.

POWER SUPPLY

The power supply is based on the widely known 78 series of voltage regulators. The output of T1 is 6V a.c. and this is rectified by D3–D6, a bridge rectifier. Smoothing of the supply is achieved using C6, a 1000µF electrolytic capacitor. The 8.5V d.c. across C6 is applied to the input of IC6, a 5V, 500mA positive voltage regulator. The output of IC6 is 5V d.c. C4 is placed across the output of the regulator to reduce any high frequencies on the supply line. R3 and D2, an l.e.d., form an indicator to tell when the interface is on. See Fig. 4.

Finally, C1, C2 and C3 are placed around the circuit to further decouple the supply for the TTL i.c.s. IC3c and IC3d have their inputs connected to +5V via R1, a 1kΩ resistor. This is done since floating inputs are damaging to TTL i.c.s.

PRINTED CIRCUIT BOARD

It is recommended that the circuit be built on a printed circuit board since the many interconnections become difficult on stripboard. Once the p.c.b. has been made up, preferably using glass-fibre board, it should be scrutinised for bridges between the tracks.

The actual-size master printed circuit board pattern used for the prototype is shown in Fig. 5. This is available from the EE PCB Service, Order code 8312-03. The layout of the components on the top side of this board is also shown in Fig. 5.

Using a fine tipped soldering iron and thin solder, construction can begin. Start by soldering in all the wire links followed by the Veropins, if these are to be used. Next, solder in the i.c. sockets. The relays are best mounted in low profile i.e. sockets, since otherwise removal will be difficult should they become faulty.

Mount the resistors and capacitors next, ensuring C6 is fitted the right way round. Now fit the transformer and finally solder in the transistor and voltage regulator. Ensure these latter components are fitted correctly.

After fitting the diode, the i.e.s may be inserted, checking their orientation is correct. Now fit the relays. The main board is now finished.

Some method of connecting the main board to the expansion socket on the Console is necessary, and a good method, especially if another peripheral is connected, is to make the header shown in Fig. 6. A double-sided p.c.b. is soldered to a 40-way edge connector and also forms an edge connector for another peripheral. Taps are taken from the appropriate lines using Veropins. Although not the neatest way of making connection, it is certainly effective.

Fig. 4. The power supply circuit diagram. Note that the mains earth is not required.
Fig. 5. The full-size p.c.b. track artwork and component layout diagram. This board is available from the EE PCB Service. Order code 8312-03. All wires (including the ribbon cable) must be terminated with a Veropin. Note that the mains input cable will require a clamp to act as strain relief at the point of entry on the case.
COMPONENTS

Resistors
R1 1 kΩ
R2 4.7 kΩ
R3 2.2 kΩ
All 1% carbon ± 5%

Capacitors
C1,2,3 100 nF miniature ceramic
C4 470 nF polyester type C280
C5 220 nF polyester type C280
C6 1000 µF 16 V elect.

Semiconductors
D1 1N4148 silicon diode
D2 TTL220 red i.e. d.
D3–D6 W005 1A 50 V bridge rectifier
TR1 2N3704 silicon npn
IC1,2 74LS30 TTL low power Schottky 8-input NAND gate (2 off)
IC3 74LS02 TTL low power Schottky quad 2-input NOR gate
IC4 74LS04 TTL low power Schottky hex inverter
IC5 74LS74 TTL low power Schottky dual D-type flip-flop
IC6 78M05 ±5 V monolithic voltage regulator

Miscellaneous
SK1 20 + 20 way double-sided card edge connector
SK2,3 5-pin DIN 180° socket
PL1,2 5-pin DIN 180° plug (2 off)
PL3,4 3.5 mm jack plug (2 off)
PL5 2.5 mm jack plug
S1 s.p.s.t. mains on-off toggle
T1 mains 0–6 V, 0–6 V
1.5 VA per secondary winding, type Clairtronic II00
RLA, RLB Ultra miniature d.i.l.
relay, 6 V, coil resistance 80 ohms double-pole change-over contacts (Maplin BK48C) (2 off)

Printed circuit boards: single-sided size 135 x 75 mm; EE PCB Service, Order code 8312–03; double-sided size 53 x 37 mm, EE PCB Service, Order code 8312–08; single-sided Verobins (72 off), 20-way ribbon cable (1 metre); d.i.l. i.e. sockets, 14-pin (7 off); mains cable (2 metres); 4-core individual screen screened cable (2 metres); 3 mm fixing hardware; plastics case, size 160 x 100 x 75 mm approximately; tinned copper wire for board links.

Approx. cost £22 excluding case

Fig. 6. Full-size track artwork of the double-sided header p.c.b. This board carries the 40-way edge connector (SK1) and also permits additional peripherals to be plugged into the TRS-80 I/O port. Top view shows the ribbon cable wiring.

Fig. 7. Wiring of the cassette lead to connect the interface to the cassette player. If the 4-core screen cable is used, the screens must not be used for the REMOTE (PL5) connections.
CABLES

A length of 20-way ribbon cable is used to link the header to the main p.c.b., as shown in Figs. 5 and 6. A length of four-core screened cable is used to connect the cassette port to the p.c.b. A 5-pin 180° DIN plug (PL1) should be soldered on the end of this as shown. Using the same cable, two 5-pin 180° DIN sockets (SK2 and SK3) are wired to the board.

The whole project may be fitted into a small plastic box. A metal box is not recommended since it would have to be earthed and the bodies of the DIN sockets are connected to computer ground. A slot may be cut in the end of the box to take the ribbon cable. Remember to pass the cable through this slot before soldering to the main p.c.b. The two output sockets, on/off switch and power indicator can be mounted as desired.

You should already have one cassette lead but another one is required for connection to the second cassette deck. This may be taken from a length of the four-core screened cable. A 5-pin 180° DIN plug (PL2) is soldered to one end as shown. The other end is stripped back about 100mm and mini-jack plugs are soldered to the ends. Two of the ends have 3.5mm jack plugs (PL3 and PL4) while the third has a 2.5mm plug (PL5). A mark such as a piece of insulation tape wrapped around the plug should be made on the plug which goes to the ear socket of the cassette deck. The connections for this lead are shown in Fig. 7.

If the recommended four-core individual screen cable is used, then none of the screen should be used in the cassette motor control circuit (REMOTE). Instead, two of the insulated cores should be used.

TESTING

First, connect the header to the expansion port of the keyboard Console. Ensure the header is the right way round. With the interface turned off and disconnected from the mains, switch on the computer. If all is well, the familiar MEMORY SIZE? will appear. Press <ENTER>. If the READY prompt appears, then all is well with the wiring. If anything unusual happens, check the connections at both ends of the ribbon cable and also check for solder bridges between tracks of both the main and header printed circuit boards.

With the computer turned off, switch on the interface. The two relays should click on. If not, check the main board for broken tracks or solder bridges. If the power light does not come on then, check out the power supply first. If the I.e.d. glows very bright, then it is probably the voltage regulator at fault. Should the relays click on, then switch on the TRS-80. All should be well, but if not it will either be IC1, IC2 or IC3 at fault.

To the MEMORY SIZE? prompt press <ENTER>. Once in Basic press POKE 14308,0 The relays should switch off. If so, enter POKE 14308,255 The relays should switch on. If all is well, continue at the next paragraph. If not, it could be any one of the i.c.s at fault. Check the connections to each one in turn and ensure that no links are missing. Note that there is a link underneath one of the i.c.s and this may have been missed out.

Next, connect the interface to the cassette port and connect two cassette decks to the interface. Place a tape with a program on it into cassette 1 and set it to play.

Type in CLOAD#1
The cassette should turn on and the program should load. If not, check the wiring to the relays and the lead to the cassette port. If all this fails it is probably a fault with one of the relays.

If all is well, then insert a tape with a program on it into cassette 2.

Type in CLOAD#2
The cassette should turn on and the program load. If not, check out the wiring as for the first cassette. Now test the saving by loading a program and entering either CSAVE#1, “A” or CSAVE#2, “A” as appropriate.

IN USE

In use, the interface may be left turned off if only one cassette is required. However, it should not be turned on while the computer is on as the computer will probably crash. All the usual cassette I/O commands may be used, but with the suffix #1, or #2. For CSAVE or CLOAD there is no need to add the suffix if the first cassette is to be used.

Material contained within has been thoroughly revised in line with new installation developments and techniques.

The book contains 13 chapters starting with basic electrical theory and finishing with an introduction to the electrical installation industry. A welcome addition to this type of book is a chapter dealing with Care and Safety which gives advice on handling materials and equipment, tool care, safety at work, electric shock treatment, and fire protection.

The text and worked examples are approached in a clear and orderly manner and each new topic has plenty of diagrams to support the text.

R.A.H.

Books in Brief

Electronic Science Projects by O. Bishop (Bernard Babani). Limp £2.25. A different type of electronics book in that all the projects have a strong scientific bias. There are 12 projects starting with A Simple Infra-red Laser and finally a more complex electronic project called Measuring the Earth’s Electric Field.

For students following electrical installation courses this book should provide some very useful reference material. All the

Everyday Electronics, December 1983
HAVE SOME PARTY FUN WITH THE CHILDREN'S LIGHT DISPLAY

When the author’s eight-year-old wanted some flashing lights for a Christmas party, some careful thought was needed. Mains-operated equipment was banned. A similar ban would also be placed on direct connections to the audio equipment.

When the problem was discussed, it appeared that any small coloured lights would be suitable just as long as they flashed in time to the music.

A circuit was devised which involves no connections to the record-player, operates from a battery and is cheap to construct. A “string” of small coloured bulbs, Christmas tree lamps for example, flash when the music plays. The sound from the audio equipment is picked up by a microphone built into the case of the project. This is interesting since the lights not only respond to music but also to other sounds in the room. Naturally, this system has limitations and is hardly suitable for serious use.

CIRCUIT DESCRIPTION

The circuit diagram for the Children’s Disco Lights is shown in Fig. 1. The microphone, in reality a miniature loudspeaker, LS1 picks up the sound of the music. This gives a weak electrical signal at its terminals which is amplified by TR1 and associated components.

This amplified signal is applied through C2 to the non-inverting input (pin 3) of the operational amplifier IC1. This input also receives a steady 4.5 V, approximately, due to the potential divider formed by R3 and R4. VR1, a miniature preset potentiometer, supplies a steady voltage to the inverting input of IC1 (pin 2). Before use VR1 will be adjusted so that the steady voltage at the inverting input is just above that at the non-inverting input. Under these conditions the op-amp will be off with no output at pin 6.

When the music plays there will be a small voltage superimposed on the steady one existing at pin 3. Thus, the voltage here will exceed that at pin 2 and the op-amp will switch on and off in time with the music. The light-emitting diode, D1, in the output circuit of the op-amp will then flash in sympathy. The l.c.d. is necessary to help in adjusting VR1 at the testing stage.

The output pulses need to be lengthened and smoothed to some extent to make them more suitable for operating filament lamps. This is achieved by D2 and C3. The pulses are then passed onto the Darling lamp driver stage TR2 and TR3. This operates the bulbs in the collector circuit. VR2 is used to match the output of the op-amp to the lamp driver stage.

No input sensitivity control is included. To adjust the response of the circuit to the loudness of the music, the case is simply moved to the best distance from the record-player loudspeaker.

COMPONENT BOARD

The component board is a piece of 0·1mm matrix stripboard having 14 strips by 29 holes and can be seen in Fig. 2. Note that all the 13 breaks in the copper track should be made in the board before any of the components are soldered in place. A holder should be used for IC1 so that damage does not occur to the l.c.d.

CASE

The plastics case used for the prototype measures 147 x 76 x 45mm although any case of similar size should be suitable. Prepare the case by making a
matrix of holes for the loudspeaker, for $S_1$ and for the battery and lamp leads. The loudspeaker is fixed in place using a quick setting epoxy resin.

**LAMPS**

The lamp driver can handle current up to 500mA, so up to eight 6V, 0.06A lamps may be used in parallel. Alternatively, Christmas tree lights may be used as in the prototype. These must be of the 6V-type normally used in 240V, 40 lamp sets. Direct solder joints may be made to the lamps which are then connected in parallel as shown in Fig. 2.

Note: up to six Christmas tree lamps may be used but only five are shown connected on the prototype.

**ADJUSTING AND TESTING**

Do not place the circuit panel in the runners of the case yet. Adjust $VR_1$ and $VR_2$ to approximately mid-track position. Connect up the battery and switch on. Adjust $VR_1$ until the balance point is reached where $D_1$ is off.

Adjust $VR_2$ so that the filament lamps glow dimly, this usually gives best results. Snap the fingers near the loudspeaker and if all is well, the i.e.d. and filament lamps will flash. The adjustment of $VR_1$ is critical. If the slider is adjusted too far clockwise the circuit will lack sensitivity or fail to work at all.

**POWER SUPPLY**

Depending on the number of lamps and periods of use, a small battery (a PP3 for example) will probably give poor service. It may seem tempting to house the battery inside the case but much better results are obtained by using a larger external battery. Excellent service is given from two 4.5V type 1289 batteries connected in series. Alkaline batteries or Nickel-Cadmium rechargeable batteries would also be a wise choice.

**PRESENTATION**

This is left to the imagination of the user. The lamps may simply be strung up. Alternatively, they may be pushed through the eyes, nose and mouth of a large mask. Another possibility is portable use with the lamps placed around a hat and the battery in a pocket.
A FILAMENT LAMP "CANDLE" THAT CAN BE BLOWN OUT BUT MAGICALLY RELIGHTS

THE Magic Candle was originally intended as a Christmas novelty but it could be used as part of a conjuring routine, as a game or simply as a conversation piece at a party.

It appears as a large candle having a filament lamp instead of a flame. After switching on, the lamp may be "blown out" and after several seconds, relights itself. This gives children great delight.

CIRCUIT OPERATION

The action of this project depends on the two thermistors, RTH1 and RTH2 (see circuit diagram, Fig. 1). These components have fixed resistors, R1 and R2, respectively, "strapped" to them with thin wire "piggy-back" fashion. Since R1 and R2 are connected in parallel across the supply battery, they will become warm soon after switching on as their power rating is slightly exceeded.

This in turn will warm the thermistors. Some heat will be developed by the thermistors themselves as they are connected in series across the battery but this will be much less than that developed by the fixed resistors. Thermistors are temperature dependent resistors and RTH1 and RTH2 are negative coefficient types which reduce resistance on heating. RTH1 and RTH2 form a potential divider and a voltage is developed at pin 3 of IC1. The value of this voltage will depend on the relative temperatures of RTH1 and RTH2. Thus, if the temperature of RTH1 becomes less than that of RTH2 the voltage will fall and vice-versa.

OPERATIONAL AMPLIFIER

The Operational Amplifier, IC1, compares the voltages at its two inputs. The voltage at pin 3 is applied to the non-inverting input (marked +) while a voltage obtained according to the setting of VR1 is applied to the inverting input (marked −). If the voltage at the non-inverting input exceeds that at the inverting input then the op-amp switches on. Otherwise it will be off. It is working as a comparator.

When on, the op-amp operates TR1 hence the filament lamp in its collector circuit. In its "normal" state, both thermistors will be warmed equally and so attain the same temperature. The voltage at pin 3 will then be approximately on half of the battery voltage, about 4.5 V. One reason why this value cannot be predicted accurately is because thermistors, even of the same type, are not truly identical in performance. VR2 is adjusted so that the voltage applied to the inverting input (pin 2) is just less than that at pin 3. The lamp will then be on.

To "blow out the candle," breath is directed at RTH1. This component will be slightly cooled while the temperature of RTH2 remains unchanged. The action of the potential divider will now be upset resulting in a fall in voltage at pin 3. This is now less than that at the inverting input so TR1 and the lamp will switch off. After a few seconds, RTH1 will regain its former temperature, its resistance will fall and the lamp switch on again.

IMMUNITY

The reason for providing two thermistors instead of just one and a fixed resistor, is to give some measure of temperature stability. If the project were moved to a room at a different temperature then both thermistors would be equally affected. In theory, the voltage at pin 3 would not change. How well this is realised in practice depends on the particular thermistors being used.

COMPONENTS

<table>
<thead>
<tr>
<th>Resistors</th>
<th>470Ω 1W (2 off)</th>
<th>4.7kΩ 1W</th>
<th>1kΩ 1W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semiconductors</td>
<td>RTH1,2 VA10555 miniature rod thermistor (2 off)</td>
<td>TR1 ZTX300 npn silicon</td>
<td>IC1 741 op-amp</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>100kΩ miniature horizontal preset</td>
<td>PP6 9V battery</td>
<td>6V, 60mA m.e.s. bulb</td>
</tr>
<tr>
<td></td>
<td>miniature toggle switch</td>
<td>0.1m matrix stripboard, 11 strips</td>
<td>S1 miniatures holder; fine copper wire (see text)</td>
</tr>
</tbody>
</table>

Approved cost Guidance only £3.80
CARDBOARD TUBE

Before constructing the circuit panel, a cardboard tube (a kitchen roll tube for example) should be chosen large enough to accommodate the circuit panel and the battery. The current requirement is about 100mA which is too high for a standard PP3 battery. If the reader intends using such a small battery, then the alkaline version (Duracell type) is strongly advised since this will give far better service. A PP6 battery may be used but this will require a tube of greater diameter than a standard kitchen roll. It is also possible to house the battery in an ornamental base. A large battery is better where heavy use is contemplated.

SENSORS

The next job is to prepare the pairs of components RTH1/R1 and RTH2/R2. These are bound together using about four turns of fine copper wire (thin fuse wire will do)—see Fig. 2.

Construct the circuit panel using a piece of 0.1m matrix stripboard, 11 strips by 19 holes as shown in Fig. 3. Although the i.c. socket should be soldered in position along with the other components, the op-amp itself should not be inserted in it until the end. Make the five breaks in the copper strips; four between the i.c. socket pins and one between the terminals of VR1 and insert the five inter-strip links.

Check all wiring and make certain that no "bridges" exist between adjacent copper tracks. Connect the lamp on two short (20mm) leads to strips B and K and two longer leads for the battery connections to strips B and I.

CHECKING

The circuit may be checked before fitting it into the candle body. Connect

---

Fig. 2. The method of fixing R1 to RTH1 (and R2 to RTH2) using fuse wire. Note these resistors must be 1W components.

Fig. 3. The stripboard component layout and trackside view. Note that the R1/RTH1 assembly must be mounted on the board so that the stream of air reaches it but not the R2/RTH2 assembly (see photo above).
the battery and wait one minute for the thermistors to reach their operating temperature. Whether the lamp lights or not is unimportant at the moment. Adjust VR1 very carefully to the point where it can be switched on or off by small movements of the slider. Leave VR1 adjusted so that the lamp is just on. Using a drinking straw, blow at RTH1 but not at RTH2. The lamp should go off and after a short while come on again. Repeat and adjust VR1 for best operation.

If all is well, the “candle” body may be prepared. Here, any artistic talents the reader might have may be freely exercised. The hole in the top of the candle is made rather large on purpose (about 12mm). The real reason for this is to allow breath to reach RTH1. It will be noted that the arrangement of the circuit panel when in position is such that RTH1 will be in “danger of fire” of breath while RTH2 is shielded.

FINAL TESTING

When finally testing the assembled project, the shielding effect of the tube may necessitate further adjustment to VR1 for best operation. It may be found necessary to make a small hole in the side of the tube to allow for adjustment of VR1. The circuit panel may be held in position using a small piece of plastic foam. The leads of RTH1 and RTH2 may be gently bent as necessary to give the correct effect.

A miniature toggle switch may be used as an on-off switch or the battery simply disconnected when the project is not in use. Readers are advised to switch off when the project is not actually in use since the battery will soon run down otherwise.

If a base is not used it may be necessary to place a piece of “Plasticine” or similar material low down in the tube to aid stability.

VARIATIONS

A variation of the Magic Candle is to blow it on as well as off! For this, RTH2 must be accessible for breath as well as RTH1. If RTH1 is blown at then the lamp will go off. If breath is now directed at RTH2 instead, the lamp will instantly re-light! By knowing this trick, readers may make a good “magic” routine.

TEMPERATURE SENSOR

The unit is very simple. It uses the fact that a germanium transistor has a varying resistance according to the temperature. It can be used as a boiling liquid alarm or for finding the temperature of a bath by putting the sensor in the water and turning the knob until the i.e.d. lights up, then reading out the temperature.

As the circuit diagram shows, the transistor collector and emitter are connected between the positive supply line and the wiper at VR1. This acts as a potential divider. The output is fed to a Darlington pair which works the alarm.

The unit reads from about 30 degrees C to 100 degrees C but this depends on the potentiometer.

Please take note

Speech Synthesiser for the BBC Micro (November 1983)

The circuit diagram Fig. 2 (page 699) shows two pins on IC1 labelled “27”. The pin connecting to R9/C5 should be labelled “24”.

The user port pin numbering on pins 8, 10, 12 and 13 of the circuit diagram are incorrect and should be re-numbered 6, 8, 10, 12, respectively.

The printed circuit board is correct.

Multimod (November 1983)

Circuit diagram (Fig. 1, page 705) shows the bottom half of S1 drawn incorrectly; the pole should be connected to 0V not to B2 +ve as shown. Wiring diagram (Fig. 4, page 707) is correct.
CONSTRUCTIONAL PROJECTS

TRS-80 Twin Cassette Interface
The p.c.b. mains transformer used in the TRS-80 Twin Cassette Interface is available from Rapid Electronics. This should be ordered as: PCB min. mains transformer, 3VA 0-6, 0-6 at 0-25A. Price £2.87 inclusive. Other transformers may be used but this may necessitate altering the p.c.b. copper strip layout.

The miniature d.i.l. 6V 80-ohm coil relays, with double-pole changeover contacts, are available from Maplin Electronic Supplies: Order code, BK48C Ultra Min, Relay 6V (DPDT).

For those readers who do not wish to make up their own cassette lead, one may be purchased from any Tandy store; ask for a Model I CPU to audio cassette lead, Code 26-1207 (£2).

Novel Egg Timer
The 14-bit binary counter (4060B) and the CMOS dual 4-input AND gate (4082B) integrated circuits used in the Novel Egg Timer are available from Enfield Electronics.

Teach-In 84
Readers wishing to purchase kits for the new Teach-In 84 series may obtain them from the following advertisers. Prices appear in their relevant advertisement in this issue.

We understand that advertisers have had difficulty in obtaining the EBBO boards which has meant a delay in sending out kits. This problem has now been resolved and the back-log of orders completed.

SUPPLIERS OF KITS FOR TEACH-IN 84
Please refer to advertisement on page stated.

Greenweld Electronics (page 846)
43 Millbrook Road, Southampton, SO1 0HX.

Magenta Electronics (page 848)
135 Hunter Street, Burton-on-Trent, Staffs DE14 2ST.

TK Electronics (page 784)
11 Boston Road, London, W7 3SJ.

EE PRINTED CIRCUIT BOARD SERVICE
Printed circuit boards for certain EE constructional projects are now available from the EE PCB Service, see list below. These are fabricated in glass-fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Remittances should be sent to: EE PCB Service, Everyday Electronics Editorial Offices, King's Reach Tower, Stamford Street, London SE1 9LS.

Rapid, Benningcross, Cricklewood and Magenta Electronics.

We have not been able to locate a "readily" available source for a 40-ohm loudspeaker. However, one of the 64-ohm, 64mm diameter range of miniature loudspeakers stocked by most of our advertisers will work in this circuit.

The final choice of housing is left to the individual, but a plastics or "soft" toy from one of the multiple stores or toy shops would make a novel finish to this project. Also, the completed board and speaker could be housed in one of those "egg baskets" in the shape of a chicken that are very popular.

Environmental Data Recorder
The MK5168 single channel 8-bit analogue-to-digital converter i.c. used in the Environmental Data Recorder may be obtained from Lock Distribution Ltd., P.O. Box L064, Neville Street, Oldham, Lancs OL9 6PY. The inclusive cost is £10.76.

Microcomputer Interfacing Techniques
The only device likely to cause any purchasing problems in this month's Microcomputer Interfacing Techniques is the ZN448 8-bit A-to-D Converter used in the Digital Board. This device is available from Magenta Electronics, Dept EE, 135 Hunter Street, Burton-on-Trent, DE14 2ST. Price £10.65 plus 50p postage.

We do not expect any component purchasing problems for the "Christmas Ideas" and the remaining constructional projects in this issue.

Cheques should be crossed and made payable to IPC Magazines Ltd.

We regret that the ordering codes for the August projects have been incorrectly quoted in the Sept-Oct issues. Correct codes are given below.

Please note that when ordering it is important to give project title as well as order code.

Readers are advised to check with prices appearing in current issue before ordering.

<table>
<thead>
<tr>
<th>PROJECT TITLE</th>
<th>Order Code</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eprom Programmer, TRS-80 (June 83)</td>
<td>8306-01</td>
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*Set of four boards. M.I.T. — Microcomputer Interfacing Techniques, 12-Part Series.
VOLTAGE DIVIDERS

Two resistances, R1 and R2, are connected in series (Fig. 3.1) across a battery. Each of these resistances "feels" the same current, and in its struggle to resist this current flow it consumes a portion of the voltage.

How big a portion? You will know from previous experiments that it depends on the relative sizes (ohmic values) of the resistances. If R1 and R2 are equal then each "drops" half of the voltage. Don't take my word for it. Try it.

Use 1kΩ resistors to keep the meter loading effect small, and remember that your resistors have a tolerance, so the voltage across R1 may not be exactly the same as across R2. (With 5 per cent tolerance resistors the worst that can happen is that one resistance is 5 per cent high and the other 5 per cent low. The difference in voltages can't be more than 10 per cent.)

If R1 is twice R2 then it drops twice as much voltage as the latter. If we divide our 9V into three equal parts, R1 drops two parts (two-thirds) and R2 one part (one-third), or in actual voltages, 6V and 3V, respectively. If we regard 9V as the input and 3V as the output of the circuit then the action of the circuit is to divide the input voltage by 3.

The circuit is a voltage divider (also called a potential divider). It is used a lot, because it often happens that we need to apply less than the full voltage to some part of a complex circuit.

We'll be doing it in earnest later in this article. First, however, I'd like to make the point that you can use this type of circuit to divide a voltage by any number, not just three.

What fixes the number? It's the relative sizes of the resistances. If for example R1 is eight times R2, then R1 must absorb eight times the voltage. Thus if R2 drops 1V, R1 must drop 8V. For an input of 9V, 1V comes out. The division is by 9.

Suppose we need a ten-fold reduction in voltage. If we imagine the output to be 1V, the input must be 10V. The "unwanted" 9V must be lost in R1. So for a ten-fold reduction in voltage R1 must be, not ten times R2, but nine times R2. It works like this for any required reduction. If the circuit is to divide the input voltage by 100, then R1 must be 99 times R2.

In articles on electronics you'll come across the expression: "voltage attenuation factor". Attenuation means reduction, and a factor is a number. So "voltage attenuation factor" is the number by which the voltage is divided. In our type of voltage divider R1 is greater than R2 and the number of times greater is one less than the voltage attenuation factor.

VOLUME CONTROLS

 Resistances behave in the same way towards a.c. and d.c. So voltage dividers of our type can be used to reduce or attenuate a.c. signals as well as d.c. voltages. Often an adjustable form of attenuator is needed. The volume control is the most familiar type. It adjusts the voltage which goes into the audio part of a receiver, or into an audio amplifier.

To make the attenuation adjustable, a resistive track (a-b in Fig. 3.2) is provided with a sliding contact c. By moving this contact to different parts of the track, different amounts of attenuation can be obtained.

With the sliding contact at a, the full input voltage is passed onto the output. With c down at b, there is no output: the attenuation is infinite. So in theory a volume control can attenuate by any factor from 1 to infinity. In practice, it can't manage that very well, but 1−100 or even 1−1,000 is practicable.

Fig. 3.1. Resistors R1 and R2 form a voltage divider across the 9V battery.

Fig. 3.2. A volume control or "potentiometer" has a resistance track a-b and a sliding contact c.

Fig. 3.3(a). How a potentiometer can "tap off" any portion of an input voltage. (Experiment 3.1); (b) Connecting R1 as a relatively low resistance "load" has a marked effect on the output voltage. (Experiment 3.2).
**EXPERIMENT 3.1**

**PREPARING YOUR POT**

Get an ordinary rotary type of volume control of the type known as a "10kΩ log, law potentiometer." Connect a length of insulated wire to each of its three tags. If you start with lengths of about 300mm (12in) they will end up about right.

To make connections without soldering, first make sure the tags are clean and bright. Then strip off about 40mm (1½in) of insulation from one end of each of these leads. Wrap this bared wire firmly round and round a tag, squeezing it from time to time with pliers to give it extra grip. When all the bared wire is wrapped, continue with a few turns of the insulated part: this helps to hold the bared wire in place. Do this for each lead.

If possible, use wire of a different colour for each lead. If not, mark the free ends of the leads in some way. You will need to strip off a few millimetres of insulation later, so don’t put your markers right at the end. When all three tags are connected, twist the wires together. Finally strip off about 6mm (¼in) of insulation from the free ends, for plugging into your breadboard.

Your finished volume control should look like the one in the photograph. When the spindle is turned fully clockwise the internal sliding contact touches terminal "a." In the fully anti-clockwise position it touches "b."

If you connect an ohmmeter to terminals "b" and "c," the resistance indicated increases as the spindle turns clockwise. For "a" and "c," anti-clockwise motion increases the resistance. (Remember to reset your meter to a voltage range immediately after making this test.)

Connect your volume control to your 9V battery (Fig. 3.3a) and measure the output voltage as shown. Note that this can be set to anything from 0V to 9V.

**LOADING ERROR**

When a resistance is connected across the output of a voltage divider the output voltage falls. This is because extra current flows through R1 (Fig. 3.1) or the corresponding resistance in Fig. 3.3a, which is the upper part of the track; that is, from "c" to "a."

The amount of extra current depends on the size of the "load"; in other words, the resistance connected across the output. If this is very large, little extra current flows through R1 and the output voltage is not much reduced. But a low-resistance load pulls down the voltage seriously.

**EXPERIMENT 3.2**

To illustrate this, connect a 1kΩ resistor to your 10kΩ potentiometer (Fig. 3.3b). Note that if the resistor is unplugged when the slider is set at an intermediate position the voltage indicated jumps up. This loading effect is worst at the point where, in the absence of a load, the meter reads half the battery voltage.

The loading effect can be reduced by making the divider resistances small compared with the load resistance. This means wasting current in R1 and R2 (or your "potentiometer") but this is often tolerable.
**EXPERIMENT 3.3**

TURNING ON A TRANSISTOR

Our next experiment will be to find out how much voltage is needed to "turn on" a transistor; that is, to make it pass current.

Referring to Fig. 3.6, a transistor has three terminals or "electrodes": they are, base (b), collector (c) and emitter (e). The main current path through a transistor lies between collector and emitter. The little arrow on the emitter shows the permitted direction of current flow. (Transistors are one-way devices; current can flow only in permitted directions.)

To permit current to flow via the collector-emitter (c-e) path the transistor must be turned on by driving a small current through the base-emitter path. Our 10kΩ potentiometer allows us to adjust this current by applying any part of the battery voltage to the resistor R1. The meter (on its 2.5V range if you are using the KEW7S) measures the resulting voltage between base (b) and emitter (e). We'll call this voltage VBE for short.

With the kind of transistor we are using at the moment (an npn transistor) the normal direction of current flow is into the base and into the collector and out of the emitter. Collector and base are then positive with respect to the emitter.

CURRENT INDICATOR

To show that collector current is flowing, connect a l.e.d. and limiting resistor as shown (Fig. 3.6), making all connections within one half of your EBBO discrete component module. Try it.

My test results were:
- D1 just glowing ....VBE = 0.65V
- D1 bright ...........VBE = 0.75V

To pinpoint the "bright" setting of VR1, I first turned it fully up then gently back to find the point where the l.e.d. just began to dim. Transistors vary. Your voltages may be somewhat different.

The collector current with the l.e.d. bright is actually about 7mA. Assuming the "dim" current to be 1mA, we can look at our results like this:

\[
\begin{align*}
V_{BE} & = 0.65V \text{ makes } 1mA \text{ flow into the collector} \\
V_{BE} & = 0.75V \text{ makes } 7mA \text{ flow into the collector}
\end{align*}
\]

From this you can see that (for my BC107B) a change in VBE of 0.1V produced a change in collector current (Ic) of 6mA.

This ability of a change in VBE to produce a corresponding change in collector current (Ic) is an important transistor characteristic. It has a name: mutual conductance or transconductance, and a symbol, gm:

\[
gm = \frac{\text{Change in Ic}}{\text{Change in VBE}}
\]

For small values of Ic, this is expressed in mA (of Ic) and volts (of VBE). Then, gm comes out in milliamperes per volt (mA/V). However, mA/V also has a name: 1mA/V = 1 milli-siemens (1mS).

My figures indicate a mutual conductance of about 60mS.

VOLTAGE AMPLIFICATION

As the collector current increases, more voltage is dropped by the l.e.d. and R2. With the l.e.d. just glowing, the total drop across it and R2 is about 3V. When the l.e.d. is bright, the drop is nearly 9V.

So a change of 6V in the collector part of the circuit has been produced by a change of 0.1V at the base.

If the change in VBE (0.1V) is an input signal, and the change in collector voltage an output signal, then the transistor has amplified the input sixty-fold. In engineer's talk, the voltage gain is 60.

CURRENT AMPLIFICATION

A transistor amplifies current, too. The input is the current which flows into the base (and out at the emitter along with the main current from the collector). The output current is the collector current. It is true that for an npn transistor this "output" flows into the transistor. But we'll see in a later article how it can be taken elsewhere.

POTENTIOMETERS (left and right) normal panel mounting volume controls; (centre) twin-ganged type with mains switch at rear. The two smaller components are preset potentiometers for direct mounting on circuit boards, screwdriver adjustment.

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To investigate current amplification, it is necessary to know the base current, \( I_b \). The most direct way of finding \( I_b \) is to connect a current meter in the base circuit (Fig. 3.8a). In practice, this is neither practical nor safe. Meters when switched to "current" ranges are easily overloaded by accidental momentary connection across the power supply. In this particular circuit there is a design error which almost guarantees it will happen!

If VR1 slider is moved up to the top of the track (a), which is the same thing as battery +, current can flow freely from battery + through the meter, through the base and emitter and back to battery +. The transistor base-emitter "junction" offers little resistance, and the resulting large current wrecks both transistor and meter.

Some meters are protected internally against overload but it is always better to play safe and measure voltages rather than currents.

On a voltage range the meter always has a fairly high resistance. (For a KEW75, whose sensitivity is 2kΩ/V d.c., the resistance is 2kΩ times the voltage range to which the meter is set. On the 10V d.c. range it is 2kΩ × 10 = 20kΩ.)

**EXPERIMENT 3.4**

In any case, the base current is likely to be too small to measure on a cheap meter. We'll avoid the problem by using the circuit Fig. 3.5b. This makes use of the fact that if we know the voltage across a resistance we can find the current flowing through it.

Here, the base current sets up a voltage across R1, 100kΩ. Every volt applied to 100kΩ produces a current of 10 microamps (10µA), that is, ten-millionths of an amp or a hundredth of a milliamp.

The voltmeter doesn't measure the voltage across R1, but merely the voltage at one end. Fortunately, we can estimate the voltage at the other end. It is \( V_{BE} \), which is never very far from 0.7V. (The most extreme values of \( V_{BE} \) you are likely to come across in silicon transistors are 0.4V and 1V; that is, 0.7V ± 0.3V). Let's call it 0.7V.

My voltmeter readings were:

- D1 dim .................. 1V
- D1 bright .................. 4V

Knocking off 0.7V for \( V_{BE} \), the voltages across R1 must have been about 0.3V and 3.3V. The corresponding base currents are 3µA and 33µA.

In the "l.e.d. dim" case, if \( I_c \) was 1mA (1,000µA) the current amplification was 1,000/3 = 333. In the "l.e.d. bright" case, if \( I_c \) was 6mA (6,000µA) my BC107B had a current gain (\( I_c/I_b \)) of 180.

You may suspect that the current gain of a transistor varies with its collector current. It does. But our results are based
CHECK YOUR PROGRESS

Questions on Teach-In 84 Part 3
Answers next month

Q3.1 In the circuit of Fig. 3.8b, why can't the meter be connected across R1 to measure the voltage directly?

Q3.2 A transistor has a current amplification factor \( h_{re} \) of 100. If its base current is 10µA what is its (a) collector current; (b) emitter current.

Q3.3 The burglar alarm circuit of Fig. 3.11 makes use of the fact that the resistance of the light-dependent resistor PCC1 falls considerably when a beam of infra-red light strikes it. If the alarm bell is to sound when an intruder's body interrupts the beam how must the circuit work?

This trick of turning on a transistor like this is called biasing. Purely by way of illustration, Fig. 3.10 illustrates how a gramophone amplifier might be set up. The voltage divider, R1, R2 sets up enough base-emitter voltage to produce a suitable collector current. This flows through a loudspeaker. Any variations in this steady current at audio frequency produces sound.

To insert these variations the magnetic pickup is connected in the base lead. Any voltage developed in the pickup coil then adds to or subtracts from the 700mV bias. So as the pickup generates a few millivolts of audio signal (which is a.c., not d.c.) the collector current rises and falls in sympathy. These a.c. variations superimposed on the steady d.c. produce sound in the speaker.

That, at any rate, is the theory. In practice, it won't work, because a single transistor doesn't amplify enough. Also, this circuit is badly affected by variations in the supply voltage \( V_{CC} \) and temperature, which changes the required \( V_{BE} \) of the transistor.

Next time we'll look at more practical circuits and at a useful way of separating the output signal from the steady collector current.

If you are buying as you go along you'll need a crystal earphone and at least two 100nF (0.1µF) capacitors, 30V (minimum) working, non-polarised. Disc types with long leads are most convenient. Also a 1,000µF electrolytic capacitor, 16V (minimum).

Next month: Transistors and Capacitance

ANSWERS TO PART 2

Q2.1 (a) 2mA; (b) 9V; (c) 18kΩ.

Q2.2 (a) 9kΩ; (b) 3kΩ (the lowest two resistors are short circuited); (c) 1kΩ (current can flow from X to Y via any one of the resistors so they are all in parallel).

Q2.3 3mA. There is 4V across the parallel resistors so the 2kΩ passes 2mA and the 4kΩ passes 1mA.

Q2.4 4V. The meter acts as a resistance of 10kΩ. In parallel with R2 this makes 5kΩ. The total resistance is then R1 (10kΩ) + 5kΩ = 15kΩ. 12V applied to 15kΩ drives 0.8mA. which produces 4V in flowing through the 5kΩ. So 4V appears across the meter and this is what it indicates.

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TOTALLY PORTABLE AND USING RECHARGEABLE BATTERIES, THIS UNIT IS IDEAL FOR FIELD WORK.

ENVIRONMENTAL DATA RECORDER
BY M. LAWRIE & L. WILKINSON
When measuring changes in biological and environmental science experiments, the quantities being measured often change very slowly. For this reason it may take days, or even weeks, to take readings of, say, pH changes in water over a length of time. If the experiments are being carried out-of-doors, then the problems of setting up the experiment and collecting the readings are far greater.

DESIGN CONSIDERATIONS

The unit described here is designed to be waterproof and weatherproof which can be left on site using its own power supply. It can be fitted with many different sensors, for example, oxygen probes, pH probes, light dependent resistors (for light) and thermistors (for heat) and with these it can measure oxygen level changes, pH level changes, light level changes and temperature changes.

The Environmental Data Recorder can take readings ranging from over 500 per second to over once per hour. The data is stored digitally in a 2K byte memory that can be read at a later date by plugging it into the expansion slot of the Sinclair ZX Spectrum. A short program is used to put the data or a graph of the results onto the screen. It is helpful to have a Sinclair ZX Printer to get a hard copy of the graph or data.

When designing the circuit, several points had to be considered because it (a) is to be portable so it must be a physically small unit, (b) should have a low power consumption, (c) must be able to be plugged into the back of the Spectrum without losing any data or crashing the computer, and (d) must be able to be used over a long period, continuously for a month if necessary.

CIRCUIT DETAILS

The unit works in one of two modes, first WRITE then READ. Switches S1 to S3 select the mode. The reset switch (S4) resets the address counter to zero in either mode. Fig. 1 shows a block diagram of the unit in write mode. Brief operating descriptions follow. The full circuit diagram is shown in Fig. 2.

The MV5516 CMOS static RAM (IC5) was used because its low power consumption when not selected (CE, and CE, both at logic 1) uses only about 1µA.

The MK5168 analogue-to-digital converter (IC3) was selected for its simplicity of operation. In the basic unit described here, the reference voltage (pin 4) is +5V but may be changed for other applications. To measure changes in light intensities, an ORP12 light dependent resistor (L.d.r.) was connected across the analogue input and +5V. If absolute values of intensity are needed, calibration against a standard must be carried out.

If other level changes are to be recorded, the output voltage of the sensor should be in the range of 0 to +5V, so a buffer or attenuator may be needed.

Provision for easy change of write pulse times (the time between each successive sample) has not been made. The time may be changed by altering the values of R3, R4 and C1. The timing period is approximately 0-7 x R3 x C3 (R4 must be small compared with R3). With $R3 = 3\times 3M\Omega$, the period is approximately 2-3 seconds times capacitance of C1 in microfarads. With a 1500µF capacitor, a reading will be recorded approximately once per hour. For all periods greater than 0-7 seconds, R4 should be 1kΩ. For periods shorter than this, R4 should be increased.

Equations for calculating the component values for a 555 timer as an astable multivibrator are given below.

Output high for

$$0.685 \times (R3 + R4) \times C1 \text{ seconds}$$

Output low for

$$0.685 \times R4 \times C1 \text{ seconds}$$

Period of one cycle

$$= 0.685 \times (R3 + 2R4) \times C1 \text{ seconds}.$$
and the clock are fed to an OR gate (in the circuit, two NOR gates, IC2b and IC2c) and the output of this selects READ if high and WRITE if low.

The process repeats itself on the next falling edge from the clock oscillator. In this way, the analogue value on pin 4 of IC3 is converted to an 8-bit digital representation and written into the memory with every sample pulse.

READ MODE

When switches S1—S3 are taken to the READ position (opposite to that shown in Figs. 1 and 2), the A/D converter is turned off as the CS input (pin 5) is taken to +5V. With the unit plugged into the back of the Spectrum, IC1, an 8-input NAND gate, is switched on (as it takes its power from the computer not the battery pack).

The program selects ports 255 or 127 (via the command IN255 or 127) and so pulses the 12-bit address counter adding one to the memory address. Data is read from the memory after each address has been incremented.

CIRCUIT BOARD

The circuit is constructed on a double-sided p.c.b., 100 x 100mm, the track pattern and component layout of which is shown in Fig. 3. This board is available from the EE PCB Service, Order code 8312-04 or can be made using the usual methods, although special care must be taken as it is double-sided, to ensure alignment of the two artworks.

The 26 shorting pins (the links between the top and bottom tracks) must first be inserted. Note that these must be soldered on both sides. Next, the resistors and capacitors are inserted and some of the leads require soldering on both sides.

The d.i.l. i.e. holders are then soldered in place but the i.c.s are not plugged-in until later. Note that IC3 and IC5 face the opposite direction to all the other i.c.s. Finally, the d.i.l. switch (S1—S4) and the 23-way edge connector are fitted.

EDGE CONNECTOR

The 23-way double-sided edge connector has the polarising key fitted at position three and this is mounted to the left side when viewed from the top with the connector pointing down (as in Fig. 3).

Fig. 2. Complete circuit diagram of the Environmental Data Recorder in WRITE mode. To set to READ mode, S1—S3 are switched to opposite position. PCC1 is connected to the analogue input to measure light intensity.

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809
The light-dependent resistor (PCC1) used for light level monitoring.

The last connections are the wires to the battery pack and to the sensor (on the prototype, a light dependent resistor, PCC1).

The battery wires should be long enough to allow the board to be withdrawn from the case to be plugged onto the Spectrum computer. Ensure that there is no short circuit on these leads as the low internal resistance of the cells compared with their high output can produce a lot of heat quickly!

When assembly is complete, the i.c.s can be inserted into their holders, observing the correct orientation shown in Fig. 3.

CASE

The Environmental Data Recorder p.c.b. is mounted into a watertight case when out in the field, which also houses the battery pack. This is a holder for four C size (HP11) ni-cad rechargeable batteries and it is held in place with double-sided adhesive tabs.

The prototype was housed in a die-cast box, 170 x 120 x 50mm with a specially fabricated bracket at one end to hold the edge connector of the board. (See photographs.) This bracket must use an insulating material (plain matrix board for example) to slot into the connector to prevent short circuits.

INSTRUCTIONS

To use the Data Recorder, the following set of instructions must be followed. First set up the correct sample period with the selected values of R3, R4 and C1 on the astable timer (IC4), the calulations for which are given in the circuit description.

1. Set switches S1, 2 and 3 to the down position (WRITE) and S4 to the up (RESET).
2. Place the ni-cad batteries in the holder (observing the correct polarity) to switch the unit on.
3. When ready, set S4 to the down position to begin recording.
4. Place the board onto its holder in the case and seal the lid.
5. When the readings are complete, set all the switches to the up position (S1–S3 to READ and S4 to RESET).
6. Remove the module from the case (but do not disconnect batteries) and plug onto the Spectrum edge connector—with or without the ZX Printer.
7. Connect the Spectrum power supply.
8. Enter the program (listed separately) and set S4 to the down position. RUN the program.
9. When complete, remove Spectrum power supply.
10. Remove batteries from holder (to switch Data Recorder off).

CONCLUSION
Like many electronics systems, further developments can be carried out. The Environmental Data Recorder described here uses less than 2mA compared with over 8mA in the original prototype unit presented for SEDAC. The timing circuit has been completely redesigned and the selection logic simplified.
Further developments could include multi-channel A/D conversion, using switches to select the timing period and increasing the memory. A selectable voltage gain unit buffering the analogue input could be a useful feature. But the prototype has been used extensively for light level comparison and no problems have been found. □

SOFTWARE
10 REM Environmental Data Recorder
20 REM (c) Everyday Electronics
30 REM December 1983
40 FOR n=175 TO 0 STEP -1
50 PLOT IN 255.n
60 IF n=0 THEN GO TO 80
70 NEXT n
80 PAUSE 10
90 COPY
100 CLS
110 GO TO 40

Boost For CB
The other day I was idly wondering why the good people advocating a Citizen’s police watch to assist the police and prevent burglaries, did not suggest that they use Citizen’s Band Radio, when I spotted an intriguing piece in a national newspaper. It appears that young girls are using CB radio to lure men to their doom. My male colleagues would no doubt phrase this differently.
No, Paul Young is not leading a headlong rush to the nearest CB emporium. When you reach my mature and serene age and I sincerely hope you will, you will appreciate the wisdom of my great Groucho. When, in his eighties, he was asked if he still chased the girls, he replied: “Yes, but only downhill”.
I mention all this, particularly for the benefit of my lady readers (if I have any). If your husband hints that you might like to buy him a CB radio for Christmas, I would suggest you should reply: “Of course darling, so long as I can have an extension speaker to listen in to you.”
Finally, the CB jargon for a meeting of two CB enthusiasts is: “Eyeball to Eyeball”. I wonder what the word spinners will dream up for this type of assignment?

COUNTER INTELLIGENCE
BY PAUL YOUNG

All At Sea
I don’t often get angry, my blood pressure prevents it but I must confess to getting hot under the collar, when I read of the plight of the transatlantic yachtsman Tom McClean.
He was crossing the Atlantic in a yacht just about eleven foot in length. His only communication was through British radio amateurs. Along comes two officials from the licensing department and forbids the two “Hams” to communicate with him because he has no licence.
How I would love to have the power to act like Gilbert’s Mikado and make the punishment fit the crime. I would place the two bureaucrats in an eleven foot yacht in mid-Atlantic, not without a paddle but without any communication.

Time Out
Hardly a week goes by without some funny story concerning digital watches. The latest concerns a small boy riding home on his bicycle wearing his sister’s watch.
Suddenly the strap broke, and in order not to lose it, he put it in his mouth. Then to add to his misery, he hit a bump which caused him to swallow it.
He went along to his G.P. who was certainly a bit behind the times, and obviously not a reader of EE. “That’s all right son, I will follow its progress with my stethoscope.”
The final outcome was a happy one, his grandfather gave him a Silver Hunter with a tick that would have done credit to Big Ben, and, to phrase it delicately, in due course time passed.

Atomic Cars
Seeing a headline a short time ago: “New ‘A’ Car Craze Sweeps Britain”, I immediately jumped to the wrong conclusion. “Aha!” I said, “atomic driven cars, the obvious answer”, only to find they were talking about number plates. Rather a let down I’m afraid, though I am certain the day will come when we shall be driving them.
Consider for example, the Polaris submarine. The fuel container is about the size of a dustbin but the atomic contents, not only propel the vessel, it also provides all the power for heating, cooking, lighting and all ancillary equipment and even turns the sea-water into oxygen for breathing. Unbelievably, it only needs replacing every seven years. Translate that into car terms and think what it could do!
Alas, they may not arrive in my life time, but by way of compensation I see the Wizard of Electronics, I mean of course Sir Clive Sinclair, hopes to have his Electric Car coming off the production line by the end of 1984. So, if you see me running up the road singing: “I’m Off to See the Wizard”, you will know the reason why.
THE TWELVE FINALISTS WILL SHARE OVER £3000 AND PARTICIPATE IN AN ALL-EXPENSES-PAID TWO-DAY VISIT TO LONDON DURING JULY 1984

For the third year running Mullard Ltd.—the largest electronic components company in the UK—and Everyday Electronics join forces to present a rewarding challenge to Secondary Schools within the United Kingdom.

As distinct from the two previous contests, this year the conditions have been somewhat broadened so that entries can relate to electronic equipment having practical use anywhere within the school, or at any external event in which the school participates.

FIRST PRIZE The Sedac Trophy and £300 Plus a selection of components valued at £200
SECOND PRIZE £200
THIRD PRIZE £100

NINE RUNNERS-UP. A selection of components valued at £100.

In addition, all twelve finalists will receive a certificate and one year's subscription to EVERYDAY ELECTRONICS—and will enjoy an all-expenses-paid two-day visit to London during July 1984.

Science teachers of Secondary Schools are invited to apply for a Registration Form which contains full details of this competition.

Write to: SEDAC Schools Competition, Room 2130, King's Reach Tower, Stamford Street, London SE1 9LS.

Secondary School Pupils—make sure your school accepts this challenge and enters this contest. So bring this announcement to the attention of your science teacher or the head of your school.

Closing date for Registration: 30 November 1983
Closing date for submission of Papers: 31 January 1984

Everyday Electronics, December 1983
In Part 4 of this series, the techniques of analogue-to-digital conversion were discussed and a practical single channel system, using the successive approximation type of converter, was described.

In this part, the associated techniques of analogue data multiplexing and signal conditioning will be dealt with together with the construction of a high-speed four channel data acquisition system.

The first part of a series dealing with transducers for use with this (and other) systems will be published in later issues of EE.

**SIGNAL CONDITIONING**

The output voltage ranges of transducers to be used with ADCs will not usually be compatible with the analogue input voltage range of the converter.

As an example, a bridge network used for developing an analogue voltage which represents the deflection of a strain gauge might produce only a few millivolts, which is far too small to apply directly to the input of the ADC.

Some form of amplification is then usually necessary and circuits based upon operational amplifiers are generally employed. The simple theory of operational amplifiers with applied negative feedback is well known, but it is helpful to deal briefly with it here.

In Fig. 6.1a, the operational amplifier is used in the inverting mode, that is, the input and output signals are out of phase with each other and the voltage gain, G, of the arrangement is dependent only on the values of input resistor \( R_{IN} \) and feedback resistor \( R_F \). The voltage gain may be obtained from the simple formula

\[
G = \frac{R_F}{R_{IN}}
\]

Note that the feedback signal is applied to the invert \((-)\) input of the device, so giving negative feedback.

Fig. 6.1b shows a non-inverting amplifier configuration and, in this case, the voltage gain \( G \) may be calculated using the formula

\[
G = 1 + \left( \frac{R_F}{R_1} \right)
\]

The input impedance of this arrangement is very high indeed—a desirable feature if it is to be used to amplify analogue voltages from transducers which may themselves possess relatively high source impedances.

In the practical four-channel system described, each analogue input is applied to its own signal conditioning amplifier, the non-inverting configuration being used. The analogue signal range of each channel is 0–100mV full scale and the full scale input range of the ZN448 ADC used is 2–5V. The amplifiers are thus required to give a voltage gain of \( \left( \frac{2.5}{0.1} \right) = 25 \).

Using the voltage gain formula, we see that:

\[
25 = 1 + \left( \frac{R_F}{R_1} \right)
\]

and, choosing a value of 10kΩ for \( R_1 \), then \( R_F \) should have a value of 240kΩ. The accuracy of the system is partly dependent upon the amplifier gains, and close tolerance resistors should be used for these components. (The channel gain is easily changed by using another value for \( R_F \), but voltage gains of more than \( \times 100 \) should not be attempted with a single operational amplifier.)

**LOW-PASS FILTERING**

Many transducers develop very low level signals and problems can arise with spurious signals originating from, for example, voltages induced into the system by 50Hz mains fields. Careful circuit layout and screening is helpful, but with data acquisition systems in which the signals are sampled and measured very rapidly, serious errors can arise if false signals are present.

Since most analogue quantities encountered will change fairly slowly, the corresponding electrical signals developed by the transducers will be of very low frequency and some signal conditioning circuits entail the use of low-pass filters which allow only the low frequency signal voltages to be passed onto the output, higher frequency spurious signals being heavily attenuated.

The response of a typical low-pass filter is shown in Fig. 6.2. A later article dealing with the development of a single conditioning amplifier for very low level biological signals will include a more detailed description of a typical low-pass filter.

BBC Microcomputer users will be aware that the model B already possesses a 4-channel analogue input facility. The ADC employed is a 12-bit device but its conversion time is rather slow. Transducers intended for application with the system described in this article can be employed with the BBC machine if the analogue section of the circuit is con-
structed and the amplifier gains are altered to an appropriate value. Details of this are given at the end of the article.

ANALOGUE MULTIPLEXING

ADCs offering multiple analogue input channels are available, for example, National Semiconductors ADC0816/ADC0817 Single Chip Data Acquisition System allows 16 analogue inputs, but Ferranti’s ZN448 is a single channel device only.

In order to accommodate several channels of analogue data, some form of multiplexing technique is necessary, in which the individual channels are connected one at a time to the input of the ADC. Integrated circuit switches which can perform this function are available in both CMOS and TTL; the switching operation is usually controlled by applying binary signals to the channel select pins of the device. Fig. 6.3 shows a typical arrangement for an eight channel system.

The 4051 analogue multiplexer behaves basically as a single-pole, 8-way switch, the switch position being determined by the binary code presented to the channel select pins. Its truth table and pin-out diagram are shown in Fig. 6.4.

CHANNEL SELECT CODE

In the project described, four channels are required and a CMOS 4052 dual 4-channel multiplexer is employed. The binary channel select code can be generated in a number of ways. A single pulse (which could be obtained from the ADC end of conversion signal, EOC) can be used to increment a three-bit binary counter and the code generated then applied to the analogue switch.

An alternative method, employed by the authors in the four channel system described, offers a “software solution” in which the appropriate code is generated by the microcomputer itself. This code is then presented at the user port and routed to the analogue multiplexer via the two least significant lines available at the user port. Clearly, these switching code signals must only be present on the port lines when the microcomputer is not engaged in a data read operation.

During the channel select period, the tri-state facility of the ZN448 output latches is utilised to effectively disconnect the ADC from the data bus lines; the tri-state enable/disable signal being generated in software.
4 CHANNEL
HIGH SPEED
ADC

THE PRACTICAL CIRCUIT

Fig. 6.5 shows the circuit of the complete 4-Channel ADC. Each of the four analogue signals to be monitored (in the range 0–100mV) is applied to the input of its signal conditioning amplifier, IC1 to IC4, CA3140 CMOS devices are used here and offer low power consumption and extremely high input impedances. As mentioned previously, the gain of each amplifier is set at x25 by the 240kΩ/10kΩ feedback resistor combination.

The amplifiers are situated on a separate PCB to that used for the channel switching and ADC sections of the circuit, thus obviating the possibility of any interaction between the large TTL level pulses present in that part of the circuit.

Fig. 6.5. Complete circuit diagram of the 4-Channel High Speed ADC.
circuitry and the relatively low level analogue voltages present at the op-amp inputs.

The amplifier outputs are connected to the inputs of the 4052 dual, one of four 
CMOS switch, IC8 (only one half of the i.c. is used), and the output pin of this provides the analogue input to the ZN448 ADC. Zener diode, D6, provides protection for the ADC in the case of over range inputs by simply conducting when the p.d. across it (and the input to the ZN448) exceeds about 3V.

The ADC section of the circuit is similar to that used in the single channel converter in Part 3 except that it has been arranged for unipolar operation (that is, it can only convert input voltages which are positive with respect to ground). Transducers employed with this system should develop voltages suitable for this mode of operation.

The conversion rate has been reduced considerably (to about 30,000 per second) by increasing the size of the clock timing capacitor C6. The slower operating rate, is again, appropriate to the transducers used with the ADC.

The two channel select lines of the 4052 switch are connected directly to the P0 and P1 (two least significant bit) lines of the user port whilst the tri-state enable pin, instead of being grounded (and permanently enabling the latches) is taken, via the ribbon cable to pin M of the user port, this pin being used to output the tri-state control signals.

The power supply section of the circuitry is constructed largely on the analogue board and is quite conventional. A single +5V supply is required for the ZN448 and this is provided by the 78L05A voltage regulator IC6.

CONSTRUCTION OF THE BOARD

Printed circuit boards are used for both analogue and digital sections of the circuit and full size patterns are given for these in Figs. 6.6 and 6.8. These boards are available from the EE PCB Service, Order codes 8312-01 and 8312-02, respectively.

Starting with the analogue board, 8-pin d.i.l. sockets should be inserted and carefully soldered, as shown in Fig. 6.7. The five link wires should now be carefully formed and soldered into the appropriate positions. 22 s.w.g. bare tinned copper wire is used here. The seven Veropins should now be inserted, pressed home and soldered to the copper tracks.

PL5 is a 4-way inter-p.c.b. plug and this should be inserted and soldered in next.

All other components should now be inserted and soldered, particular care being taken with electrolytic capacitors and the three voltage regulators. (Readers should note that the p.c.b. appears in the photograph is the prototype. The layout given in Fig. 6.6 is an improved version and hence differs slightly from the original.)

Construction of the digital board, Fig. 6.9, follows along similar lines and again readers should note that there are slight differences between the p.c.b. layout of original and published designs.

Connection to the microcomputer user port is by a 12-way cable and two inter-p.c.b. plugs, a 10-way and a 4-way type are employed for this purpose. Ribbon or multicore cable can be used.

An aluminium case of dimensions 27.5 \( \times \) 19 \( \times \) 9cm was used to house the prototype. The front panel should be drilled to accommodate the four bnc analogue input sockets (SK1-SK4), the mains switch and the power on indicator L.e.d. The rear panel needs drillings for the fuse, mains lead, and ribbon or multicore user port cable.

The mains transformer (6-0-6V at 100mA) should be mounted as shown in Fig. 6.10, which also gives the interwiring arrangement for the boards. With all of these components mounted, the boards should be fixed in place and the various interconnections completed.

SETTING UP AND TESTING THE UNIT

After switching on, power supplies to both analogue and digital boards should be checked. If either is incorrect, switch off immediately and locate the fault. If all is well, the operational amplifier offsets should be nulled.

A digital voltmeter should be connected between GND and the output

<table>
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<th>COMPONENTS</th>
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<td>IC9</td>
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<tr>
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</tr>
<tr>
<td>D5</td>
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<td>D6</td>
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**See Shop Talk page 801**

Printed circuit boards: Analogue board single-sided size 127 x 95mm, EE PCB Service, Order code 8312-01; Digital board single-sided size 127 x 95mm, EE PCB Service, Order code 8312-02; d.i.l. sockets: 8-pin (4 off), 16-pin (1 off), 18-pin (1 off); single-sided Veropins (18 off); bare tinned copper wire; 12-core cable (1m); rubber grommets (2 off); cable retaining clips (2 off); 4BA fixings (2 sets); 8BA fixings (6 sets) and 20mm spacers (4 off); metal case approx. 280 x 190 x 90mm; rubber feet for case.

*Everyday Electronics, December 1983*
Fig. 6.6. Full-size printed circuit board master for the analogue board.

Fig. 6.7. Complete component layout for the analogue (ADC) board.
Fig. 6.8. Full-size printed circuit board master for the digital board.

Fig. 6.9. Complete component layout for the digital (clock) board.
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Fig. 6.10. Interwiring diagram for the two boards.
PET
5 REM PET 4 CHANNEL ADC
10 POKE 59468,PEEK(59468)OR12
20 POKE 59468,PEEK(59468)AND223
30 POKE 59456,PEEK(59456)OR8
40 POKE 59459,255
50 INPUT C
60 IF (C-1)*(C-3)*(C-2) 6255 THEN GOSUB 500
70 GOTO 50
80 POKE 59471,C
90 POKE 59456,PEEK(59456)AND247
100 POKE 59456,PEEK(59456)OR8
110 POKE 59459,0
120 POKE 59468,PEEK(59468)AND223
130 POKE 59459,0
140 POKE 59468,PEEK(59468)OR8
150 POKE 59459,0
160 POKE 59468,PEEK(59468)AND223
170 POKE 59459,0
180 POKE 59468,PEEK(59468)OR8
190 POKE 59459,0
200 POKE 59468,PEEK(59468)AND223
210 POKE 59459,0
220 POKE 59468,PEEK(59468)OR8
230 POKE 59459,0
240 POKE 59468,PEEK(59468)AND223
250 POKE 59459,0
260 POKE 59468,PEEK(59468)OR8
270 POKE 59459,0
280 RETURN

VIC-20
5 REM VIC-20 4 CHANNEL ADC
10 POKE 37147,PEEK(37147)AND227
20 POKE 37148,PEEK(37148)OR12
30 POKE 37148,PEEK(37148)OR8
40 POKE 37139,PEEK(37139)OR32
50 POKE 37139,0
60 POKE 37148,PEEK(37148)AND223
70 PRINT PEEK(37136)
80 POKE 37148,PEEK(37148)OR8
90 IF C-1)*(C-3)*(C-2) THEN GOSUB 500
100 GOTO 70
110 POKE 37136,C
120 POKE 37151,PEEK(37151)AND223
130 POKE 37151,PEEK(37151)OR32
140 POKE 37139,0
150 POKE 37148,PEEK(37148)AND223
160 PRINT PEEK(37136)
170 POKE 37148,PEEK(37148)OR8
180 PRINT PEEK(37147)
190 POKE 37148,PEEK(37148)AND223
200 POKE 37138,255
210 RETURN

COMMODORE 64
5 REM COMMODORE 64 4 CHANNEL ADC
10 POKE 56578,PEEK(56578)OR4
20 POKE 56576,PEEK(56576)OR4
30 POKE 56579,255
40 PRINT C
50 IF C-1)*(C-3)*(C-2) THEN GOSUB 500
60 GOTO 40
70 POKE 56577,C
80 POKE 56579,B
90 POKE 56576,PEEK(56576)AND251
100 PRINT PEEK(56577)
110 POKE 56576,PEEK(56576)OR4
120 POKE 56579,255
130 RETURN

BBC MODEL B
As previously mentioned, the BBC Model B Microcomputer has an internal 4-channel 12-bit ADC. The full scale analogue voltage of each channel is 1-8V and the analogue board design given can be used to give a 100mV range if the feedback network is modified slightly. The gain required is now x18 and, using the op-amp gain equation for the non-inverting mode:

\[ G = (1 + R_F/R_IN) \]

gives a ratio of 17 for \( R_F \) and \( R_IN \). Suitable resistor values for \( R_F \) and \( R_IN \) are 220k\( \Omega \) and 13k\( \Omega \), respectively (\( R_F \) should actually be 221k\( \Omega \), but a 220k\( \Omega \) resistor is within 0.5% of this). Once again, close tolerance resistors should be employed.

The +5V regulator for the digital board supply can be omitted. Outputs from the board should be taken to the BBC analogue input via screened cable and the appropriate miniature 15-way D-type plug.

BBC MICRO SOFTWARE
The form the BASIC statement used, to extract digital information from the BBCs ADC, is

\[ X = ADVAL(N) \]

where \( N \) refers to the channels numbered 1,2,3,4. The number returned is in the range 0 to 65520 in steps of 16. This may seem odd when the converter itself produces a number in the range 0 to 4095. The reason for this is to allow for future converters with higher resolutions.

It should be added that a resolution of 1 part in 256 (that is, approximately 0.4% for 8-bit resolution), is quite adequate for most applications since transducer and signal conditioning tolerances are seldom better than 1%.

The number for each channel is stored in the twelve most significant bits of two eight-bit memory locations so that the largest digital value is

\[ 111111111111110000 \]

in binary which is 65520 in decimal. As the least significant four bits are always zero the numeric result increases in steps of 16. To obtain digital values in the range 0 to 4095 then the actual value must be divided by 16.

As the channel readings are taken sequentially on an interrupt basis every 10 milliseconds then if less than four channels are required it is sensible to disable those channels not in use so that time is not wasted converting them.

The command to accomplish this is

\[ *FX16,N \]

where \( N \) is the number of channels enabled. (If \( N = 0 \) then all channels are disabled.)

Next month: Biological Amplifier with High Speed ADC

**Everyday Electronics, December 1983**
NEW ELECTRONICS—BBC puts schools on right wavelength

BBC School Radio is breaking new ground with three innovative series designed to prepare schoolchildren for the new electronic age: (1) Using Your Computer, a 5-part series for 9 to 12 year olds; (2) Junior Electronics, a 5-part series for 9 to 12 year olds and (3) Microtechnology, a 10-part series for 'O' level and CSE students. These series have been prepared by the BBC with help from the Microeletronic Education Programme (MEP) and the Department of Industry.

Using Your Computer

Using Your Computer started on Nov. 1, 2.20pm on Radio 4 VHF. It is expected that this series will help teachers in primary and middle schools to introduce children to the computers supplied to schools under the DoI "computers in schools" scheme, that is the BBC Micro model B, the Sinclair Spectrum and the Link 480Z. The series offers a completely new dimension in educational broadcasting in which recorded radio broadcasts are synchronised with specially prepared software to use the graphic, sound and "computing" abilities of these micros to provide a fully integrated audio/visual presentation. In this way the computer is given a friendly voice (it is in fact the voice of Fred Harris well known to children in the mentioned age group) which guides the children through the initial stages of the operation and application of the machine. Thus children learn to use a computer by using a computer.

Junior Electronics

Junior Electronics begins on Feb. 28, 1984, on Radio 4 VHF at 2.20pm. In this series of programmes the children are piloted through very simple practical work, learning to construct basic electrical and electronic circuits on a custom designed circuit board, which is a component in a special kit of parts, on sale from BBC Publications.

The last of the five broadcasts is a Radiovision programme in which the children are shown the relevance of the real-life applications of the circuits they have been working with, such as—why a street light automatically lights up, and how a burglar alarm works.

This and the previous series are designed so that they can be handled by teachers with little or no previous knowledge of the subjects. Comprehensive teacher's notes are provided.

Microtechnology

Microtechnology starts on Jan. 20, 1984, on Radio 4 VHF at 10.45am. It forms an introduction to basic microelectronics leading to ideas of control technology and is dependent on the medium of Radiovision associated with practical work. There is a kit of parts, film strips and software, as well as a specially developed circuit board and a "safe" power supply unit for the experiments.
DIGITAL ROUTE FINDER

Signs of future developments in the digital audio field were in evidence at the recent International Audio and Video Fair held in Berlin.

One of the items that was shown for the first time was the Philips In-Car Compact Disc Player. Research, it is claimed, shows that the improved sound quality is clearly noticeable in the acoustic environment of a moving car.

Also, because of the large information storage capacity, the unit is not limited to sound reproduction applications only. Future developments could include the presentation of route or touring information, for example, with a single disc replacing a number of conventional maps and guide books.

The system is based on a 12cm diameter disc, carrying up to one hour of digitally encoded programme material which is read by a focused laser beam. The prototype car player will undergo a number of changes before it finally reaches the market, probably in two years time.

PLAY IT AGAIN SAM

From the nostalgia of movie classics like "Casablanca" and "Hard Times" to the latest film hits such as "On Golden Pond" and "A French Lieutenant's Woman", Humphrey Bogart (alias Kenny Wymark) was on hand to launch the long awaited CED VideoDisc system and video library from RCA.

This totally new videodisc system, which the manufacturers believe will have a major effect on the market, was announced in London recently. Launched initially as a joint venture by RCA, Hitachi and GEC, the new system is claimed to provide high quality pictures and sound at around half the price of most conventional VCRs.

The CED VideoDisc player—CED stands for Capacitance Electronic Disc—works on a principle similar to that of a hi-fi turntable. The disc is contained in a caddy, rather like a long-playing record sleeve. This is inserted into the player, the sound is then withdrawn and playing begins automatically.

This simple operation ensures the disc itself need never be touched. A stylus reads the grooves on the disc, playing them back through any black and white or colour television receiver. The signal produces both audio and visual playback.

The CED VideoDisc players are available in both mono and stereo versions and different models offer infra-red or wired remote control. The three models available include the VIP 101P, incorporating visual search, mono sound, scan, pause, which will sell for around £199.95 and the VIP 202P, which will sell for around £229.95 and which also includes stereo sound, full visual search and as an optional extra, wired remote control.

At the top of the range is the VIP 201P. This player, incorporates stereo sound, full visual search, full scan, pause and infra-red remote control. This will sell at around £259.95.

Disc prices, and there will be 100 titles available, will be £9.95 and £12.95. RCA plan to add new releases each month, starting December.

FIRE PROOF

When Data Dynamics claimed that their metal cased ZIP printers would stand up well to rough industrial usage they did not have incineration in mind.

However, when a fire broke out in a warehouse the printer received extensive damage from heat and flames—see Photo. The printer was retrieved from the remains and was found to be in perfect working order.
Confusing Law
The Olympia "Great Home Entertainment Spectacular" show typified the confusion that now exists over what electronic gadgets are, and are not, legal.

For example, we have already explained how the law now requires people who sell telephones to mark them either with a sticker or a label. They were giving away a red triangle, to show that they are prohibited from connection to the British telephone lines. But plenty of prohibited phones are on sale, sometimes but not always marked, and you don’t risk a fine or prison if you connect one to your line. What you do risk is getting your supplier, whether in Britain or by British Telecom, if their engineers find out and you refuse to disconnect the prohibited equipment.

Although CB is now legal in Britain, it is only legal on the carefully specified frequency. Likewise cordless telephones, which use a radio link to the handset, are only legal if they operate on carefully specified frequencies. Many cordless radio phones are not legal, or at least not legal in this country. In this case you don’t just run the risk of annoying British Telecom and losing your phone service; you could risk a fine of three months in jail and/or a £1,000 fine for contravening the Wireless Telegraphy Act.

Not surprisingly the public is very confused about the situation. The Home Office recently forecast that an incredible 60% of the public were unaware of the new legal position. The Department of Trade and Industry took on the job soon after the last election. During the show the DTI confirmed to me that the penalty for illegal TV transmissions was still a £1,000 fine and/or three months in jail.

Citizen’s Band TV
Even more confusing was the stand across the hall, which was selling what the show catalogue described as "at last - your very own portable colour TV transmitter!" This neat little gadget, which costs £1,000, works as a miniature u.h.f. TV transmitter. You plug in a video camera, or video recorder, and it broadcasts the signal to any TV set tuned to the transmitted frequency.

The unit has three watts output power, which, according to the company’s salesman, carries up to seven miles. But for another £600 the salesman could offer a 100-watt amplifier that carries the signal 20 to 25 miles.

For £600 less, a Citizen’s Band TV on the way? asked the Olympia Show publicity. I asked the firm demonstrating the system about the law, and they told me that they were "speaking to the Home Office".

In fact, the Home Office is no longer responsible for radio regulations. The Department of Trade and Industry took on the job soon after the last election. During the show the DTI confirmed to me that the penalty for illegal TV transmissions was still a £1,000 fine and/or three months in jail.

To be fair, the firm selling the system did say, right at the bottom of the data sheet, that "the unit is not approved for use in the UK". But that’s after a suggested list of uses, including amateur TV.

For this reason, I didn’t play spoilt-sport and tell the Department of Trade and Industry where they could go to catch the firm breaking the Wireless Telegraphy Act.

Flat-Screen TV
Suddenly flat-screen television, or rather pocket televisions with flat TV tubes, are in. At the Great Home Entertainment Spectacular at Olympia, no-one could actually buy one. When quizzed over availability, Sir Clive hedges, and talked about going to the "press conference".

My bet is that they won’t be readily available until around Christmas. But at least Sir Clive has learned from past mistakes. He isn’t taking money up-front from mail orders until he is ready to supply.

This is what caused such bad feeling over his computers. People were encouraged to send money for something that wasn’t actually available.

On the "multi-standard" operation, I don’t doubt that the set will, as Sir Clive says, automatically switch between 525-line operation and cope with the different sound and vision frequencies used in Europe. But note well that the Sinclair set receives only u.h.f. TV, whereas most television in 525-line countries like America and Japan is on v.h.f. Some Continental TV is also on v.h.f.

Later models will have a tuner which sweeps between 40MHz and 900MHz, to receive all television and f.m. radio broadcasts around the world. But that’s in the future. So far the sets are u.h.f. only.

And how will they work on tubes, buses, trains, cars and planes? I asked to borrow a set after the press launch, but wasn’t even allowed to buy one to test. They weren’t, I was told, ready. So I took a Sony Watchman TV to the press conference and tried one against the other.

The Sony, at three times the price, pulled in a better picture. But watch out for a low cost Watchman in the near future. It’s already on sale in America.

I then took the Sony Watchman on some trips. It won’t work at all on an underground train. It works reasonably well, but erratically, on overground transport, like a bus.

I can’t imagine watching for pleasure, because you keep losing the picture as you turn a corner or pass a building. Remember that u.h.f. waves travel in straight lines, and don’t penetrate into concrete boxes or men cabins half as easily as long or medium wave radio transmissions.

In The Air
I then tried using the Sony on board an aircraft flying to Munich last year. It was stopped by the cabin crew. The airlines are frightened that TV equipment may interfere with their navigation equipment.

I used it long enough to find out about another problem. At ground level a u.h.f. TV set picks up only local stations. That’s why different transmitters around the countries can share the same frequency. But up in the air you pick up everything from hundreds of miles around.

The Sony worked well in Germany, picking up both u.h.f. and v.h.f. TV pictures in my hotel room. But most hotels now have a TV set in each room, often colour.

So, who wants to watch a two-inch black and white picture off expensive batteries, if there is a mains-powered flat-screen colour set on the table? And how often do you want to watch TV while sitting in a park or sight-seeing in a foreground? And don’t forget that foreign TV programmes have foreign language sound-tracks.

Bear all this in mind before rushing out to buy a pocket TV set just for the sake of buying a pocket TV set.

Hot Memory
A few words of advice for anyone buying a memory bank that stores strings of numbers for reiterative dialing.

Some of the most powerful memories on the market are not officially approved and use a two-wire connection to the phone line. This means that the memory jangles the bell of every other phone in the house as you make a call. But approved memory banks, which use three wires and don’t cause bell jangle, usually offer less memory capacity for more money.

Check also whether you are buying a battery-back-up. The more expensive memory banks contain a string of ni-cad rechargeable cells in series across the low voltage d.c. power line.

If the power fails this battery pack keeps the memory alive. Otherwise even a short interruption of power will lose every number you have keyed into the memory.

Cheaper memory phones may not have battery back-up. It is not a condition of official approval. For instance, I bought the Ace-Telcom approved phone, which for just under £100 has a memory store of 30 numbers.

Essentially it’s an approved version of a previously unapproved Lamda phone from Hong Kong. But the Ace-Telcom does not have a battery back-up. So even a brief break in the power supply loses every number you have laboriously keyed into the memory.

I solved the problem by stringing six ni-cad pen cells in series with a 20-ohm resistor, and put them across the 9V d.c. supply. The resistor limits charging current, to prevent damaging the cells, but it lets through enough current to keep the memory alive if the mains cuts out.

But far better, in the first place, to buy a memory phone with a battery back-up built-in. So check this before buying.

Ace-Telcom in Britain now tell me they are thinking of making some kind of modification. What a pity they didn’t think about that before starting to sell a memory phone that is prone to amnesia.

Everyday Electronics, December 1983
Gas & Smoke Sentinel

This four-channel monitoring and alarm system gives early warning of gas leaks, and also of imminent danger of fire. Each of the four sensors can be installed in optimum position to detect either gas leaks or smoke in various parts of the house. The master control unit is equipped with red and green I.e.d.s which indicate status of each sensor. External 12V alarms can be connected and extended to any convenient point.

Guitar Tuner

A phase-locked loop is the basis of this tuner. Six tones corresponding to the notes from the open strings of an electric guitar are available for initial tuning and the final accurate adjustment of each string is performed with the aid of the tuning meter.

Scoreboard

Adds individual scores of between 1 and 99 and stores the totals for up to four players. Total scores are displayed on a three-digit seven-segment display. The ideal (and indisputable) electronic scorekeeper for games where running totals are kept.

Central Heating Pump Delay Unit

Senses the temperature of the circulating water and after the boiler has been switched off at the end of the heating period, keeps the pump running until the water has fallen below a preset temperature. This allows the radiators to extract most of the stored energy and deliver it as useful room heating.

Everyday Electronics, December 1983
UNLIKE most normal egg-timers, this project is based on an electronic circuit. The Novel Egg-Timer makes use of a deceptively simple circuit which makes a creditable imitation of a cackling chicken that has just layed an egg.

CIRCUIT DESCRIPTION

The complete circuit diagram is shown in Fig. 1. IC1 is a 14-bit binary counter with built-in oscillator and reset facilities. R2, R3, VR1 and C2 set the oscillation frequency to about 50Hz, the exact value is adjustable by means of VR1.

When the circuit is switched on, pin 12 is momentarily carried to +9V by C1, resetting all 14 counter stages to zero. C1 charges up via R1 releasing the reset and the counter starts counting. For the first 8092 cycles the output of the 14th stage, Q14, stays low (0V) and the outputs of the two 4-input AND gates therefore also remain low.

On the 8093 cycle of the built-in oscillator, after approximately three minutes, Q14 goes high (+9V). This enables IC2a and from then on the gates produce groups of four pulses (pin 13) and single pulses (pin 1) as shown in Fig. 3. Up until now the 555 timer IC3, which has been connected as an oscillator, has been inhibited by the low voltage on its reset pin (pin 2).

However, each time a positive-going pulse appears at pin 13 of IC2 its leading edge is differentiated by C3 and R4. This results in a narrow positive spike being applied to pin 4 of IC3, briefly enabling the oscillator.

The few cycles of oscillation that take place constitute a "cluck". On the fourth cluck the lower end of R4 is taken to +9V by the pulse at pin 1 of IC2, so pin 4 of the oscillator IC3 sees a full width pulse instead of a narrow pulse (Fig. 3).

Simultaneously, the pulse at pin 1 of IC2 turns on TR1 with the result that the voltage at pin 5 of IC3 starts to fall as C4 discharges via R6. This results in the extended fourth burst of tone having a rising pitch, the characteristic chicken's squawk following the three clucks.

The output at pin 3 of IC3 is coupled to the loudspeaker LS1 via C6 and the egg-timer produces sufficient volume to be heard even if there is no-one in the kitchen.

COMPONENT BOARD

The components are laid out on a piece of 0.1 inch matrix stripboard which is 39 strips by 31 holes and the layout is shown in Fig. 2. The use of d.i.l. sockets is recommended for the integrated circuits which should only be inserted when all the soldering is completed. Note that the CMOS devices should be handled with care.

The power supply is provided by a 9V PP3 battery which is contained within the case. The housing used for the project is left to personal choice.

Fig. 1. The complete circuit diagram of the Novel Egg-Timer.
TESTING

Using an oscilloscope, check that groups of four pulses are obtained at pin 13 of IC2 and single pulses at pin 1 as shown in Fig. 3.

Fig. 2. The component layout and trackside view of the Egg-Timer circuit board. Note that on the prototype the author has used unfamiliar style electrolytic capacitors but any suitable type can be used.

![Component layout and trackside view of the Egg-Timer circuit board.](image)

**COMPONENTS**

**Cost** £7

<table>
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| Capacitors | |
| C1,2,5  | 10nF ceramic | (3 off) |
| C3,6,7  | 10μF 16V elect. | (3 off) |

| Semiconductors | |
| TR1  | BC109 silicon npn |
| IC1  | 4060BE CMOS |
|      | 14-stage ripple counter |
|      | and oscillator |
| IC2  | 4082BE CMOS dual |
|      | 4-input AND gate |
| IC3  | NE555 timer IC |

| Miscellaneous | |
| VR1  | 1MΩ lm. miniature carbon preset |
| S1   | S.p.s.t. miniature toggle |
| LS1  | Miniature, 64Ω, 60mm dia. approx. |
| B1   | 9V PP3 |
| Stripboard | 0.1in matrix size 39 strips by 31 holes; case, 180 x 110 x 50mm; 8-pin d.i.l. i.c. holder; 7-pin d.i.l. i.c. holder; 4-pin d.i.l. i.c. holder; battery clip |

Component board shown fitted to the lid of the case, with off-board wiring details also shown.

Everyday Electronics, December 1983
Switch the unit on and check that the waveforms at pins 13 and 1 of IC2 only commence after approximately three minutes. Increasing or decreasing the value of C3 will make the clucks longer or shorter. Decreasing or increasing the value of R6 will cause the final squawk to rise higher or not so high.

Reducing the value of C5 will cause the sound of a squawk to rise more rapidly. The final values of these components may be chosen to produce what sounds you like but the values shown will generally prove satisfactory.

One final note, if you leave the egg-timer switched on after it has started to sound, it will continue to do so for the set amount of time (as set by VR1). It will then fall silent for a set time and then start to sound again, this will continue indefinitely.

All the aerials described are inexpensive and easy to construct, and each new aerial has a diagram to support its introduction with clear informative text. Finally, there are a complete set of dimension tables which will help you identify an aerial on a particular frequency. Data is also provided for the spacing and cutting of phase lengths.

R.A.H.

**BEGINNER’S GUIDE TO INTEGRATED CIRCUITS SECOND EDITION**

<table>
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<th>Author</th>
<th>I. R. Sinclair</th>
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<tr>
<td>Size</td>
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<td>Publisher</td>
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As the name suggests “Beginner’s Guide to Integrated Circuits” is a book intended for the comparative new-comer to electronics. The book contains nine chapters and the first deals with basic electronic theory, which gives a good grounding for the more complex chapters to come.

Many examples are given of practical i.e. circuits; and linear, digital integrated circuits are also covered. The microprocessor and associated chips are also described with comprehensive diagrams to support the text. As before Ian Sinclair has managed to produce an outstanding book for the beginner to electronics.

R.A.H.

**SERVICING MONOCHROME PORTABLE TELEVISION**

<table>
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<th>Author</th>
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<tr>
<td>Size</td>
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If you are involved with, or merely interested in, the servicing of TV sets, then this book will be an invaluable addition to your library. Mr. Wilding has spent over 40 years servicing and writing about televisions and this guide presents a comprehensive insight into how current portable black and white receivers operate (which, incidentally, represent the largest proportion of “second” sets throughout the world).

Covering a diversity of British, European and Japanese models, the well illustrated text discusses typical faults and their rectification with special emphasis on new and unusual circuitry. A large section of the book is given over to the reproduction of circuit diagrams and board layouts of many popular and currently available portables.

G.P.H.

**Books in Brief**

IBA Technical Review No 20, “Developments in Teletext” by Technical Editor Paul Gardiner (IBA). This 69-page book, with 57 illustrations, includes seven papers written by engineers working the teletext field. The Review covers the ten years of teletext development; the enhancements of additional levels including the possibility of using alpha-geometric coding; networking; integrated circuit decoders; and the NEWFOR system of teletext subtitling developed at the University of Southampton.
Where Have All The Viewers Gone

Over six years ago, in one of the broadcasting journals, I wrote an article "Broadcasting to the two-set home". In this I pointed out that if, as to me seemed likely, the number of homes with more than one TV set continued to rise (in the period 1970-75 it had doubled from only 3 per cent to about 6 per cent) this would need to be taken into account in the planning of broadcast programmes and schedules.

I began this article as follows: "Generals, it is often said, always prepare to fight the last war all over again. Broadcasters, if they are to avoid this mistake, need to be more perceptive of change; to detect the way in which the public taste and viewing patterns are gradually changing". Programmes I stressed, need to be on the basis of current public viewing habits suitable for the conditions under which the public views, the times when it views, and the sets on which it views.

Not everyone in broadcasting agreed with me. One senior administrator told me that the second set was just a passing phase amounting to little more than keeping an old black-and-white set when buying or renting a new colour set.

Another was much upset by my suggestions that it could no longer be taken for granted that everybody sitting in a room in which there was a switched-on TV set was necessarily watching the programmes and advertisements with bated breath, but might be doing other things such as reading or even dozing, using the programme as a background accompaniment to other activities. Nor did the quote that "television is the only activity that occupies more time in the home than sleeping—though some would observe that the two pastimes are synonymous"—go down too well. The stream of television, I suggested, goes on—the mind wanders off to its own explorations or just sinks into timeless oblivion!

In the intervening six years the number of two-set homes has continued to increase—until today about a third of UK homes are in this category. But, potentially even more significant, has been the impact of almost three-million video recorders.

This enables viewers both to choose and make up their own programme schedules, either by buying or renting cassettes or by using the recorders as time-machines to view broadcast programmes at convenient times. A breach of copyright but who takes notice of this?

It now seems certain that two-set homes, and more especially video recorders, are affecting TV audiences, not only the head-counts of people watching top-rated programmes at the time they are transmitted, but also public attitudes to television. The old idea of programmes being "compulsory viewing" is being by-passed by the new technology.

One does not worry over much about bad programmes—more significant is what, by any standard, are some extremely good programmes seem no longer to attract the audiences that would have watched them six years ago. And as a final straw a scientist is now suggesting that the brain rhythms of a TV-viewer are almost the same as those of someone asleep!

Still Spinning

Most people believe that interest in low-definition mechanical television came to a stop in 1939 with the ending of BBC's transmissions of the 30-line Baird system, although a few European radio amateurs continued transmitting low-definition patterns up to about 1939.

Very few seem to have heard about the revival of interest in NBTV (narrow band television) in the past few years, sparked off initially in Australia. Today there is in the UK a very active Narrow Bandwidth Television Association made up of members interested in mechanical forms of television, though much of it is considerably more sophisticated than the old spinning Nipkow discs of the Baird era.

The NBTVA under chairman D. B. Pitt (1 Burnwood Drive, Wollaton, Nottingham) publishes a quarterly newsletter that reflects a good deal of active interest in closed-circuit home-built mechanical systems and there are plans to transmit 32-line pictures on 144MHz in a bandwidth of 9.6kHz. An NBTVA convention was held recently (10 September) near Manchester, and another at Nottingham last May.

One of the developments is a camera based on solar cells. The pictures may seem crude, but enthusiasm still runs high.

Happy Workers

A survey of how electronics engineers feel about their work, based on 650 replies to a questionnaire in the American "Electronics" magazine, suggests that almost 86 per cent are very or reasonably satisfied with their work. Only 14 per cent unsatisfied or hardly satisfied; 72 per cent believe they are fairly paid, against 24 per cent who think the opposite.

Two-thirds would again study, engineering, if they had their time over again, though some 11 per cent would switch to the medical or dental professions. Some 9 per cent would opt for pure science and 6-5 per cent for business administration.

Almost 88 per cent would encourage their children to study engineering; 28 per cent believe that what they are doing is very important to the well-being of society; 54 per cent believe their work is "fairly important", only 1-6 per cent rate it as "unimportant".

Fewer than half American engineers earn more than $40,000 per year, and average starting salary for fully qualified engineers is about $25,000. About 10 per cent top the $60,000 mark.

In the States, as in the UK, the quickest way to top earnings appears to be developing new computer-based video games. However, market-busting software tends to have a more modest rise. An equally fast fall, often all within a single year.

Tiny TV

It is too early to predict whether Sir Clive Sinclair will succeed in making a financial as well as a technical success of his pocket TV set. I remember an earlier Sinclair model shown at Earl's Court in the 1960s that never really got going.

The flat tube in his new set represents the fulfillment of ideas first proposed in the 1950s by Denis Gabor, the man who also predicted the development of holography. Then again, the Ferranti chip used by Sir Clive succeeds in putting virtually all the basic stages of a black-and-white, multi-standard TV set onto a single chip, a remarkable feat.

Similarly, the 15-hour Polraid lithium battery must be the first time one of these high-energy batteries has been used in British consumer electronics. It will also be interesting to see whether his mail-order-now, pay-later approach (to cover the possibility of production delays) will succeed: it is an approach that is unlikely to prove popular with the retail trade! Walk-about audio has proved a winner but does not involve the problem of looking at a picture while watching where you are going.

A Pen Radios

For over a year I have had one of those low-cost Japanese digital watches in the stem of a ball-point pen. The watch has worked perfectly, the miniature battery seems easy to replace though this has not been necessary so far. My trouble is that I have never succeeded in finding out how to fit an ink refill! I have a compact watch but a full-size empty pen.

Now I see Mullard/Philips have marketed an integrated circuit (TDA 7070) that contains virtually all the circuitry (except for 14 tiny ceramic capacitors) needed to form a complete V.H.F./I.F. radio small enough to fit inside a pen, wristwatch or key-ring. I suppose you could also fit a tiny earphone in the pen and then stick it in your ear. Sounds fine, but I hope the set manufacturers make it simpler to fit those ink refills!
CONTINUITY TESTER

**BY R.A. PENFOLD**

Despite the fact that a Continuity Tester is an extremely simple piece of test equipment it can nevertheless be very useful when fault-finding on electronic equipment. Uses of continuity testers include such things as checking fuses, tracing broken wires or printed circuit tracks, checking diodes, and tracing short circuits on printed circuit boards.

An ordinary multimeter switched to a low resistance range can be utilised as a continuity tester, but this method is often inconvenient in use due to the need to look away from test prods or probes and at the meter each time a check is made.

When checking complex circuit boards, switches or something of this nature, it is often necessary to concentrate on the test prods in order to keep them in good contact with the appropriate two points. Another problem is simply that some multimeters pass quite a high current when used on a low resistance range and there is a consequent risk of damaging delicate semiconductor components.

**AUDIO TONE**

This simple Tri-State Continuity Tester design provides an audio tone to indicate continuity, and the maximum current that can flow through the circuit under test is only a little over 1mA. This means that there is no real risk of components being damaged while making tests using the unit. An unusual feature of the circuit is its indication of three levels of continuity rather than the usual two.

It provides a low frequency tone if a very low resistance of just a few ohms is detected, a higher tone if a higher resistance is detected, and no tone if a resistance of more than a few hundred ohms is present across the test prods.

Many continuity testers will indicate continuity if a forward biased semiconductor junction is present between the test points. This can produce misleading results when checking circuit boards for broken tracks or short circuits as there are likely to be numerous semiconductor junctions present in the circuit, bearing in mind that these junctions can be part of a transistor or integrated circuit and do not have to be present in the form of a diode.

This tester clearly differentiates between a true low resistance path, a slightly higher resistance or semiconductor junction, and a high resistance path, so that much of the ambiguity that can occur when testing circuit boards with a conventional continuity tester is avoided.

**CIRCUIT DESCRIPTION**

The full circuit diagram of the continuity tester is shown in Fig. 1, and the only active device used in the unit is an MC3930P quad comparator (ICI). A voltage comparator of this type has an npn output transistor which is used in the common emitter mode, but does not have a built-in load resistor or other form of collector load.

The output transistor is switched off if the inverting (-) input is taken to a higher voltage than the non-inverting (+) input, and is switched on if the comparative input states are reversed.

There is no built-in triggering in the comparators and they can have the output transistor partially switched on if the input voltages are balanced. It is therefore possible to use a comparator as an operational amplifier by adding a load resistor at the output and ICIc is used in this way. R10 is the load resistor and this comparator is used in what is a well-known operational amplifier oscillator configuration. The values specified for R9 and C1 set the operating frequency of the oscillator at a fairly low audio frequency of only about 100Hz.

The potential divider chain consisting of R1, R2, D1 and R3 biases the inverting input of IClb to about 0.75V, and the inverting input of IClb to only a few millivolts above the negative supply potential. R4 takes the non-inverting input of the comparator outside its normal operational range and the voltage rises to +10V when the potential divider chain again biases the inverting input of the comparator back to about 0.75V.

The circuit is based on two voltage detectors and an audio oscillator. The oscillator drives a loudspeaker which then produces the audio tone and indicates continuity between the test prods. By indicating two degrees of continuity the unit eliminates the misleading results that can be produced by a simple continuity tester.

![Circuit Diagram](https://www.everydayelectronics.co.uk/issue-1983-12/CONTINUITY-TESTER-1983-12.png)
The inputs of both IC1a and IC1b to virtually the full positive supply voltage, and the output transistors of both devices are switched on with the circuit as it stands. The output transistor of IC1a holds the input of IC1c at little more than the negative supply potential and prevents the oscillator from operating.

If a low enough resistance is connected across the test prods the non-inverting input of IC1a will be pulled down to a lower voltage than the 0-75V bias fed to the inverting input, causing IC1a's output transistor to switch off and the oscillator to operate.

However, the oscillator will not operate normally unless a resistance of about 8 ohms or less is placed across the test prods, so that the input voltage to the non-inverting input of IC1b is taken below the minute bias voltage fed to the inverting input of this comparator. Unless this requirement is met the output transistor of IC1b effectively connects R5 in parallel with R7 so that the operating frequency of the oscillator is boosted to around 300Hz.

Thus the required tri-state indication is obtained with a high resistance giving no oscillation, a very low resistance giving low frequency oscillation, and an intermediate resistance giving a higher frequency tone. IC1c could be used to drive the loudspeaker (LS1), but its output transistor is switched on under stand-by conditions and this would result in a rather high quiescent current consumption.

The loudspeaker is therefore driven via IC1d which is used as an inverter, and this gives a quiescent current drain of only about 3mA, with the current consumption rising to about 10mA when the unit is activated. R13 ensures that the current fed to LS1 does not exceed the maximum permissible output current for comparators in the MC3302P device and this 20mA limit means that the unit does not generate a very loud tone.

In this application high volume is not necessary and this is not of any practical importance.

CASE

A plastic case having an aluminium front panel and approximate outside dimensions of 111 x 71 x 48mm is suitable for this project, and represents about the smallest case that will comfortably accommodate all the components. A matrix of holes about 3mm to 5mm in diameter are drilled in
the left-hand portion of the front panel to produce a speaker grille, and as miniature speakers invariably lack any provision for screw fixing it will be necessary to glue the speaker in place behind the grille using a good quality general purpose adhesive.

The test prods connect to the unit via a 3.5mm jack or any other convenient type of socket. This is mounted on the front panel on the right-hand side, beneath the ON/OFF switch.

PRINTED CIRCUIT BOARD

The components are mounted on a single-sided printed circuit board as shown in Fig. 2 measuring 64 × 51mm. The board is constructed using the usual techniques and this should be perfectly straightforward. The board is available from the EE PCB Service, Order code 8312-08.

The completed board is mounted on the rear panel of the case using 6BA fixings and this leaves sufficient space for the battery on the right-hand side of the case. The power source is provided by a 9V PP3 battery and after wiring the battery clip into the circuit and completing the component interwiring, the unit is then ready for testing.

TESTING

When the unit is switched on there should be no tone or other sounds from the speaker, but with the test prods touched firmly together there should be a low frequency tone of reasonable volume. Placing a resistor of between 10 ohms and 470 ohms in value across the test prods should give the higher frequency tone, and the difference in pitch should be large enough to be readily apparent.

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- a.c. V 10V, 30V, 100V, 300V, 1000V,
- a.c. 1mA, 10mA, 30mA, 100mA, 1A, 10A
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- d.c. 10mA, 100mA, 300mA, 1A, 10A
- a.c. V 10V, 30V, 100V, 300V, 1000V,
- a.c. 1mA, 10mA, 30mA, 100mA, 1A, 1A
- Ohms 5kΩ, 50kΩ, 500kΩ, 5MΩ, 50MΩ.

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Everyday Electronics, December 1983
TOUCH OPERATED DIE

BY C.J. BOWES

A LARGE number of games require some sort of random number generator to make decisions as the game proceeds. The most common of these devices is the cubic die which gives a random number between one and six.

There have been a number of designs published detailing how an electronic die can be made. Most use some form of counter which drives a matrix of i.e.d.s in the familiar pattern. The die described in this article is specifically designed to enable the use of two alternative displays, one the standard spot pattern and the other a numeric display using a 7-segment display.

In order to make the die simple to use, and pack away, the design incorporates a touch switch and automatically turns off after a short time.

CIRCUIT DESCRIPTION

The circuit diagrams for the die are shown in Figs. 1, 2 and 3. Fig. 1 shows the main logic circuit, which is common to both designs, whilst Figs. 2 and 3 are alternative display designs, only one of which is needed for each die.

The main logic circuit consists of a touch operated system which controls the number generating and display systems. In order to dispense with a mechanical switch, use is made of the fact that skin is a high resistance conductor.

TOUCH SWITCH

The touch switch, which is either laid out on the front panel as a printed circuit track or made up of commercially available pads, is in effect two conductors which can easily be bridged with a finger. One of the pads is connected to the 9V supply and the other is connected, via R1, to the base of TR1, one half of a Darlington pair with TR2.

When the tracks are bridged, a very small current passes through the finger and into the base of the transistor. The current gain of the Darlington pair is extremely high and the minute current is sufficient to make the transistors conduct, causing a current to flow both through them and R2. R1 is included as a precaution to prevent damage to the transistors in the event of a low resistance being inadvertently connected across the touch pads.

When TR1 and TR2 conduct, a voltage drop occurs across R2. This is used to operate the count enable input of IC2 and also causes a voltage difference between the base and emitter of TR3. This voltage causes TR3 to conduct, allowing C1 to charge up and TR4 to conduct. Which in turn, energises the display and counter circuits.

RANDOM NUMBER GENERATOR

IC1 is a cmos version of the 555 timer and has been chosen for this design in preference to the standard bipolar 555 which has a rather unpleasant habit of producing spikes on the power supply lines that can upset other devices connected to the same power supply. The cmos 555 does not suffer from this but operates in exactly the same way as the standard timer.

In the design shown, it is connected as

Fig. 1. Circuit diagram of the control logic section of the Touch Operated Die.
an astable multivibrator with a high frequency output. The output frequency is in fact set by the values of R6, R7 and C2, and is about 700Hz. The output from the timer is connected to the CP (clock pulse) input of IC2, which is a CMOS 4510 programmable up/down counter. This device is used because it has the ability to be reset to any number from 0 to 9, set on the \( P_r \) to \( P_t \) inputs, by a logic 1 signal to the PL (parallel load) input.

Whilst the touch pads are bridged, the input to the CE pin of IC2 is held at logic 0. This allows the output pulses from IC1 to be clocked through IC2. Pin 10 of IC2 is held at logic 1 by being connected to the 9V line via R8 causing the counter to count up. The outputs \( Q_0 \) to \( Q_7 \) are connected to the display and cause it to change so rapidly that the actual value shown is not apparent.

The outputs are also connected to IC3 which is a triple 3-input NAND gate configured so as to reset the counter by producing a logic 1 state at the PL input every time the count reaches 7. When the PL input goes to logic 1 the counter is set to the value set on the \( P_r \) to \( P_t \) inputs. \( P_r \) is held at logic 1 and the other inputs are held at logic 0, so the counter is reset to 0 every time the outputs \( Q_0 \) to \( Q_7 \) are all at logic 1. This causes the counter to cycle through the numbers from one to six for as long as the touch pads are bridged.

When the user's finger is removed from the touch pads, TR1 and TR2 no longer conduct and the CE input to IC2 is pulled up to logic 1 by R2. This causes the counter to be disabled and the counter to stop at the value it reached immediately before the finger was removed. The b.c.d. (binary coded decimal) value of this number is present on the output lines and is decoded and displayed on the chosen display system.

As soon as TR1 and TR2 stop conducting, TR3 also ceases to conduct and C1 starts to discharge through R4, but as it is also connected to the base of TR4 through R5, this causes TR4 to continue conducting for a time dependent on the values of C1, R4 and the base current of TR4.

As long as the base-emitter voltage of TR4 exceeds about 0-7V, it conducts. This enables the counter and display circuitry to remain operative for a short period after the touch pads are released. When TR4's base-emitter voltage falls below the turn on voltage, the transistor turns off and the display fades and eventually, is switched off.

**DOT DISPLAY**

To operate the die display it is necessary to decode the outputs from the counter to illuminate the required number of I.e.d.s which are arranged as shown in Fig. 2. Decoding of the b.c.d. information is accomplished by the use of two 2-input NAND gates and two diodes. The standard packaging of the 2-input NAND gates in the CMOS 4011 i.e. provides four gates in one package. Advantage has been taken of this to use two of these gates as a buffer, thereby reducing the load on the outputs of the counter. The truth table for the display is shown in the table below.

<table>
<thead>
<tr>
<th>I.C.4 outputs</th>
<th>I.e.d. groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Q_0 )</td>
<td>( Q_1 )</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>

The single i.e.d. (D6) mounted at the centre of the display is required to be on for the odd numbers (1, 3 and 5). Inspection of the truth table shows that this coincides with the presence of a logic 1 level on output \( Q_0 \). This i.e.d. can therefore be wired, through resistor R9 directly to the \( Q_0 \) output. The remaining i.e.d.s are operated as pairs in series.

When the truth table is consulted, it can be seen that i.e.d.s D3 and D9 are on only when output \( Q_2 \) is at logic 1. This pair could be connected via a suitable resistor directly to this output but as \( Q_2 \) is also used to drive other i.e.d.s they are in fact wired through the two spare gate, which are each wired as inverters. These buffer the output and reduce the load on it.

The two i.e.d.s D5 and D7 are required to be on when either output \( Q_1 \) or \( Q_2 \) are at logic 1. This could be achieved by using an OR gate but is more easily done by using the simple matrix of D1 and D2 as shown. The final pair of i.e.d.s (D4 and D8) are required to be illuminated only when both \( Q_0 \) and \( Q_2 \) are at logic 1. This is in fact the AND function which has been obtained by using a NAND gate followed by another NAND gate wired as an inverter.

The circuit diagram for the die display is shown in Fig. 2. The only component not mentioned in this description is C4 which is merely a decoupling capacitor which should be mounted as close as possible to IC5.

**NUMERIC DISPLAY**

The alternative display to the traditional spot pattern is to use a 7-segment display as shown in Fig. 3. This circuit is conventional and uses CMOS 4543 decoder/driver i.e. This device enables either a common anode (as used on the prototype) or a common cathode display.

If a common cathode display is used, the p.c.b. must be modified to provide the correct connections to the display and pin 6 of IC5 must be connected to the 9V line instead of the 9V line. C5 is included as a decoupling capacitor and should be mounted as close as possible to IC5.

![Fig. 2. Circuit diagram of the dot matrix display.](image1)

![Fig. 3. The 7-segment display circuit.](image2)

Everyday Electronics, December 1983
CONSTRUCTION

LOGIC BOARD
The unit has been designed to fit inside the specified case, size 85 x 56 x 35mm. Other cases can be used but care should be taken to ensure that the p.c.b.s will fit. The components for the main logic circuit are mounted onto the p.c.b. as shown in Fig. 4, and the full size track layout is also shown. This can be made using conventional techniques or ordered from the EE PCB Service. Care should be taken wherever the tracks are closely packed or pass between the pins of the i.c.s. When the board has been etched and drilled it should be closely inspected for broken or short circuited tracks.

The components can then be mounted as shown starting with the smallest components. C1 must be left until last as it is mounted above the adjacent resistors with its leads passing between R3 and R4. Care must also be taken to ensure correct polarity of the capacitors.

The components are very closely packed on this board and it should be thoroughly inspected before attaching the battery or installing the i.c.s.

DISPLAY BOARDS
The track design for dot display board is given in Fig. 5. It is important that the cut-out in the corner, which enables the face plate mounting screw to be fitted, is made before attempting to fit any of the components. Care must be taken to ensure correct polarity of all the components as incorrect orientation will produce a strange display and some extremely interesting problems in fault diagnosis.

The display board is mounted directly under the face plate and, in order to reduce the space required, IC4 is soldered directly onto the p.c.b. and not fitted into a socket. This operation should be done with care, taking precautions to avoid the risk of static electricity destroying the device. In practice, this should not present any problems providing that a buffered type of 4011 is used.

When making this board care should be taken to ensure that the resistors do not foul the holes used for mounting the board to the face plate.

7-SEGMENT DISPLAY
The 7-segment display board is constructed using the track diagram shown in Fig. 6. As with the dot display, the driver/decoder, IC5, is soldered directly to the p.c.b. and the same precautions as detailed earlier should be taken to avoid damage.

In common with the other display board, there should be no major problems but the cut-outs should be made before mounting any of the components.

COMPONENTS

<table>
<thead>
<tr>
<th>CONTROL LOGIC</th>
<th>DOT MATRIX DISPLAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistors</td>
<td>Resistors</td>
</tr>
<tr>
<td>R1.3, R1.4</td>
<td>R9, R11, R12</td>
</tr>
<tr>
<td>R2.6, R8.8</td>
<td>R10</td>
</tr>
<tr>
<td>R4, R23</td>
<td>560Ω (3 off)</td>
</tr>
<tr>
<td>R5, R34</td>
<td>10kΩ</td>
</tr>
<tr>
<td>R7, R35</td>
<td>10V</td>
</tr>
<tr>
<td>All 1/4W carbon film ±5%</td>
<td>page 801</td>
</tr>
<tr>
<td>Capacitors</td>
<td>Capacitor</td>
</tr>
<tr>
<td>C1</td>
<td>2-2µF 10V tantalum bead</td>
</tr>
<tr>
<td>C2</td>
<td>0-1µF 10V tantalum bead</td>
</tr>
<tr>
<td>C3</td>
<td>2-2µF 10V tantalum bead</td>
</tr>
<tr>
<td>Semiconductors</td>
<td></td>
</tr>
<tr>
<td>TR1, TR2</td>
<td>BC107 npn silicon</td>
</tr>
<tr>
<td>TR3, TR4</td>
<td>BC479 pnp silicon</td>
</tr>
<tr>
<td>IC1</td>
<td>7555 CMOS timer</td>
</tr>
<tr>
<td>IC2</td>
<td>4510B CMOS</td>
</tr>
<tr>
<td></td>
<td>presettable up/down</td>
</tr>
<tr>
<td>IC3</td>
<td>4023B CMOS triple</td>
</tr>
<tr>
<td></td>
<td>3-input NAND gate</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
</tr>
<tr>
<td>Printed circuit board: single-sided, size 80 x 20mm, EE PCB Service, Order code 8312-05:</td>
<td></td>
</tr>
<tr>
<td>moulded plastic case with internal guide slots and aluminium lid size 85 x 56 x 35mm, material for face plate size 85 x 56mm (see text); touch pads; 16-pin d.i.l. holder; 14-pin d.i.l. holder; 8-pin d.i.l. holder; battery clip; self-tapping screws; 6BA screws and nuts; ribbon cable (7-way x 150mm).</td>
<td></td>
</tr>
<tr>
<td>Capacitor</td>
<td>2-2µF 10V tantalum bead</td>
</tr>
<tr>
<td>Semiconductors</td>
<td></td>
</tr>
<tr>
<td>X1</td>
<td>0-3in common anode 7-segment display</td>
</tr>
<tr>
<td>IC5</td>
<td>45-438 CMOS b.c.d. to 7-segment decoder</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>9V PP3</td>
</tr>
<tr>
<td>Printed circuit board: single-sided, size 73 x 32mm, EE PCB Service, Order code 8312-07.</td>
<td></td>
</tr>
</tbody>
</table>
TESTING

After both the main logic board and the display board have been constructed and checked, they should be connected together and tested. It is advisable to use ribbon cable to join the main board and display board together since this will reduce the problems of the "spaghetti" like tangle that would otherwise result every time the die is opened.

To check the boards for correct operation, the battery should be carefully inserted into its clips without either of the p.c.b.s being touched. If all is well, there should be no sign of life on the display. The touch pads should then be touched with the finger so that a current flows to the base of TR1.

The display should immediately light, showing either the figure "eight" on the numeric display or all seven dots on the matrix display. In the latter case, i.e.d.s D4 and D8 will appear to be at low brightness. This is perfectly normal and results from the fact that as the device cycles rapidly through the numbers from one to six, these diodes are only lit for one-sixth of the cycle period.

When the contact to the touch pads is released, the display should stop cycling and show a number between one and six for a short while before fading away. The test should be repeated several times in order to check that the die is not "loaded".

If it is suspected that the die does not give a random result but is biased to a particular number or set of numbers, then the operation of the number generator can be checked by temporarily connecting a 100µF capacitor across C1 and letting the die pulse slowly through the sequence from one to six. The first few numbers displayed may be random or out of the required range but after a maximum of four changes, the die should reset and start to go through the repetitive sequence from one to six.

If the time for which the die remains illuminated after the touch pads are released is incorrect, this can be adjusted by altering the value of C1. Increasing the value increases the delay time and reducing it will reduce the delay time.
FACE PLATE

The face plate of the unit must be made of an insulating material and not the aluminium panel supplied with the case. If it is desired to make the touch plates as printed circuit tracks, this can be done by the same method as that used for making p.c.b.s. Alternatively, commercially available touch pads can be screwed through suitable material. In each case, it is important to ensure that the pads are placed at least 2mm apart and are not fouled by the display or mounting screws.

It is important to note that the face plate fits on top of the case and is not inset into the recess in the case, as is the aluminium plate supplied. The face plate must be cut to the same size as the outside of the case and appropriate mounting holes drilled through it to line up with the pillars moulded into the inside of the case.

The appropriate display board is fixed to the underside of the display panel so that the i.e.d.s protrude through the face plate or the 7-segment display fits flush into a cut-out in the face plate.

The mounting holes are then marked and drilled ready for mounting the board as shown in Fig. 7. If the 7-segment display is used, the shape should be marked out on the face plate and then carefully drilled and filed out until a good fit is obtained. The positions of the mounting holes can then be determined.

With both types of display, it is important that a dry run is conducted with the boards to ensure that they will fit into the case, leaving room for the battery, in the marked positions before committing the face plate to the attention of the cutting tools.

The face plate and display board are fixed together by using three screws, each fitted with three nuts, as shown in Fig. 8. After the holes have been drilled, the boards should be given a final check before being assembled. The control logic p.c.b. should then be fitted into place in the grooves moulded in the main case. The battery is then connected and placed in the case and the face plate fitted to the case using longer self-tapping screws than those supplied with the case.
CAR LIGHTS ALARM

My car is a Ford Falcon with a negative earth and as such I thought your Car Lights Alert (October 1982) circuit would work. The main trouble I found was with the courtesy lights. As I considered the circuit and logic behind the circuit too good not to use, I re-designed the circuit still using the same logic. I feel other readers may have had the same trouble as myself so I am offering the circuit I "designed" for my car's existing wiring.

The pillar switches are positioned between the lamp and positive. I have taken out the transistor and used the circuit, so that with the switches open, the reset of IC1 (pin 4) is held low through the lamp filament.

E. Westerman, Victoria, Australia.

Editorial note: This circuit will not work with cars having earthed door pillar switches.

TRAFFIC LIGHT SIMULATOR

This circuit simulates the sequence of lights at a typical cross-roads. The circuit is based upon a 16-bit counter which provides the inputs to the combinational logic gates.

The clock for the 16-bit counter is derived from a 555 timer which is connected as an astable multivibrator. The components around the 555 are chosen so that its period of oscillation is approximately five seconds, meaning that the lights change at a realistic rate.

The 16-bit counter is based on four JK flip-flops connected in such a way that each divides the clock frequency by two.

The outputs of the 16-bit counter are used for the inputs for the logic gates which have been arranged to generate the necessary sequence of lights.

Since the logic gates are required to drive I.E.D.s, each output needs buffering. All six buffer stages are identical, except of course for the colour of the I.E.D. used. Any I.E.D. can be used but for realism it is best to use red, orange and green.

W. Barlow, Basildon, Essex.
TELEPHONE RING SIMULATOR

The two close-rings of a phone are provided by IC2 being switched on and off by IC3. The longish space between the two short close-rings is provided by IC1. VR1 adjusts the period between the ring-ring... ring-ring, that is the long space. VR2 adjusts the space between one ring and the next, that is ring... VR2. ring... VR1. ring... VR2. ring. The tone from IC2 is not 25Hz like a telephone bell, it is nearer perhaps 2kHz.

If a 2kHz tone is required, increase value of C3 (use an electrolytic). Note the telephone ring simulator is designed to ring like a phone, not sound like it but ring in the manner of a phone.

Brian S. Craigie, Edinburgh, Scotland.

FIRE ALARM—ELECTRONIC TEMPERATURE CONTROLLER

Transistors TR1 and TR2 are the master comparator pair with TR2 base, maintained at around 5-6V by the Zener, D2. Transistor TR3 regulates the current and thence the base voltage of TR2 in relation to the common emitter voltage which is also TR3 base drive.

Unlike many comparator switching circuits, my circuit latches permanently on (for example, the l.e.d. glow) once activated. In my experiment a thermistor with a rating of 30 kilohms at around 70°F was used to form a voltage divider with a 1 kilohm and 10 kilohm potentiometer in series. In practice, about 6.5V is required to trigger TR1 on, slightly raising the common emitter voltage and cutting transistor TR2 off. TR2 collector voltage rises, D3, R7 and C3 detect this rise and activate transistor TR4, thus lighting the l.e.d. D4 (setting off the alarm).

Of course, a miniature relay can take the place of the glowing l.e.d. for control applications—for instance, to switch a device on or off when a set temperature is reached. Once latched on, TR4 will continue to conduct unless reset switch S1 is depressed to open transistor TR2 base connections to 0V. The circuit is then ready to begin a new cycle.

Capacitors C1 and C2 are stabilising capacitors. Diode D1 maintains the conductive sensitivity of TR3 and thence TR2. Potentiometer VR1 is provided to set the limiting temperature which could go higher than the 70°F for this project.

The thermistor is the temperature detector and should be mounted on the object which is the temperature source, the other parts of the circuit could be placed remote from the same source. Applications are very wide, it would include the switching off of appliances such as water heaters or kettles, when the limiting temperature is reached. Besides alarm, the same circuit could be used in industrial automation and many other critical services.

I have suggested and actually used 1⁄2 watt resistors, except R4 which is 1 watt, for my experimental circuit.

Toh Eng Kiong, Singapore.

Everyday Electronics, December 1983
FUNCTION GENERATOR

A versatile function generator providing sine, square, triangle, ramp and pulse waveforms over the frequency range 0.1Hz to 2MHz in seven decade ranges has just been marketed by House of Instruments. Output is continuously variable to 20V p-p from and into 50 ohms, with switchable d.c. offset available to +10V. A variable duty cycle and symmetry control enables adjustment of main, square and TTL outputs. Other facilities include: external sweep over a 1kHz to 1MHz range; polarity invert and sync output.

The IFG422 Function Generator is guaranteed for one year and costs £195, excluding VAT and carriage.

House of Instruments,
Dept EE, Clifton Chambers,
62 High Street, Saffron Walden,
Essex CB10 1EE.

EPROM ERASERS

Three new low-cost EPROM Erasers have been specifically designed by J. P. Designs, for use in the laboratory, classroom and by the hobbyist. All three versions use the same simple drawer construction which allows easy access.

The drawer section, with antistatic foam, holds either 20 EPROMs (Model 82) or 40 EPROMs (models 84 and 84T).

TIME CONTROLLER

A time controller for the ZX81 and Spectrum computers is now being marketed by Glannire Electronics.

The timer consists of a battery back-up real time clock with eight programmable inputs and eight programmable outputs. It provides the computer with the month, day, date, hours, minutes and seconds.

The controller has its own built-in program, in PROM memory. Only a single instruction in the users program is required to read or write the time or date.

Applications include: diary with alarm; home control; burglar alarm; sound effects; games and process control. The recommended retail prices for the Time Controller for ZX81 and Spectrum are £34.50 and £38.50 respectively.

Glannire Electronics Ltd.,
Dept EE, Wesley House,
Trinity Avenue, Bush Hill Park,
Enfield EN1 1PH.

DIGITAL FREQUENCY METER

The launch of a new range of professional quality low-cost test instruments designed and manufactured in the UK is announced by Black Star.

The first products to be released come under the Meteor series and consist of three Digital Frequency Counters with a measurement range up to 100MHz, 600MHz and 1GHz.

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Black Star Ltd.,
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St. Ives, Huntingdon,
Camb PE17 4EB.
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