### TECHNOMATIC LTD

MAIL ORDERS TO: 17 BURNLEY ROAD, LONDON NW10 1ED

SHOPS AT: 17 BURNLEY ROAD, LONDON NW10

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305 EDGWARE ROAD, LONDON W2

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**CPUs **

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<thead>
<tr>
<th>Model</th>
<th>Price</th>
<th>Description</th>
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<tr>
<td>8086</td>
<td>£100</td>
<td>8-bit microprocessor</td>
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<tr>
<td>8088</td>
<td>£150</td>
<td>16-bit microprocessor</td>
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<td>80286</td>
<td>£250</td>
<td>16-bit microprocessor</td>
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**Memory**

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<tr>
<td>RAM</td>
<td>£50</td>
<td>16K RAM chip</td>
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<td>ROM</td>
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<td>64K ROM chip</td>
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**Logic Gates**

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<tr>
<th>Type</th>
<th>Price</th>
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<tbody>
<tr>
<td>74HC00</td>
<td>£1.5</td>
<td>AND gate</td>
</tr>
<tr>
<td>74HC04</td>
<td>£2.0</td>
<td>OR gate</td>
</tr>
<tr>
<td>74HC138</td>
<td>£3.5</td>
<td>3-8 line decoder</td>
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**Multiplexers**

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<thead>
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<th>Type</th>
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<tr>
<td>74HC4050</td>
<td>£1.0</td>
<td>8-1 MUX</td>
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<td>74HC4051</td>
<td>£1.2</td>
<td>1-8 MUX</td>
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**Interface Cards**

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<th>Type</th>
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<tr>
<td>ISA</td>
<td>£25</td>
<td>Input/output card</td>
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<tr>
<td>EISA</td>
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<td>Extended ISA card</td>
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**Expansion Boards**

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<th>Type</th>
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<td>S-video</td>
<td>£35</td>
<td>S-video interface board</td>
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<td>VGA</td>
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<td>Video Graphics Adapter</td>
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**OTHER COMPONENTS**

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<tr>
<th>Type</th>
<th>Price</th>
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<tr>
<td>Resistors</td>
<td>£0.50</td>
<td>1KΩ 1%</td>
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<tr>
<td>Capacitors</td>
<td>£0.10</td>
<td>0.1μF 10%</td>
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<tr>
<td>2.54mm</td>
<td>£0.50</td>
<td>Male/Female pinheaders</td>
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<tr>
<td>0.1inch</td>
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**OTHER ITEMS**

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<tr>
<td>74HC00</td>
<td>£1.0</td>
<td>40-pin DIP package</td>
</tr>
<tr>
<td>74HC04</td>
<td>£1.5</td>
<td>28-pin DIP package</td>
</tr>
</tbody>
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**ATTENTION**

ALL PRICES ARE SUBJECT TO CHANGE WITHOUT NOTICE.

---

**P.A. SYSTEMS**

- **EXACT P.A. SYSTEMS**
- **ADD-ON P.A. SYSTEMS**
- **ACCESSORIES**

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<td>To convert the video signal from a home computer into a suitable signal for a UHF TV set, a modulator is needed. The design here provides good video and also has high quality audio.</td>
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<tr>
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<tr>
<td>Voltage dependent resistors are not very commonly used by electronics hobbyists but due to their specific characteristics they are eminently suitable for protecting electronic circuits and semiconductors from overvoltages.</td>
<td></td>
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<tr>
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<td>3-48</td>
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<tr>
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<td></td>
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<td>3-60</td>
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Our front cover this month shows Elabyrinth our electronic maze game. We toyed with the idea of calling it 'Red Tape' as we have often thought that dealing with ERT (Executive Red Tape) is somewhat akin to trying to find your way out of a maze. Indeed, looking at the front cover picture, we even see a striking resemblance between the open jaws of our Elabyrinth and some of the ERT lovers we have met over the years. So if you see anybody lurking in your area who bears a likeness to our front cover, don't panic, it is probably only your local (this section has been deleted as we cannot afford a libel suit right now – Ed.).

---

A selection from next month's issue:
- real-time analyser (part 2)
- a.c. power supply
- intelligent EPROM eraser
- pulse generator
- microprocessor simulator
What is 10 n? What is the EPS service? What is the TG service? What is a missing link?

Semiconductor types
A large number of equivalent semiconductors and ICs exists with different type numbers. For this reason, 'universal' type numbers are used in Elektor wherever possible: for instance, '741' stands for \( \mu A 741 \), \( LM 741 \), \( MC 741 \), \( MIC 741 \), \( RM 741 \), \( SN 72741 \), and so on.

Type numbers 'BC 107B', 'BC 237', 'BC 547B' all refer to the same 'family' of almost identical good-quality silicon transistors. In general, all members of the same family can be interchanged.

Many Elektor articles in-clude a layout for a printed circuit board service. All, of these boards are available ready-etched and pre-drilled. The EPS in the current issue gives a list of available boards, front panels, and software cassettes.

Resistance and capacitance values
Decimal points and large numbers of zeros are avoided in values of resistors and capacitors wherever possible. Instead, the following prefixes are used:

- \( p \) (pico-) = \( 10^{-12} \)
- \( n \) (nano-) = \( 10^{-9} \)
- \( \mu \) (micro-) = \( 10^{-6} \)
- \( m \) (milli-) = \( 10^{-3} \)
- \( k \) (kilo-) = \( 10^3 \)
- \( \Omega \) (ohm) = \( 10^6 \)
- \( \text{F} \) (farad) = \( 10^9 \)

A few examples of resistance values:
\[ 2k7 = 2700 \Omega; 3M3 = 3000000 \Omega; 820 = 820 \Omega \]
Resistors used are \( \frac{1}{4} \% \), 5% carbon types, unless otherwise stated.

A few examples of capacitance values:
\[ 47p = 4.7 \text{ pF} = 0.000 000 000 047 \text{ F}; 10n = 0.01 \text{ mF} = 10^{-5} \text{ F} = 10000 \text{ pF} \]

The DC working voltage of capacitors (other than electrolytic or tantalum types) is normally assumed to be at least 60 V. As a rule of thumb, a safe value is usually approximately twice the DC supply voltage.

Test voltages
DC test voltages shown are measured with a 20 k\( \Omega \)/V instrument, unless otherwise specified.

Mains voltage
Mains (power line) voltages are not given on Elektor circuits as it is assumed that our readers know what voltage is standard in their part of the world!

Technical services to readers
- EPS: Elektor printed-circuit board service
- Technical queries relating to articles published in Elektor may be submitted by telephone (Tel. 0227-53474) on Mondays between 13.30 and 16.15, or in writing. The telephone service does not operate during July/August. Letters should be addressed to Dept. TQ Please enclose a stamped self-addressed envelope or, if you live outside the United Kingdom, an International Reply Coupon.
- Missing links
Any important modifications to, additions to, improvements to, or corrections in, Elektor circuits are generally published under 'Missing Links' at the earliest opportunity.
Satellite TV

Monday 16 January, 1984, saw another milestone in the history of British television with the inauguration of Satellite Television's Sky Channel. The first transmission to Britain was 'piped' to about 10,000 subscribers on a private cable network in Wiltshire.

Satellite Television is a private company, in which News International (owned by Mr. Rupert Murdoch) holds a 65 per cent share. The company began transmitting in 1982 via the European Space Agency's Orbital Test Satellite, but its programmes are now broadcast via the European Communications Satellite ECS-1. Sky Channel is already received by more than half a million cabled homes in Norway, Finland, and Switzerland, as well as hotel rooms in France, Finland, and Switzerland.

As the British government is intent on liberalizing the rules for British cable television, British cable TV systems will be allowed (provided they pay Satellite Television 10 pence per month per subscriber) to distribute it over their wires. As Sky Channel's programmes will carry advertising, cable viewers will get them free: Sky Channel is not pay-TV.

Low-powered satellites such as ECS-1 require a dish aerial of 2.5-3 metres in diameter for best reception. It is, however, possible to receive the transmissions with dishes of only about 1 metre diameter. This will make it almost as easy for the individual to receive Sky Channel as a high-powered DBS (direct-broadcast satellite) service. There could be difficulties, however: low-powered satellites are legally classified as telecommunications satellites. To receive their transmissions, you need a special licence. At the time of writing, the government does not appear to know whether it will invoke the law or not.

Some history

During their 1977 meeting in Geneva, the ITU (International Telecommunications Union - a UN agency) allocated five channels in the 11.7-12.5 GHz band to each country. This band accommodates 40 channels. Each channel has a bandwidth of 27 MHz, while channel spacing has been set at 19.2 MHz. At the same meeting positions for a number of satellites were allocated. These are geo-stationary above the equator at 6° intervals (but of course not every position is, or will be, filled). The satellite position for the United Kingdom, Ireland, Iceland, Spain, and Portugal is 31° west, while that for Belgium, France, West Germany, Italy, Luxemburg, the Netherlands, and Switzerland is 19° west (25° west is not used).

In 1982, some years after countries like the USA, USSR, and India had taken similar decisions, the home secretary finally gave the go-ahead for satellite TV in Britain with two BBC stations to start transmitting in 1986. Originally, the BBC had planned to begin broadcasting on the two channels (only films on one, general interest on the other) during the autumn of 1986. But over the past twelve months doubts about the commercial viability have grown, culminating last December in rumours that the governors of the BBC wanted to shelve the project. A later statement said, however, that it had been decided that the BBC would continue to explore all possibilities for the completion of the first British DBS service by late 1986.

BBC vs IBA

At about the same time it was stated that the BBC are discussing with the IBA (Independent Broadcasting Authority) a plan for sharing the £350 million estimated costs of the proposed system. This would presumably entail joint operation of the satellite.

Ever since the government decided in early 1983 to back the IBA's C-MAC (multiplexed analogue component type C) system in favour of the BBC's EPAL (extended phase alternation line) proposal, there have been many meetings between the
two broadcasting organizations. However, as the IBA has been granted its own satellite system (to start in the late 1980s), it is likely to be cool to a proposed sharing. Unit Satellites (UNISAT), the consortium of British Aerospace, GEC-Marconi, and British Telecom, which is building the satellites (one operational, one back-up), is of course anxious that a speedy solution be found to ensure the continuation of the project in which they are reputed to have invested about £50 million already.

As stated, early in 1983 the British Government took the somewhat startling decision to accept IBA's C-MAC system rather than the BBC's proposal for extended PAL. The chosen system is totally incompatible with any other television system; no doubt television receiver manufacturers will welcome this as it opens a huge new market for (new) dual-standard receivers, converters, and what-have-you.

EPAL vs C-MAC

A composite video signal comprises two parts: the luminance signal (brightness) and the chrominance signal (colour). The luminance signal is obtained by combining the outputs of the three colour channels — red, green, and blue — and is then used for amplitude modulation of the main picture carrier frequency. This produces the black-and-white image. The chrominance signal is obtained by combining, in a colour encoder, portions of the separate video signals into sum and difference signals. In PAL and SECAM systems, two quadrature components of the chrominance signal are produced and used for phase and amplitude modulation of the chrominance sub-carrier.

The basic system for transmitting TV picture information was established some 35 years ago for monochrome transmissions. The choice of 625 lines per frame and 25 interlaced pictures (frames) per second was a compromise between picture quality and technical and economical feasibility.

The 625 horizontal lines composing our TV picture cannot be seen separately at distances greater than 4...5 times screen height. Together with an aspect (width/height) ratio of 4:3 and the requirement for good resolution, this results in a video bandwidth of 5.5 MHz. When a video signal with this bandwidth is used for the amplitude modulation of a carrier, sidebands of +5.5 MHz and -5.5 MHz are produced: a total bandwidth of 11 MHz. However, in vestigial-sideband transmission (which is used almost universally), by attenuation of spectral components, one of the sidebands is reduced to 1.25 MHz (at least in the U.K., Ireland, France, and Belgium; in most other western European countries to 0.75 MHz). The bandwidth is therefore reduced to 6.75 MHz. Add to this the FM modulated sound and, of course, some space for the separation of adjacent channels, and it becomes evident that the internationally agreed channel width of 8 MHz does not leave much room for the chrominance signal. Fortunately, as the human eye is much less sensitive to colour detail than to light and shade, the chrominance signal can be of considerably lower definition than the luminance signal. None the less, the two signals sometimes mix which results in so-called cross luminance; the display of false colours in the image.

By almost unanimous agreement, the sound of satellite broadcasts will be digital. In the C-MAC system, the whole channel is switched into the digital mode during the interval between picture lines for transmission of the 9 μs sound data burst. The C-MAC system will continue to use the same number of lines and frames as current terrestrial television. This means that, for instance, projector TV will remain almost as dead as the proverbial dodo: when projected onto a large screen, 625 lines are not a pretty sight! A pity, because the new high-definition standard (1125 lines and an aspect ratio of 5:3) for use with satellite broadcasts as developed by the Japanese Broadcasting Corporation seemed at last to have overcome this great draw-back of present-day television. However, Philips of Eindhoven, the Netherlands, are working on a new IC which may become our last hope for some time to come for a real improvement in picture quality.

IBA's Multiplexed Analogue Component type C (C-MAC) system is totally different from PAL and SECAM and cannot therefore be received with existing equipment (nor can such equipment be suitably modified). In the PAL and SECAM systems the chrominance signal is resolved into two quadrature components (red and blue signals; green is obtained by adding and subtracting the red and blue signals with the luminance signal). In the PAL system the two quadrature components are used for phase and amplitude modulation of the 4.43 MHz chrominance sub-carrier which is interleaved with the video signal. In the SECAM system the two components are transmitted sequentially on alternate lines. Each is fed to a delay line which stores it for one line and then mixes it with the incoming one. Each displayed line is therefore a mixture of the present and previous lines. The colour resolution in SECAM is reduced compared with PAL, but SECAM does not suffer from cross luminance. In the C-MAC system, the chrominance and luminance signals are transmitted sequentially but not on alternate lines. Both signals are time-compressed and the 64 μs line period is divided into 9 μs for the sound data, 17 μs for the chrominance signal, and 35 μs for the luminance signal, with 1 μs gaps between the three.

The human eye is much less sensitive to colour detail than to light and shade, the chrominance signal can be of considerably lower definition than the luminance signal. None the less, the two signals sometimes mix which results in so-called cross luminance; the display of false colours in the image. In the C-MAC system, the chrominance signal is interleaved with the video signal. In the C-MAC system, the chrominance and luminance signals are transmitted sequentially but not on alternate lines. Both signals are time-compressed and the 64 μs line period is divided into 9 μs for the sound data, 17 μs for the chrominance signal, and 35 μs for the luminance signal, with 1 μs gaps between the three.

By almost unanimous agreement, the sound of satellite broadcasts will be digital. In the C-MAC system, the whole channel is switched into the digital mode during the interval between picture lines for transmission of the 9 μs sound data burst. The C-MAC system will continue to use the same number of lines and frames as current terrestrial television. This means that, for instance, projector TV will remain almost as dead as the proverbial dodo: when projected onto a large screen, 625 lines are not a pretty sight! A pity, because the new high-definition standard (1125 lines and an aspect ratio of 5:3) for use with satellite broadcasts as developed by the Japanese Broadcasting Corporation seemed at last to have overcome this great draw-back of present-day television. However, Philips of Eindhoven, the Netherlands, are working on a new IC which may become our last hope for some time to come for a real improvement in picture quality.
The ever increasing cost of petrol has ensured that fuel consumption is something few drivers can ignore. The size of the average car is steadily reducing but these smaller cars are becoming more comfortable to compensate for their dimensions. More importantly, however, they are also becoming more efficient, especially as regards fuel consumption. That is all very well for those fortunate few who can afford to simply go out and buy an efficient new car but the rest of us have to do what we can to reduce our fuel bills with our ‘old’ cars. The circuit described here can help do this by cutting down on the amount of petrol wasted in a car engine.

**petrol saver**

The importance of fuel economy in cars can no longer be denied when the motor manufacturers of the world are working ever harder to make their products go further on less fuel. The ‘in’ fad at the moment is advanced aerodynamics complete with flush glass bonded to the body, and car salesmen make full use of a car’s low Cd figure (drag coefficient: a measure of the car’s aerodynamic efficiency) to entice prospective customers. Certainly, when combined with low weight, good aerodynamics do make a car more efficient, and therefore more economical. Other manufacturers take a different approach to motoring economy and prefer to tackle the notoriously bad efficiency of the internal combustion engine. Engine control computers are now so common that they only invoke comments as to their particular advanced features over their competitors’. It is all very well to read about these wonderful new cars in the motoring press but for most of us that is as far as we will get for a long time. So let’s forget about the pie in the sky and see what can be done to make our present ‘steed’ more economical.

Like more than one car manufacturer, we decided to try and reduce the wastage of petrol. Most carburettors have idling jets through which a small amount of fuel is fed to keep the engine running when the throttle is closed. When the driver’s foot is on the accelerator this fuel is mixed with the main fuel flow and so it produces power. When the driver lifts his foot from the accelerator the throttle is closed but the idling jets continue to direct a certain amount of fuel to the engine. This is unnecessary until the engine is almost at idling speed. This wastage can, however, be reduced.

Since about 1975 most new cars have been equipped with a solenoid valve on the fuel line to the idling jets. The purpose of this is to stop the supply of fuel when the ignition is off, thus preventing ‘running on’. The circuit here was designed to control this valve so that it is always closed above a certain engine speed.

**Can I use it?**

Before rushing out to buy the parts for this circuit you should first determine whether it is suitable for your car or not. Obviously the first thing to look at is whether the car has an electric fuel cut-off valve on the fuel line to the idling jets. If not, then our old friend Murphy has struck again.
Figure 1. The block diagram here shows the main parts of the circuit and gives an indication of its operation. The speed of the engine is sensed and compared with a reference value and this information is used to determine whether the fuel cut-off valve for the idling jets should be opened or closed.

If the valve is fitted then try the following: start the engine and let it run at somewhat above tick-over. Pull the plug off the valve (i.e. remove the power) and stick it back on. Release the accelerator and the engine should idle. If not, the valve is not suitable for use with this circuit (Murphy-2, The Opposition-0). Those of you who are still reading this may now rejoice and start building.

The block diagram and circuit

The basic operation of the circuit can be seen from the block diagram of figure 1. A signal is picked up from the c.b. (contact breaker) points and is fed via a pulse shaper to a Schmitt trigger. This then gives a measure of the engine speed as one pulse is output to correspond to each opening of the c.b. points. This signal goes to a circuit that compares the time between two pulses with a reference time and based on this comparison it opens or closes the fuel cut-off valve via the driver stage.

Relating this to the circuit diagram of figure 2, we see that the terminals a and b are connected across the c.b. points. Every time the points open this information is transmitted via the filter network to T1 so this transistor conducts for a short time. This provides a signal that is fed to one of the inputs of the Schmitt trigger N1. The output of N1 generates one pulse corresponding to each opening of the c.b. points and this output is fed to the trigger inputs of MMV1 (TR) and MMV2 (TR).

What happens next depends on the time, t, between two successive pulses. If the engine speed is high the time between two pulses (t) will be smaller than the reference time (T) set with C5 and P1. This is shown in the timing diagram of figure 3a. The falling edge of the first pulse triggers MMV1 causing its Q1 output to go 'high'. This, in turn, makes the reset input (R2) of MMV2 high for a time equal to T. This input is therefore still high when the rising edge of the next pulse triggers MMV2. The 'low' level of Q2 then closes...
the valve via the driver stage built around T2 and T3. Simultaneously the Q2 output of MMV1 takes pins 6, 9 and 13 of IC1 high and causes the LED to go out. The falling edge of this second pulse triggers MMV1 and this renews the time T. If the engine speed is low MMV1 is triggered and takes the R2 input of MMV2 high, but before the next pulse arrives this reset line has gone low again. Again, this is indicated by timing diagram 3b. The Q2 output then lights the LED via N1, N2 and N4. More importantly, of course, the Q2 line is 'high' so T2 and T3 conduct and open the valve.

Construction and calibration

The parts used in this circuit are all commonplace and readily available. The only question about components concerns the choice of IC2. As we have shown on the circuit diagram, this can be either a 4098 or a 4528 as in principle both types are the same. Obviously, there are some differences or they would not have different type numbers. If the 4098 is used the MMV time, T, can change whenever the time (t) between trigger pulses is approximately equal to T. This change in T appears as a hysteresis in the on/off switching frequency of the valve and is dependent upon the value of C5. This phenomenon is unknown to the 4528 so if this IC is used the performance of the circuit will be more predictable. However, as the hysteresis inherent in the 4098 means that the valve is not constantly opened and closed if T is approximately equal to t, we recommend that this be used instead of the 4528.

The circuit is not very complicated so building it on a piece of vero board should not be any problem. The LED (D3) to indicate that the valve is open must be mounted in the car dashboard if it is used. The same is true of switch S1. This is a safety feature to enable the circuit to be by-passed. Without this facility any failure in the circuit would cause the valve to close so the engine would stall instead of idling. The circuit must be connected to the fused side of a 12 V line that is live when the ignition is switched on. With its few components, the circuit draws little current so it is hardly likely to drain the car's battery.

In order for the circuit to operate as we want, P1 must be set so that the valve operates at about 1500 r.p.m. There are two ways of doing this. The in situ method involves fitting the circuit in the car and running the engine at about 1500 r.p.m. The potentiometer is then adjusted until the valve operates at this value. The second method of calibration requires that the frequency of the signal from the c.b. points first be calculated (frequency = r.p.m. x number of cylinders in the engine). A signal at this frequency is fed into the circuit at points a and b and P1 is adjusted so that the Q2 output (pin 9) of IC2 just goes high.

Using the circuit

As far as the driver is concerned there are no instructions for how to use this circuit so he need not even know the circuit is in use except that the car's fuel consumption should drop. There are a few points to note however. This circuit has no effect below 1500 r.p.m., so below this speed the engine simply works as normal. Above 1500 r.p.m., however, the fuel supply to the idling jets is cut off so that when the car is on over run (i.e. with the throttle closed) the petrol consumption is nil. This is where the saving is made so this circuit is best suited for cars that are often in this condition. This occurs most frequently in city driving or in a hilly countryside. The usefulness of the circuit also depends to a certain extent on the driving style of the driver. Freewheeling, with the car out of gear on the over run, apart from being a potentially dangerous practice defeats the purpose of the circuit as the revs then drop very quickly below 1500 r.p.m. and the idling jets again get their fuel supply. The fuel consumption is then no longer nil.

Now if we could just find a way of making the petrol consumption nil when the car is accelerating ... but maybe that's just too much of a pie in the sky.
The circuit described here is a triac-controlled mains lamp firing circuit consisting of eight independent channels. Each channel contains an opto-isolator to maintain complete isolation between the control circuit and the mains power supply. The board was primarily designed for use with the 'programmable disco light display' published in the February 1984 edition of Elektor, but it has many more applications. It will, for instance, be ideal for use as an interface between the I/O outputs of a computer and mains powered equipment. It can also be used to expand existing circuits which have only an LED display.

The circuit consists of eight channels on one printed-circuit board each of which is a self-contained mains lamp firing circuit. Complete isolation between any control circuit and the mains supply is ensured by the use of opto-isolators. This also means that the circuit can be used with any other control system that is capable of driving an LED.

As will be seen from the diagram of figure 1, the circuit is very simple with each channel consisting of an opto-isolator, a driver transistor, and a triac. The LED in the isolator is driven from the control circuit. In the quiescent state, that is, when the LED is not lit, the transistor in the isolator is effectively open circuit. The driver transistor is then held hard on by the base current derived via the base resistor connected to the negative supply line C (A). In this condition the gate of the triac is held to the 'zero' line D (B) and the triac therefore cannot fire.

If the control circuit now causes the LED to light, the transistor in the isolator will switch on, causing the driver transistor to switch off. The triac will now derive a gate current via the resistor connected to the negative supply line and the triac will fire. The gate current is about 5 mA and remains constant as long as the LED in the opto-coupler is lit. This is an advantage that enables the use of relatively low load currents, lower in fact than the holding current of the triac. This allows low-wattage (e.g. 5 W/240 V) mains lamps to be used.

The maximum power handling of each channel depends on the cooling of the triac and the heat sinks should therefore be chosen for the expected load. The TIC 206 triac without a heat sink will handle up to 250 W. If a TV 4 or 5 type (17°C/W) heat sink is used, the load can go up to 500 W for each channel. A better heat sink still, the TV 21 type (10°C/W), will allow a load of up to 750 W. It is advisable that some form of heat sink is used even with low power requirements or the printed-circuit board material may deteriorate over a period of time.

The printed-circuit board is suitable for fitting in a standard 19 inch rack mounting.
Figure 1. The circuit diagram for the triac control board. It will be seen that all eight channels are identical.

Figure 2. In general, the mains wiring of a single triac control board should follow that shown here.
Figure 3. If a single triac control board is used in conjunction with the Programmable Disco Light Display, the mains wiring should be as shown here.

Figure 4. The mains connections for the Disco Light Display and two triac control boards are given here.
Display connection

It is important that the utmost care is taken when the display is connected to the (potentially lethal) mains supply. It must be pointed out that there are a whole host of regulations in force covering this topic, enough in fact to deter all but the most strong minded from attempting it at all! Without wishing to appear too gloomy, it is only fair to point out that insurance companies can get rather paranoid about the possibility of an accident involving this type of equipment at a public venue. A great deal of care must therefore be taken when wiring the display plugs and sockets. Use only approved mains plugs and sockets of the correct current rating. The P551 and P552 8-way plug and socket from the Bulgin range will be useful in this respect. The common return power line should be made separately via a very substantial connector, or by commoning a number of pins together.

Figure 5. The wiring for triac control boards in a matrix. It must be noted that in this case the X terminals are not connected together and that two transformers are required.
3.26

direction.

Note that all diodes are required, a diode should be included in the same direction (see figure 7). The driven lamps will then be powered at half the mains supply voltage (which will mean less light, of course) and tend to flicker slightly.

The printed-circuit board

The triac control board can be used for many applications and, in general, the wiring should follow that given in figure 2. If the triac control board is to be used with that of the Elektor Programmable Disco Light Display, the wiring should be as illustrated in figure 3 for a single triac control board or figure 4 for two boards. Three or more boards are connected in the same way.

A number of display configurations are possible up to a maximum of 225 lamps. For a matrix display (15 rows each containing 15 lamps) the wiring is rather more complex as can be seen in figure 5. It should be noted that, in this case, the $X$ terminals are wired independently to the live and neutral of the mains.

The $X$ terminals are not connected together. Any number of boards (up to the maximum) can be connected in the form of a matrix but care must be taken at all times with the connections to the mains supply. A minor problem can occur in the form of faint lighting of the lamps that should not be lit. This problem is removed if all horizontal lamps are always driven simultaneously. The vertical channels may however be programmed in any sequence. It is also possible to reverse this.
If the triac control board is to be used for other applications, the LED in the optocoupler must then be provided with a current of at least 5 mA to ensure reliable operation: this normally means that a biasing resistor must be used. The voltage drop across this LED is about 1.2 V.

Figure 8. The component layout and track pattern of the triac control printed-circuit board. A 'spare' line is provided to act as either the common anode or common cathode line for the opto-couplers.
Modulators which convert the video signal from a home computer into a suitable UHF television signal must nowadays meet stringent requirements. This is, of course, not for fun, because modern TV receivers are tuned to the selected channel by a synthesizer. This means that deviations from the correct channel frequency cannot be tolerated and the modulator must therefore be accurately tunable to a given channel. To meet this demand we have developed a modulator which not only meets these requirements as regards video, but which also provides good-quality audio.

UHF video and audio modulator

for all television standards

A video signal has a shape as shown in figure 1a: when this is modulated by the signal from the television transmitter, the negative-amplitude modulation shown in figure 1b ensues. Our modulator must therefore generate a similar signal which is then fed to our television receiver on a specific channel. This is normally channel 36, ‘guarded’ by channels 35 and 37, which is also used by most video recorders. Note that these are the only three channels which have not been allocated for television transmission.

TV standards

Most European countries operate their television networks in accordance with the recommendations of the CCIR. These embrace amongst others 625 lines per frame (picture) and 25 interlaced frames per second. Interlacing is a system in which the lines of successive rasters (fields) are not superimposed on each other but are interlaced: two rasters therefore constitute one frame. The frame frequency is therefore half the field frequency.

There are, however, differences as regards vision modulation and sound modulation: the first may be negative or positive and the latter FM or AM. These differences are highlighted in table 1, from which it is seen that, at least as far as UHF transmissions are concerned, in western Europe only France, Greece, and Monaco differ from the rest. Negative vision modulation means that the
carrier amplitude reaches its highest value when the video signal amplitude is lowest, that is, when the synchronization (sync) pulse is present (see figure 1a). With positive vision modulation it is exactly the opposite. A glance at the block diagram in figure 2 will show that the outlay for the modulator is very modest. Basically, an oscillator is modulated by the video signal and produces a signal which is suitable for feeding to the aerial input of the TV receiver. However, we have incorporated three additional features: (a) the possibility of modulating the oscillator positive or negative; (b) the facility for adding a modulated audio signal to the video signal, and (c) the choice between amplitude and frequency modulation of the audio signal. These features will make the modulator usable in any TV system.

Overtone oscillator (see figure 3)

An AT-cut quartz crystal, although manufactured for operation in its fundamental mode, can be induced to oscillate at a much higher frequency. In our modulator a 5th-overtone crystal operates between 146 and 150 MHz. It is followed by a quadrupling circuit which has an output frequency range of 584...600 MHz covering channels 35...37. The crystal is tuned to its fifth overtone by inductor L3 and capacitors C7...C9: trimmer C8 enables the exact setting of the required frequency.

Modulation of the video signal is effected by feeding the signal to the base of quadrupler T2 via inverter T1 and inductor L1 (negative modulation) or directly to the base of T2 if positive modulation is required (points A and B are then connected together). The modulated output of T2 is tuned to four times the oscillator frequency by means of tuned band-pass filter L4C13. Inductor L4 is a film type (that is, deposited onto the printed-circuit board) which is frequently used in UHF techniques.

Audio modulation

Compared with the vision modulation, the audio modulator constructed around IC1 appears rather more complicated. The well-known symmetrical mixer SO42P is used as AM/FM modulator. You may well say: 'How do you use a symmetrical mixer as a modulator?' Well, the answer is that we have made the SO42P asymmetrical by means of resistor R10. The mixer operates at a frequency of 5.5...6.5 MHz, depending on which television standard is in use in your particular country (see table 1). In the U.K. and Ireland standard I is used, and in those countries the vision/sound separation is 6.0 MHz. The frequency is generated by the internal and external circuits connected to pins 10...13 of IC1. The IC operates as an AM modulator when the audio signal drives the two internal differential amplifiers on pin 8 direct. The amplitude of the output signal on pin 2 then varies in rhythm with the AF input.

The SO42P functions as an FM modulator if the audio input signal changes the frequency of the oscillator on pins 10...13: this is effected by means of variable capacitance diodes D1, D2. The output of the modulator is taken through a ceramic 6.0 MHz band-pass filter to a capacitive divider, C6/C5, and then fed to the base of T2.

Construction

As is usual with printed-circuit boards for VHF and UHF applications, that for the modulator is double-sided. Therefore, do remember to solder the earth connections of the relevant components also.

Table 1

<table>
<thead>
<tr>
<th>System</th>
<th>Number of lines</th>
<th>Channel width MHz</th>
<th>Vision bandwidth MHz</th>
<th>Vision sound separation MHz</th>
<th>Vertical sync-band MHz</th>
<th>Vision modulation</th>
<th>Sound modulation</th>
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<td>B</td>
<td>625</td>
<td>7</td>
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<td>0.75</td>
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<td>FM</td>
</tr>
<tr>
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<td>625</td>
<td>7</td>
<td>5</td>
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<td>+6</td>
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<td>FM</td>
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<td>6</td>
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<td>FM</td>
</tr>
<tr>
<td>N</td>
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<td>4.2</td>
<td>+4.5</td>
<td>0.75</td>
<td>Neg</td>
<td>FM</td>
</tr>
</tbody>
</table>
UHF video and audio modulator
Elektor March 1984

Figure 2. Block diagram of the UHF video and audio modulator. The carrier frequency is amplitude-modulated by the video and audio signals.

Figure 3. The circuit of the modulator appears more complicated than it is. The video signal is routed via T1 and crystal oscillator X1. The audio signal, whether AM or FM, is fed to mixer IC1. The video and audio signals are added together in T2.

P1 Depth of modulation
- video
P2 Depth of modulation
- audio
C8 Oscillator frequency and amplitude
C13 Output circuit tuning
(affects amplitude of the output signal)

The centre terminal of this component should be bent and then soldered at the components side to film inductor L4.
The crystal oscillator should be screened by a suitable size piece of tin plate bent at right angles and soldered to the earth plane at the components side. You will notice that capacitor C12 is in the way, but this can be overcome by drilling a small hole in the screen and feeding one of the terminals — fitted with a piece of insulating tube — of the capacitor through the hole. The circuit can then be fitted in an appropriate metal case, which has been provided with suitable connectors for the video and audio inputs, the UHF output, and the input for the supply voltage.
A final point: the capacitor fitted by the manufacturers inside the housing of coil L5 must be removed!

Alignment
Connect the modulator between the video output of the computer and the television set and apply a suitable supply voltage. Tune the television receiver to channel 36, and then the modulator to 591.25 MHz. The setting of C8 and P1 is, of course, critical and is best done as follows. Turn P1 fully clockwise (no modulation) and then adjust C8 carefully until the television screen shows a black image. Then adjust P1 to obtain a picture to your personal liking. When you are satisfied that the picture is the best obtainable, apply a video signal...
UHF video and audio modulator

Figure 4. The printed-circuit board for the modulator is double-sided. All earth connections should therefore be soldered at the components side. The crystal oscillator should be screened with a suitable piece of tin plate.

Parts List

Resistors:
- R1,R4,R5 = 270 Ω
- R2,R7 = 10 k
- R3 = 5 k
- R6 = 2 k
- R8 = 1 k
- R9,R10,R16 = 1 k
- R11 = 47 k
- R12 = 22 k
- R13 = 47 k
- R14,R17 = 47 k
- R15 = 100 k
- P1 = 100 k preset
- P2 = 5 k preset

Capacitors:
- C1,C3,C19 = 47/16 V tantalum
- C2 = 470 n
- C4,C5,C9 = 470 n
- C6,C12,C22 = 1 p
- C7 = 68 k
- C8,C13 = 10 p trimmer
- C10 = 22 k
- C11 = 2 p
- C14,C15 = 100 n
- C16,C18 = 180 p
- C17 = 330 p
- C20 = 1 n
- C21 = 1 μ/16 V

Inductors:
- L1,L2 = 2 turns SWG 27 enameled copper wire on ferrite bead
- L3 = 0.15 μH
- L4 = film inductor deposited onto printed-circuit board
- L5 = TKX/CA 34735EMD (available from Ambit)
  (Note: the capacitor in the housing must be removed!)

Semiconductors:
- D1,D2 = BB 1058 or BB 405B
- T1 = BC 55713
- T2 = BFR 91
- T3 = BC 550C
- IC1 = SO42P

Miscellaneous:
- FL1 = ceramic filter type SFE6
- X1 = 5th-overtone crystal 147.8125 MHz

Printed-circuit board 84029

(but only the test card from your video recorder or local transmitter, or a test line from your computer). Again, adjust C8 and P1 alternately to obtain the best possible image. Note that turning P1 anticlockwise increases the modulation, and also that there are several positions of C8/P1 which give 'the best possible image'. Next, C15 is adjusted for minimum noise after partially removing the aerial plug from the TV receiver (but not so far that the image completely disappears).

The audio noise from the loudspeaker should disappear when the ferrite core of L5 is properly adjusted. Then apply an audio signal and re-adjust the core to give minimum distortion at the largest signal input. Here again, alternate adjustment of L5/P2 is necessary. This completes the modulator and you can concentrate once again on your programming!
Personal computer users often like to try to change the operating system of their machines, however slight the changes may be. This, of course, is a way of personalising the machine and making it more suitable for the user's own particular needs. The modification described here is both elegant and efficient. It improves TM (Tape Monitor) by adding a new function to automatically start programs read from cassette. This function explains the title of this article: 'GET' = load the program, and 'GO' = run it!

The software given here lets the Junior Computer automatically start programs after transferring them from magnetic tape via the cassette interface and TM to random access memory. The principle is that, during the RDTAPE routine, the return address saved on the stack by the JSR-RDTAPE instruction (executed as soon as the user presses the GET key during TM) is replaced by the start address (SA) of the program read from the cassette. After loading, the processor leaves the RDTAPE routine by means of the RTS instruction and finds on the stack, not the address it left in order to execute RDTAPE, but rather the start address of the program it has just read from cassette. Therefore it goes to this address to run the program. This presupposes, of course, that the start address of the block of data transferred to RAM is also the start address of the program, and also, that the stack is empty (stack pointer equal to SFF) when the GET key is pressed (executing the RDTAPE routine). This last condition is met when TM is used 'normally' as we will see later.

DUMP

In order to achieve the desired effect a DUMP routine has been created. This is simply a modified copy of the DUMP routine of TM and it registers on cassette a heading containing three specific items of data: address $01FE which acts as a load pointer, the start address of the program, which RDTAPE places at addresses $01FE and $01FF - the top of the stack in other words --, and byte $20 which RDTAPE will not accept, so it starts RDTAPE anew, normally this time. DUMP ends by jumping to TM resulting in the DUMP routine being executed normally. Comparing the listing of table 1 with the listing of DUMP (on page 194 of JC book 4), it is clear that the instructions for initializing CHKL and CHKH, and also for POINT and SA ($0A1A ... $0A1B), have been omitted and an instruction to initialize the stack pointer at $0750 (TXS on the listing in table 1) has been added.

We then see that DUMP outputs address $01FE to the tape (which RDTAPE considers as a load vector), and then changes the start address of the block of data to be loaded before storing it in its turn on the tape. This correction is needed to ensure that the RTS instruction works properly at the end of RDTAPE. The last character given by DUMP is $20 The JMP TM instruction now leads to the normal procedure during which DUMP loads the program from the cassette.

Reading

From the listing of RDTAPE (page 197 of JC book 4) the sequence of operations after loading the heading prepared by DUMP can easily be followed. Having read the synchronization characters, the start character of the file (*), and the identification number ID, subroutine RDTAPE reads address $01FE as a load vector (POINT). It then immediately loads the two next bytes which it then places in $01FE and $01FF, thus changing its own return address on the stack. The new address is none other than the start address of the program that is to be loaded. The next byte loaded by RDTAPE is the 'space' character ($20). This, however, does not get past the BMI instruction at $0B73 (page 196 in book 4) so RDTAPE is started again and this time it simply reads the program registered by DUMP after executing DUMP. At the end of the load, the RTS instruction at $0B9A leads the processor to look for the return address on the stack. As we have seen, it finds the start address of the program it has just loaded and it then proceeds to run this.

Using DUMP

In order to avoid having to modify TM, the author of DUMP used quite an imaginative solution. The instructions in table 1 should be loaded in memory starting at $0700 (or whatever address you like) and the NMI vector ($1A7A, $1A7B) positioned at the start address of DUMP ($0700 in our case).

Then TM is just used normally, except that the ST/NMI key on the hexadecimal keyboard is now used for the SAVE function with DUMP.

Finally we would like to draw your attention to the fact that while using this automatic start, the configuration of the output ports is still that of RDTAPE and not that of the hexadecimal monitor.
<table>
<thead>
<tr>
<th>PAGE 31</th>
<th>PAGE 32</th>
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<tbody>
<tr>
<td><strong>Table 1.</strong> This short program is all that is needed to make the Junior Computer start programs automatically after loading from cassette by <strong>TM</strong> (tape monitor).</td>
<td></td>
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</table>
Puzzle-solvers are well acquainted with the idea of a maze. It is made up of a complex pattern of passages and corridors, the object of the exercise being to find the route from the entrance to the exit. With a maze drawn on paper this is relatively simple because of the 'bird's eye view' effect. This makes it easy to see the complete situation at the same time and 'dead ends' are easy to avoid. If an easily solved 'paper' maze is actually laid out in hedges or walls, however, it becomes far from easy to find the way out. It is then a matter of frequent 'U-turns' and it is really memory-taxing trying to remember where you have and where you have not been. Whenever you come to a dead end you must first find back the way you came before you can head in the right direction.

In short, a 'real' maze, or labyrinth, is a lot more difficult, but also much more interesting and exciting than the paper puzzles of the same name. In order to make an interesting electronic version of a maze it is clear that one of the most important prerequisites is that the player may not under any circumstances be able to see the whole map of the labyrinth. This must be kept secret and can only be indicated, as in a real maze, step-by-step as the player 'walks' around.

How is it played?

Unlike the Hampton Court version where all you need is a pair of hedge cutters in case of emergency, this Elabyrinth requires a short description of how the game is laid out and how it is played. We started with a piece of software to design the map for a maze, or strictly speaking mazes, as we made eight versions and programmed them into a 2716 EPROM. The layout of one of these is shown in figure 1 and we will return to this later. The player does not see the whole map but has a control panel at his disposal. This looks more or less as it is shown in figure 2.

The player moves through the maze using push buttons S1 ... S4: S1 to go left, S2 for right, S4 for forward and S3 for backward. If you get stuck, pressing the reset button (S6) returns the player to the start position. The LED display consisting of η1 ... η12 indicates the walls around the player. The player can only move in a direction in which there are no LEDs lit, in other words where there is no wall.

An example will help clarify the situation. Imagine the player is in some (unidentified) corridor that looks like that shown in figure 3. Following the direction of the arrows in the corridor the LEDs will light in the sequence shown in figure 4. In the

Even King Henry VIII, when he was not busy with other activities, liked to solve puzzles. No 'crosswords' for him, of course, as his preference tended more towards the large maze cultivated for him in the garden of his Hampton Court retreat on the bank of the Thames. This maze is still there today and, like the buildings themselves, is open to the public. Consisting of a complex pattern made up of hedges, the maze is tended by a constantly decreasing number of gardeners and summer visitors are sometimes shocked to hear gardener-like cries of 'Help' coming from somewhere within... Seems to us an electronic version might be slightly safer!
beginning (completely left) the upper and lower rows of LEDs light (4a). We go right (S2) and get the same display again (4b). Go one more step right and the bottom and right LEDs light (4c). We cannot now go right so we go forward (S4) and then we only have a wall to the left (4d). If we continue to go forward a wall appears before us (4e). We must now go right and that brings figure 4f to the display. If we go one more step right we get the display shown in figure 4g.

That should explain the most important functions of the control panel, but, as figure 2 shows, there are several other elements on the panel that require some explanation. Starting with switches S7, S8 and S9: these are used to select which of the eight labyrinths stored in the EPROM we want to solve. The on/off switch is S10, while S5 decides whether we are playing with the ‘handicap key’ or not (we will return to this later). Five LEDs, D13 ... D17 form a sort of rough map of the maze to indicate from time to time in which approximate section of the labyrinth the player is.

Finally, at the far right, is another row of LEDs whose function is to signal various events. One of the perils of playing this game is the possibility of falling into a hidden hole, and this is indicated by LED D18. We will return later to this subject of ‘falling’. If the player is heading in the correct direction to locate the hidden key, D19 will light at certain points in the maze. Heading in the right direction for the exit is indicated at various points by D20 lighting. If the player has found the key or if the handicap key option has been switched off via S5, LED D21 will be lit. Lastly, D22 indicates that the player is standing in front of the gate which cannot be passed unless it is opened with the key.

The LED display, D1 ... D12, apart from showing the positions of the walls has one more function: if the player succeeds in escaping from the labyrinth, all the LEDs in the display will flash.
Construction of the maze

Slowly but surely we are working round to the technology involved in this project, and for this we return to figure 1. This shows one of the eight labyrinths stored in the 2716 EPROM which will be the heart of our circuit. The complete hexdump for the contents of the EPROM is given in table 1. This 2716 can also be ordered pre-programmed from Technomatic.

The maze of figure 1 consists of 236 (16 x 16) blocks, each of which is assigned an eight-bit address in the EPROM. Four of the bits define the positions of the walls of the block. Each of these four bits can be either ‘1’ indicating a wall, or ‘0’ indicating no wall. Figure 5 gives an example of this.

The vast majority of the blocks share one or more walls with another block or blocks. Just the same, each block must be defined individually; a common wall between two blocks must be programmed in both blocks. If this is not done the player might, for example, be able to move from block A to B. If block B ‘knows’ it is not from B to A. This ‘one way wall’ could appear somewhat unrealistic in some cases. As we have said, there are eight bits available for each block address, four of which are used for the walls, as we have just described. The remaining four are used for two things. First of all, they give the player extra information by causing certain LEDs to light if he ‘walks into’ certain blocks. The LEDs in question are D13 . . . D17 and D18 . . . D22, shown in figure 2. The positions for the hexadecimal figures giving this extra information

<table>
<thead>
<tr>
<th>Block</th>
<th>Wall 1</th>
<th>Wall 2</th>
<th>Wall 3</th>
<th>Wall 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td>000</td>
<td>000</td>
<td>000</td>
<td>000</td>
</tr>
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<td>010</td>
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<tr>
<td>011</td>
<td>000</td>
<td>000</td>
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<tr>
<td>110</td>
<td>000</td>
<td>000</td>
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<tr>
<td>111</td>
<td>000</td>
<td>000</td>
<td>000</td>
<td>000</td>
</tr>
</tbody>
</table>

Table 1. This is the hexdump of the EPROM data containing the eight labyrinths conceived by our devious designers.

Table 1

<table>
<thead>
<tr>
<th>HEXDUMP:</th>
<th>1980, 1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000:</td>
<td>01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F</td>
</tr>
<tr>
<td>0001:</td>
<td>10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E</td>
</tr>
<tr>
<td>0003:</td>
<td>30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E</td>
</tr>
<tr>
<td>0004:</td>
<td>40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E</td>
</tr>
<tr>
<td>0005:</td>
<td>50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E</td>
</tr>
<tr>
<td>0006:</td>
<td>60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E</td>
</tr>
<tr>
<td>0007:</td>
<td>70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E</td>
</tr>
<tr>
<td>0008:</td>
<td>80 81 82 83 84 85 86 87 88 89 8A 8B 8C 8D 8E</td>
</tr>
<tr>
<td>0009:</td>
<td>90 91 92 93 94 95 96 97 98 99 9A 9B 9C 9D 9E</td>
</tr>
<tr>
<td>000A:</td>
<td>A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 AA AB AC AD AE</td>
</tr>
<tr>
<td>000B:</td>
<td>B0 B1 B2 B3 B4 B5 B6 B7 B8 B9 BA BB BC BD BE</td>
</tr>
<tr>
<td>000C:</td>
<td>C0 C1 C2 C3 C4 C5 C6 C7 C8 C9 CA CB CC CD CE</td>
</tr>
<tr>
<td>000D:</td>
<td>D0 D1 D2 D3 D4 D5 D6 D7 D8 D9 DA DB DC DD DE</td>
</tr>
<tr>
<td>000E:</td>
<td>E0 E1 E2 E3 E4 E5 E6 E7 E8 E9 EA EB EC ED EE</td>
</tr>
<tr>
<td>000F:</td>
<td>F0 F1 F2 F3 F4 F5 F6 F7 F8 F9 FA FB FC FD FE</td>
</tr>
</tbody>
</table>

Table 1
Figure 7. The heart of the circuit shown here is the 2716 EPROM (IC3).
Figure 8. All the push buttons, switches and LEDs are mounted on the 'control' board.

Parts list

Resistors:
R1 ... R4, R16 ... R18 = 100 k
R9 ... R17 = 10 k
R8 ... R11 = 220 k
R12 = 470 k
R13,R15 = 100 k
R14 = 270 k

Capacitors:
C1,C2 = 470 n
C3 = 1 μ/16 V
C4 = 10 μ/16 V tantalum
C5 = 1000 μ/16 V
C6 = 220 μ/10 V
C7 = 100 n

are clear from the drawing in figure 1 (letters A ... F, numbers 1 to 9).
The second use for the four unused bits is to introduce certain hazards in the maze.

Hazards

There are two different kinds of hazard built into this game. These, as we have already seen are 'falling' and the 'handicap key'.

Let us deal with falling first. Falls are hidden traps indicated in figure 1 by dashed lines. These lines can be considered as diodes: you can go through the lines in one direction but then you cannot go back. This is very frustrating, of course, but in most cases we have given a clear warning. If the player is standing on the edge of one of these yawning chasms, LED D18 (generally - not always!) lights. If the player chooses to ignore the warning he will be irrevocably trapped. The way the falls work is shown in figure 6. The upper sketch shows a normal dead end and the indication on the LED display if the player walks from block A into block B; nothing unusual happens. The lower drawing is slightly different as there is a fall between block A and block B. The LEDs give the same image for block A as previously. If the player takes a step to the right, all four walls suddenly light. He is then hopelessly imprisoned and can only escape by pressing the reset button to start the game again. The trick in programming this one-way wall is very simple. The dashed line is not programmed as a wall for block A but is for block B.

Now to the handicap key, which is switched on by means of S5. This hazard is based on a gate and a key, shown just right of centre (dotted line) and lower right respectively in figure 1. More gates can, of course, be programmed although one can cause enough problems on its own.

When the player comes face to face with the gate (D22 then lights), he can only cross it if he has the key in his possession. If he has not got the key, he must first look for the block containing the key, aided by D19, which lights to indicate that he is heading in the right direction. When the 'key' block is found, D21 lights to show that the key has been found. The player can now head for the gate with a vengeance knowing that the key will open
it for him. The way in which the key and gate work is quite simple, but is best understood when seen in the context of the whole circuit.

**The circuit diagram**

The complete circuit, including the power supply, is shown in figure 7. It is built up around a 2716 EPROM (IC3) that can store 2048 bytes. There are eleven address inputs needed. The lowest eight address bits are divided into two groups. Each of these two gets its data from an up/down counter (IC1 and IC2). The upper 4-bit counter controls horizontal movement and the lower takes care of the vertical. This should not be taken literally, of course. A matrix is formed by driving the counters for programming the EPROM and the shape of the maze. The player then gets the impression that he is moving along the co-ordinate axes of a flat plane.

The counters are driven somewhat differently than usual. Before the clock pulse appears at pin 15, the logic level on pin 10 must be set to indicate counting up or down. For this reason push buttons S1 and S2 (S3 and S4) drive an RS flip-flop made up of N5 and N6 (N7 and N8). The mono-

flops consisting of N9...N12 ensure that the clock signal only reaches the counters if pin 10 is at the right level. The reset button, S6, can be used to simultaneously set both counters to zero, to start the game again. This is why all games start at the position with the address 0000 0000. The output can be at any position.

The push buttons are blocked by means of N1...N4 if the information about the walls demands it. This prevents the player from walking through walls. Assume, for example, that there is a wall above a certain block. The counter must then be prevented from incrementing any more. The least significant data bit, D0 (pin 9 of IC3), is logic '1'. This '1' goes to OR gate N3, thus blocking the information from 'up' switch S4.

Outputs D4...D7 (pins 14...17) of the EPROM are used to drive demultiplexer IC4. This demultiplexer drives, among other things, the LEDs that give the 'extra' information.

One or more 'gates' can be inserted using output pins 4, 8, 9, and 10 of the 74LS154. Each output must be connected to a NOR gate. If the player comes up to a

---

**Figure 9. The printed circuit board and component overlay shown here are for the 'electronics' board.**

**Semiconductors:**
- D1...D22 = LED
- D23...D26 = 1N4001
- T1 = BC 547
- IC1,IC2 = 4516
- IC3 = 2716
- IC4 = 74LS154
- IC5 = 4071
- IC6,IC7 = 4011
- IC8 = 4001
- IC9 = 4093
- IC10 = 4081
- IC11 = 74LS32
- IC12 = 74LS40
- IC13 = 7805

**Switches:**
- S1...S4,S6 = Digitast
- S5 = single pole toggle
- S7...S9 = SPST
- S10 = Double pole mains switch

**Miscellaneous:**
- F1 = fuse, 500 mA slow blow
- T1 = mains transformer, 9...12 V/300 mA
Figure 10. This drawing gives an indication of how this whole project fits together. The 'control' board is covered by a piece of red-coloured perspex in which holes are cut to accommodate the switches and push buttons.

'gate', the input of the NOR gate is fed a logic '0' by the demultiplexer. The other input of the NOR gate will be logic '0' or 'I', depending on whether the key has been found or not. If the key has been found this input will be 'I' and the output will be '0'. If the key has not been found, however, the output will be '1', and the player will not be allowed to move in this direction because the push button will be blocked. In the maze shown in figure 1 only one 'gate' is used. Whenever pins 4, 8, 9 or 10 are '0' the output of NAND gate N28 will be 'I' and LED D22 will light. A number of hexadecimal figures are programmed to specify the 'extra' information that is indicated by LEDs D13 ... D22.

These are: for D13 ... D17: B F; for D18: A; for D19: 5; for D20: 4; and for the key, or D21 in other words: 6. As figure 1 shows, each character is programmed into a number of different locations in the labyrinth. When the player reaches one of these blocks, the hexadecimal code will be sent to demultiplexer IC4 in binary form. One of the outputs will then go low and the relevant LED will light.

Whenever the player is close to a wall the appropriate output (9, 10, 11 or 13) of the EPROM becomes 'I'. This signal goes to one of the four NAND gates N23 ... N26. As long as the player has not yet reached the exit from the maze, the outputs of these gates will be '0' and the LED display D1 ... D12 will work normally. When the exit is reached pin 3 of IC4 will go to '0'. The signal from oscillator N20 then feeds the inputs of N23 ... N26, so the walls of the LED display flash.

Construction

The circuit plus power supply (excluding transformer) is built up on two printed circuit boards, one of which is an 'electronics board' and the other is a 'control board'. These two boards are shown, along with their component overlays, in figures 8 and 9. The electronics board is quite straightforward and just requires the usual care and attention to detail that any board does. The control board is designed in such a way that it can serve directly as a control panel. The best switches to use for S1 ... S4 and S5 are Digitasts, while the layout lends itself to using rectangular LEDs for D1 ... D12, as this is aesthetically better. The other LEDs can be any normal common type.

The two boards must be interconnected at no less than 25 points. This sounds more difficult than it actually is as all the points are clearly marked and, if the boards are mounted relative to each other, the appropriate points on both boards more or less line up. Using ribbon cable where possible will keep this wiring tidier.

The construction of our prototypes followed the lines shown in figure 10. The 'sandwich' shown consists of the two printed circuit boards and a front panel made of translucent plastic or perspex, coloured red and with openings cut for the Digitast switches S1 ... S4 and S5. The other switches, S6 and S7 ... S10, are mounted directly on the front panel. The three sections of the sandwich are fixed together using spacers to form a complete unit. Then all that is required is to connect up the supply transformer of 9 ... 12 V at 300 mA.

Finally

This Elabyrinth is a difficult game, that's for sure, but then if it was simple it would quickly become boring. In case of emergency or the first time you play, finding the way out is greatly simplified by keeping a pencil and some squared paper at hand and mapping the maze as you go through it. Even though our maze is not intended to be modelled on the version at Hampton Court we think King Henry VIII would have approved of it. Our design even has some distinct advantages. It is portable, does not require trimming every week and of course you're not so likely to get rained on while playing!
Prelude (part 3)
(April 1983 – page 4-52)
In tone control circuit
(figure 1 on page 4-53)
the values of R16 and
R16' are given erroneously
as 6k8: as correctly shown
in the parts list on page
4-54 these values should be
1 k.

digital cassette
recorder
(January 1984 – page 1-29)
In the parts list on page
1-33 the values of four
resistors are shown incor-
rectly: R11, R26, R29
should be 470 Ω NOT
470 k; R27 should be
330 Ω and NOT 330 k.

power controller
for model railways
(November 1983,
page 11-26)
The operation of the emerg-
ency brake is incorrectly
described in this article. It
should read ‘The brake is
operated by setting S2 to
position ‘stop’ and opening
S3 at the same time’. Also
the transistors have not
been listed in the parts
list. They are:
T1,T2 = BC 5478,
T3,T4 = BD 679,
T5,T6 = BD 680.

Note: due to lack of space, we have not in-
cluded the layouts for the double-sided UHF modu-
lator printed circuit board on the following pages.
They are, however, shown in the article.
The following pages contain the mirror images of the track layout of the printed circuit boards (excluding double-plated ones as these are very tricky to make at home) relating to projects featured in this issue to enable you to etch your own boards.

To do this, you require:

- An aerosol of 'ISOdraft' transparentizer (available from your local drawing office suppliers; distributors for the UK: Cannon & Wrin), an ultraviolet lamp, etching sodium, ferric chloride, positive photo-sensitive board material (which can be either bought or home made by applying a film of photo-copying lacquer to normal board material).

- Wet the photo-sensitive (track) side of the board thoroughly with the transparent spray.

- Lay the layout from the relevant page of this magazine with its printed side onto the wet board. Remove any air bubbles by carefully 'ironing' the cut-out with some tissue paper.

- The whole can now be exposed to ultra-violet light. Use a glass plate for holding the layout in place only for long exposure times, as normally the spray ensures that the paper sticks to the board. Bear in mind that normal plate glass (but not crystal glass or perspex) absorbs some of the ultra-violet light so that the exposure time has to be increased slightly.

- The exposure time is dependent upon the ultra-violet lamp used, the distance of the lamp from the board, and the photo-sensitive board. If you use a 300 watt UV lamp at a distance of about 40 cm from the board and a sheet of perspex, an exposure time of 4...8 minutes should normally be sufficient.

- After exposure, remove the layout sheet (which can be used again), and rinse the board thoroughly under running water.

- After the photo-sensitive film has been developed in sodium lye (about 9 grammes of etching sodium to one litre of water), the board can be etched in ferric chloride (500 grammes of FeCl₃ to one litre of water). Then rinse the board (and your hands!) thoroughly under running water.

- Remove the photo-sensitive film from the copper tracks with wire wool and drill the holes.
Voltage dependent resistors, also called varistors, are hardly known or used by electronics hobbyists. A pity, because due to their specific characteristics they are eminently suitable for the protection of electronic circuits and semiconductors against overvoltages. To make these useful components better known, this article describes their operation and characteristics and gives some typical applications.

Varistors, conventionally classified as 'non-linear resistors', are produced from silicon-carbide, zinc oxide (zincite), or titanium oxide. Granules of these materials are sintered at high temperatures in a vitreous ceramic. One outstanding feature of voltage dependent resistors (VDRs) is that their resistance/voltage characteristic (figure 1a) is symmetrical, that is, independent of polarity. This is due to the fact that although any single contact in the resistor mass may rectify, random distribution of large numbers of contacts in series and parallel results in equal numbers of contacts rectifying in opposite directions. This makes them eminently suitable for AC applications where protection diodes cannot be used.

The operation of a varistor is best understood by considering it as two zener diodes connected back-to-back. Below a certain voltage the current is small because the resistance is large. When the voltage rises, the resistance decreases and the current increases exponentially (figure 1b).

The relation between the voltage, U, and the current, I, of a varistor may be expressed by $U = CI^\beta$, where $U$ is in volts, $I$ in amperes, and $C$ and $\beta$ are constants of the resistance material. Practical values for $C$ range from 14 to a few thousand; values for $\beta$ are given in table 1. When the voltage and current are plotted on a double logarithmic scale, the U/I characteristic becomes a straight line with slope $\beta$. This characteristic deviates from a straight line only when the current is very small.

To be able to use a certain type of VDR, it is not strictly speaking necessary to know its characteristic. It is normally sufficient to know some data, such as:

- the voltage level at the 'knee', that is, the voltage where the varistor begins to operate. The sharpness of the knee in the characteristic is a function of the material used: zinc oxide varistors, for instance, have a more sharply defined knee than silicon-carbide types. Titanium oxide varistors have a relatively low knee level (from 2.7 V). The knee voltage is stated for a certain current, which depends on the value of the VDR.
- $\beta$ (see figure 2). This constant is smallest for zinc oxide varistors, which means that even a small increase in voltage causes a very large increase in current.
- maximum peak current or maximum pulse energy that can be dissipated. The latter is, of course, a very important parameter in protection circuits!
- continuous loading, which is of importance where the varistor is used in a regulator circuit or with fast pulse rates.

Applications

Varistors are particularly used for the suppression of high-energy noise pulses, such as lighting or those generated when an inductive circuit is switched off. This switching may be effected by a (magnetic) switch, a fuse, or a semiconductor. If this semiconductor is a thyristor (also called silicon-controlled rectifier or triac), you would expect no trouble because...
This component switches off only at the mains zero-crossing point so that no counter-e.m.f. is induced. This is, however, not entirely true, because the switching occurs as soon as the current drops below the holding value (the current necessary to keep the thyristor conducting). The holding value is not zero and a small counter-e.m.f. is therefore induced. In most cases the magnetic energy, $1/2LI^2$, is dissipated in a diode and the resistive part of the self-inductance ($I$ is the current at the moment of switch-off and $L$ is the total inductance in the circuit).

Often, however, the self-inductance is AC controlled, which makes the use of a diode impossible: a varistor is then the only solution.

A typical thyristor protection circuit using a varistor is shown in figure 4. In position 1 the varistor is connected immediately across the inductive load and attacks the noise at source. Note that the self-inductance of the connection to the thyristor, in combination with the parasitic capacitance of the (cut-off) thyristor, forms a series circuit in which oscillations may occur. It

Figure 1. The resistance of a varistor (voltage dependent resistor) is dependent on the applied voltage (a). The current increases exponentially when the voltage is raised (b).

Figure 2. Plotting voltage and current on a logarithmic scale enables the determination of $\beta$. This is the standard characteristic supplied by the manufacturer.

Figure 3. The generation of noise pulses on the mains voltage. When a fuse switches off a device, it causes a momentary rise in the mains voltage. Other equipment, if not protected, may be damaged by this pulse.
is not simple to calculate the consequences because the VDR, taking its parasitic capacitance and self-inductance into account, has a fairly complicated equivalent circuit.

With the varistor in position 2 (figure 4), that is, across the thyristor, it may be that the noise suppression is slightly less than in the first method. On the other hand, the thyristor itself is better protected. If you choose the first method, that is, suppression at source, it is advisable to place a varistor at position 3 also. This serves to suppress any noise which may enter the circuit via the mains supply.

Some further applications of the varistor are shown in figure 6, where a, b, and c are intended as protection against overvoltage or voltage break-through. Application d is different as it gives voltage regulation in a similar way as can be realized with a zener diode. A special feature of the varistor is that the polarity of the input voltage is immaterial. In principle, it is possible to convert a sinusoidal input voltage into a rectangular output voltage. Note, however, that a varistor in a regulator circuit must be able to dissipate quite a lot of power.

A few more points which need watching when you select a VDR for a particular application are given below.

The peak voltage which the protected component can stand without being damaged. The level of the knee voltage of the VDR must be lower than this peak voltage.

The maximum voltage, $U_p$, across the VDR under normal conditions (in AC applications: $U_p = 1.414 U_{RMS}$). As a rule of thumb, the current through the VDR at this voltage must be smaller than 1 mA.

The maximum transient current.

The power dissipated in the VDR during a noise pulse. With the VDR connected across an inductance, this power is always smaller than $1/2L_i^2$.

<table>
<thead>
<tr>
<th>Compound</th>
<th>$\delta$</th>
<th>Voltage range</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>zinc oxide (ZnO)</td>
<td>0.025</td>
<td>50 V ... 500 V</td>
<td>high-energy noise pulses suppression of high-energy noise pulses, e.g. in voltage regulator circuits</td>
</tr>
<tr>
<td>silicon carbide (SiC)</td>
<td>0.3</td>
<td>8 V ... 75 kV</td>
<td>continuous loading, e.g. in voltage regulator circuits protection of low-voltage equipment</td>
</tr>
<tr>
<td>titanium oxide (TiO2)</td>
<td>0.25</td>
<td>2.7 V ... 70 V</td>
<td>protection of low-voltage equipment</td>
</tr>
</tbody>
</table>

Table 1. Comparison of various types of varistor.

Figure 4. Protection of a thyristor in an electronic relay: VDR1 suppresses the noise at source and VDR3 suppresses externally generated noise. Alternatively, the VDR (2) may be connected across the thyristor itself.

Figure 5. Representative diagram of a VDR with a self-inductance (incl. that of the terminals) L, parasitic capacitance C, series resistance $R_s$, and parallel resistance $R_p$.

Figure 6. Some further applications of a varistor: 
- a: contact protection, analogous to thyristor protection;
- b: commutator protection in a d.c. motor;
- c: protection of a bridge circuit with inductive load;
- d: voltage regulation or limiting (peak chopping).
A real-time analyser is an audio measuring instrument that defines which frequencies are present in an audio signal and in what strengths. To do this the audio spectrum is broken up into so-called harmonic bands. It is in fact an ideal measuring instrument for audio enthusiasts. The term 'real-time' indicates that the whole frequency range is analysed simultaneously, and this method ensures extremely accurate and quick measurements.

A real-time analyser is not something most people are likely to use every day. In general it would be considered a fairly specialised instrument so perhaps we should first of all clarify exactly what it is and what it does.

As we said in the introduction, the real-time analyser is an instrument that is purely suited for measurements in the audible frequency range, from about 20 Hz to 20 kHz. This audio spectrum is divided by this analyser into 30 frequency bands, each of which has a bandwidth of 1/3 octave. The centre frequency of the lowest band is 25 Hz and the centre frequency of the highest band is 20 kHz. The signal strength of each of these thirty bands is shown on a display.

A real-time analyser can be compared to a spectrum analyser, even though they operate quite differently. The real-time analyser gives just as accurate a frequency analysis as a spectrum analyser but it has the advantage that it examines an incoming signal immediately and completely. A spectrum analyser generally

Figure 1. The block diagram for the real-time analyser. Note that not all thirty band filters and rectifiers are shown here.
uses a swept filter system whereby the whole frequency range is run through in sequence. The signal to be measured must then be constant for a certain length of time. This is not needed with a real-time analyser as each signal is analysed in one go.

The range of the real-time analyser means that its use is almost exclusively limited to audio. This branch of electronics is very popular with hobbyists and this can make a real-time analyser an indispensable instrument. The frequency characteristic is important in every part of an audio installation. Most amplifiers today are linear right up through the frequency range so these can generally be ignored. The frequency response of pick-ups, tape recorders, and loudspeakers, is very interesting and useful to know. The 'curve' for any particular audio element can easily be shown on the display thanks to the built-in pink-noise generator. Admittedly this measurement can also be done with a spectrum analyser, but the advantage of the real-time analyser is that the result of a measurement is immediately visible on the display and that audio signals (which are not periodic) can also be analysed.

This real-time analyser can also be used in combination with a 1/2 harmonic equaliser. These are now being offered by a few manufacturers at reasonable prices, and the combination of these two instruments can enable a stereo system to be as perfectly tuned as is possible in any listening area.

After using this real-time analyser to study an audio system, you don't have to simply pack it up and put it into a cupboard somewhere until you change some part of the system. It can also be used as a sort of super-deluxe output analyser for a power amplifier or recorder. The real-time analyser can, of course, be very useful in the field of speech analysis.

The real-time analyser is a precision instrument. This is a result, not only of the complex layout of the circuit and the large number of components this demands, but also of the components themselves, which must be of a high quality. The circuit will operate best using the components stated and care is required during construction as even a couple of the (more than 300) resistors misplaced can have a drastic effect on the accuracy.

The circuit is built up on a number of different printed circuit boards: the base board, a pink-noise generator board, an input board, four filter boards and a display board. This, of course, makes it a large project so we decided to divide it over several months.

The layout of the circuit

Now we are starting to get down to the nitty gritty of this project, the block diagram of which is shown in figure 1. The analyser has two inputs: one for the line signal and one for a microphone (acoustic measurements). The microphone amplifier brings the microphone signal up to line level. The next element is an attenuator with graduated steps of 10 dB. After the necessary amplification, the incoming signal goes to the thirty 1/2 harmonic filters with centre frequencies of 25 ... 20,000 Hz. Each band filter is followed by an active half-wave rectifier. The outputs of the rectifiers are fed to a 30 to 1 multiplexer whose output is connected to a comparison circuit. This circuit compares the signal supplied by the multiplexer to a number of reference voltages, and the output of the comparator ICs drive the eleven rows of the display. The display consists of a matrix of 330 LEDs, arranged in 30 columns of 11 rows. The columns are switched by means of a 1 to 30 line multiplexer. Both multiplexers in the circuit are connected to a common clock circuit which ensures that they continually work through all 30 lines and that the two are synchronised. If the first filter is connected to the comparator via the multiplexer, then the other multiplexer activates the first LED column. For the second filter, the second column is selected, and so on.

There are a few extras included in this circuit that are not shown on the block diagram. These enable the resolution of the display to be changed, and different LED indications can be selected to make life easier for the user, and, of course, there is the previously mentioned pink-noise generator that is an integral part of this analyser.

Some may wonder why we used a LED display rather than a fluorescent type. A fluorescent display would probably have been both easier to incorporate and better looking but at the moment there are none available that are suitable for this application. The LED solution would probably cost less in any case. Furthermore there will also be an option of a video interface for the analyser, and this will give a choice of displays.

The block diagram makes the circuit seem fairly simple. In practice it is quite straightforward but the sheer numbers of some components makes the total circuit rather big.

In the beginning...

This first 'instalment' deals with the input, power supply and filter circuits. The next article will be concerned with the base board with the rectifiers, a pink-noise generator and a display board which also contains the multiplexers and the comparator circuit. Later we will also describe a circuit to enable the output of the analyser to be shown on a television screen.

The input stage

The input section of the analyser is shown
Figure 2. The input circuit and the power supply. The incoming signals are brought to a suitable level here before going on the filters.

In Figure 2, with the two inputs for line signal and microphone at the left hand side. One of these inputs is selected via switch S1.

The circuit around A1 is a microphone pre-amplifier with an input impedance of 47 k, which is suitable for most types of microphones. The amplification can be varied between about 50 and 75 times with P1, or, if desired, if can also be changed by selecting a suitable value for R2. (The amplification is defined by: \[ A = \frac{R_2 + P_1 + R_3}{R_3} \].)

The attenuator is built up around S2 and 1% resistors R5...R10. The steps are quoted in dBm, where 0 dBm corresponds to 775 mV_rms. If a microphone is used to pick up a signal the output voltage of A1 should be adjusted with P1 so that a level of 0 dBm is given by the instrument at an SPL (sound pressure level) of 100 dB. The --10 dB position then corresponds to an SPL of 90 dB, and so on.

The input of op-amp A2 is protected from high input voltages by means of diodes D1 and D2 and resistor R4. This op-amp is set to have a fixed amplification of just less than 6x. It is immediately followed by a second amplifier stage whose gain can be varied between 3x and 11x by means of P2. This potentiometer serves as a "variable adjustment" in combination with the attenuator. If the wiper of P2 is turned as much as possible towards R16 (maximum amplification) the calibrated values of the attenuator are valid. This potentiometer then enables the input level to be continuously variable over a range of 10 dB from the selected attenuation position. With the values indicated the complete input stage amplifies an input signal of 7.75 mV_rms (--40 dBm position) to give an output value of about 0.5 V_rms. The output of A3 drives all thirty filters.

The output of this input stage is also equipped with an overload indicator. This circuit, based on A4 and T1, gives a warning by lighting LED D4 when the input amplifiers are over-driven. This indicates that the input signal must be reduced or that the attenuator must be switched to a less sensitive position. The actual circuitry involved simply consists of a comparator (A4), which compares the output signal of A3 with a reference voltage derived via R17 and R18. The output signal from the comparator is 'extended' by D3 and C6 so that the LED will light even when the over-
Third harmonic filters

Centre frequency: \( f_0 \) -3dB-points: \( f_1 \) and \( f_2 \)

\[
f_1 = \frac{1}{2}\sqrt{f_0 f_2}
\]

\( f_1 \) and \( f_2 \) are symmetrical around \( f_0 \) so:

\[
f_1 = f_0 - 2^{1/2} f_0,
\]

\[
f_2 = f_0 - 2^{1/6} f_0
\]

The band frequencies are defined by:

\[
f_n = 10^n f_0 \text{ Hz}, \quad n = \text{band number}
\]

for example:

\[
n = 14 \rightarrow f_0 = 25 \text{ Hz}
\]

\[
n = 30 \rightarrow f_0 = 1000 \text{ Hz}
\]

\[
n = 43 \rightarrow f_0 = 20 \text{ kHz}
\]

Because \( 2 = 10^{0.32} \) so:

\[
2^{5/6} \approx 10^{0.32}
\]

For the changeover points:

\[
f_1 \approx 10^{n-0.5/20}
\]

\[
f_2 \approx 10^{n+0.5/20}
\]

where \( n = 14 ... 43 \)

Example:

\[
n = 30
\]

\[
f_0 = 10^{30/10} \text{ Hz}
\]

\[
f_1 = 10^{23.5/10} = 10^{2.35} = 891.25 \text{ Hz}
\]

\[
f_2 = 10^{26.5/10} = 10^{2.65} = 1122.02 \text{ Hz}
\]

Figure 3. This shows the contents of one filter board, containing eight of the thirty filters. Some filter sections (A1, A2, A3 and A4) are used for two filter bands.
Figure 4. The sketch here shows how one filter is formed by connecting three band filters in series. The result is a very precise filter with a flattened top.

Figure 5. Printed circuit board and component layout of the input and power supply board. The voltage regulators must be mounted on a heat sink.

driving peaks are very short.
The power supply for the real-time analyser is located on the input board. This is clearly seen in figure 2. Two voltage regulators ensure a stable symmetrical supply of + and −8 V. The current which can be provided by the supply, almost 1 A, is quite sufficient for the circuit.

The filters
One of the most difficult points of any real-time analyser is the filters needed. Because the bands are very narrow and must be very close to each other, the band filters must be very precise. For this reason we need three op-amps per filter, which for 30 filters adds up to a total of 90 op-amps. By using a few tricks we managed to reduce this total to 75, as we will see shortly, so if we use quad op-amps the number of ICs required begins to seem a bit more reasonable.

All the filters have the same layout so we have only indicated a few of them in figure 3. The eight filters shown are the contents of one filter board. There are four filters boards in total, the last of which contains only six filters.

The notes in the margin on the previous page indicate the theory behind the filters used in this analyser. With a centre frequency of 1 kHz, for example, the −3 dB points of the relevant filter are at 891 Hz and 1122 Hz. The next filter has a centre frequency of 1.26 kHz, rounded off to 1.25 kHz, and its −3 dB points are at 1122 Hz and 1414 Hz. And so it goes on!

The international (ANSI) specifications for 1/3 harmonic filters in professional measuring equipment require that the −40 dB points of a 1 kHz filter lie at 552 Hz and
1.81 kHz. This gives an idea of the precision needed in such filters. For correct operation, the precision of the filters is of critical importance, otherwise a signal with a frequency of 1 kHz would not only be visible on the 1 kHz LED column but also on the adjacent columns. With three normal op-amps a band filter can be made that meets ANSI standards in practice. By 'in practice' we mean that the filter reaches the -40 dB points with an accuracy of a few dB.

One filter in the circuit diagram, for example, consists of op-amps A1, A5 and A6. Each op-amp is set up as a multiple feedback band-pass filter. The three filter bands are slightly shifted with respect to each other, as figure 4 shows. One of the filters lies precisely on the centre frequency, \( f_0 \) of the third harmonic, whereas the centre frequencies of the other two filters are exactly at the changeover points, \( f_1 \) and \( f_2 \) of this third harmonic band. Carefully choosing the Q factor and amplification of each filter can ensure that the final result is an extremely narrow band filter with a very flat 'top'. The Q factor of all the filters here is slightly more than four, the amplification of the 'middle filter' is 1 and of the 'side-band filters' 1.4.

The calculation involved for an equivalent filter is quite complex, even with the aid of the ubiquitous computer. In principle, an equivalent set-up should give even greater precision, but it would require an even higher Q factor. This is not feasible if we want to use ordinary, fairly cheap, op-amps. The formulae for such an equivalent filter have already been dealt with in Elektor (June 1983, spectrum display) so we will not go any further into this sort of single element filter here.

The upper sideband filter of one band is identical to the lower sideband filter of the following band, so one filter can do double duty, as shown in the diagram. This makes A1 the high sideband filter for the A1, A5, A6 band and the lower sideband filter for the A1, A7, A8 band. This saves 15 band filters over the range of 30 filters.

The accuracy of the components for the filters is very important. This explains the use of components with tolerances of 1% or 2.5%, but we will deal with this further under construction.

Construction

Even though the circuit has certainly not been described in full yet, we can already begin putting some of the boards together. They cannot be tested, however, until the construction of the analyser has advanced a bit further. This applies in particular to the filter boards.

We cannot stress strongly enough the importance of keeping to the components listed in the parts list for this analyser. The tolerances stated must be used and we also recommend that good quality sockets be used for the ICs.

In the input and supply circuits, contained on the same board, there are only a few 1% resistors used. Their values are indicated by four colour rings in place of the usual three. Ideally these should be sorted out and if possible measured with a multimeter before mounting anything on the board. The voltage regulators must be mounted on a heat sink. Switches, LEDs and so on should not be connected until

---

**Parts list, input and supply board**

**Resistors:**
- R1 = 47 k
- R2 = 150 k
- R3 = 3 k
- R4 = 1 k
- R5 = 68 k 1%
- R6 = 2 k 5 1%
- R7 = 6 k 81 1%
- R8 = 2 k 15 1%
- R9 = 68 0 9 1%
- R10 = 316 0 1%
- R11, R20 = 10 M
- R12 = 10 k
- R13 = 180 k
- R14 = 220 k
- R15 = 68 k
- R16 = 22 k
- R17 = 18 k
- R18 = 68 k
- R19 = 1 M
- R21 = 560
- R22 = 1 k
- P1 = 100 k preset
- P2 = 100 k log pot

**Capacitors:**
- C1, C3 = 470 n
- C2 = 10 µ/16 V
- C4 = 4 p7
- C5 = 220 n
- C6 = 47 n
- C7, C8 = 2200 p/25 V
- C9, C10 = 24/16 V
- C11 = 100 n

**Semiconductors:**
- D1 ... D3 = 1N4148
- D4 = LED, red 3 mm
- D5 ... D8 = 1N4001
- D9 = LED, green 3 mm
- T1 = UC 517
- IC1 = TL 084
- IC2 = 7808
- IC3 = 7908

**Miscellaneous:**
- F1 = fuse, 0.5 A, with fuse holder
- Heat sink for IC2 and IC3, e.g. SK 13 (17°C/W — 35 x 17 x 13 mm)
- S1 = single pole toggle switch
- S2 = single pole 6-way wafer switch
- S3 = double pole single throw switch
- Tr1 = mains transformer, 2 x 15 V/1 A with 10 V tapings
Figure 6. The filter board is shown here. Four of these boards in all are needed, three with eight filters and one with six, to make up the thirty filters.

Parts needed for the filters:

| Resistors (all 1%) | | | | | |
|---|---|---|---|---|
| 3 x 887 Ω | 3 x 2k49 | 3 x 4k12 | 6 x 105 k |
| 3 x 1k00 | 3 x 2k55 | 3 x 4k2 | 3 x 107 k |
| 3 x 1k13 | 3 x 2k80 | 3 x 4k7 | 9 x 118 k |
| 3 x 1k27 | 3 x 2k87 | 3 x 5k23 | 3 x 130 k |
| 3 x 1k40 | 3 x 3k16 | 6 x 53k6 | 3 x 133 k |
| 3 x 1k43 | 3 x 3k24 | 6 x 58k0 | 3 x 147 k |
| 3 x 1k58 | 6 x 3k57 | 6 x 60k4 | 6 x 150 k |
| 3 x 1k62 | 3 x 4k02 | 9 x 66k5 | 3 x 165 k |
| 3 x 1k78 | 3 x 2k10 | 6 x 75k0 | 6 x 169 k |
| 3 x 1k82 | 3 x 2k47 | 3 x 76k8 | 6 x 187 k |
| 3 x 2k00 | 3 x 3k24 | 6 x 82k5 | 3 x 210 k |
| 3 x 2k05 | 3 x 3k2 | 3 x 84k5 | 3 x 215 k |
| 3 x 2k21 | 3 x 3k7 | 6 x 93k1 | 6 x 237 k |
| 3 x 2k26 | 3 x 3k83 | 6 x 95k3 | 3 x 267 k |

Capacitors:
- 20 x 220 nMKH 5%
- 30 x 100 n MKH or polystyrene 2.5% or 5%
- 30 x 22 n MKH or polystyrene 2.5% or 5%
- 30 x 10 n polystyrene 2.5%
- 20 x 2n2 polystyrene 2.5%
- 30 x 1 n polystyrene 2.5%
- 24 x 100 n

Semiconductors:
- 19 x TL 084
real-time analyser part 1
elektron march 1984

Table 1
Parts list for the filter boards

<table>
<thead>
<tr>
<th>R1</th>
<th>R2</th>
<th>C1, C2</th>
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<tr>
<td>70</td>
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<tr>
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<td>1.4</td>
<td>100 n</td>
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<tr>
<td>271</td>
<td>936</td>
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<tr>
<td>220</td>
<td>100</td>
<td>1 n</td>
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<tr>
<td>1C2</td>
<td>T1084 T1084</td>
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<td>TL 034, TL 064</td>
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<table>
<thead>
<tr>
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<table>
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<tr>
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<tr>
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<th>R24</th>
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<table>
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<th>C29, C30</th>
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<table>
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<th>R42</th>
<th>R43</th>
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<td>265</td>
<td>142</td>
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<table>
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<tr>
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<th>C44</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 n</td>
<td>1 n</td>
</tr>
</tbody>
</table>

The whole circuit has reached the stage where a case can be selected and a front panel layout made.

The only part of this board that can be tested is the power supply. The values measured for — and + 8 V must not vary by more than 0.5 V from the nominal value.

As we have already stated, the filters are built on four of the boards shown in figure 6. The values of the components used on each board are itemized in table 1. Board no. IV is not completely filled. Instead of our usual parts list, we have simply listed everything here by value and number required. This is particularly handy for sorting out the resistors.

All resistors on the filter boards must be 1% types. The capacitors should ideally all be 2.5% types, but in practice that can cause some problems. Capacitors with this tolerance tend to be quite large, or at least they are for some of the values that we need here. This could make the dimensions of the filter boards excessively big.

To alleviate the problem we came up with this compromise: all capacitors up to and including 10 n are 2.5% poly styrene types; larger values can be 5% MKH or MKM capacitors. In practice the accuracy of these 5% types is usually better than 3%. If the analyser is to be kept as inexpensive as possible, all the filter capacitors could be MK types. The board has been designed to allow for this possibility.

The accuracy of the analyser can still be kept to an optimum if the capacitor values are measured with a capacitance meter and those closest to the desired values are used.

All the resistors and poly styrene capacitors are mounted vertically on the board. The ICs should come from a reliable manufacturer, but here again there is a cheaper alternative. On the two 'lowest' boards LM 334s may be used in place of the TL 084s. As these two ICs are pin compatible this does not cause any problem on this score.

It is a good idea to number the boards I, II, III and IV as they are constructed in order to avoid confusion later.

That is all for this month. Next month you can expect the display board and the base board and then the whole lot will start to look more like a complete analyser.
single chip colour decoder

Following last month's colour encoder, we now offer you a colour decoder based on the Plessey TDA 1365. This is a bipolar integrated circuit intended for use as a complete TV colour signal processor. Designed to decode PAL signals directly, it can be extended to decode SECAM signals with automatic standards switching. Additional information is available from the manufacturers for simplifying the minimum component circuit to demodulate the NTSC standard, adding a simple tint control, incorporating an on-screen display, and an alternative output stage for larger screen televisions which have Teletext or other on-screen display.

The TDA 1365, which is encapsulated in a 28-pin dual in-line, plastic package, contains all the circuitry required for luminance and chrominance signal processing with the facility of DC control of brightness, contrast, and colour, as well as the facility for fast data blanking and colour killer.

Figure 1 shows the internal block diagram and some relevant CRT pictures. Note that these pictures also apply to figure 3.

The application has few external components with minimal external adjustments (see figure 3). The circuit is supplied from a single 12 V supply with a low power dissipation.

The main advantage of using the Plessey TDA 1365 with Teletext is its capability for fast data blanking. This data blanking at pin 2 of the device allows the Teletext 'mix with picture' to be used without the usual flaring of the characters. This is simply achieved by feeding pin 2 with the text information. This will open-circuit the TDA 1365 outputs in the character period so that the character and picture beam currents cannot add together. The flaring effect often seen with other on-screen displays is due to addition of these beam currents which causes incorrect focus of the characters.

Operation

The chroma signal is burst-gated to detect the peak amplitude of the burst. The detected voltage is used...
Figure 2. The component and copper sides of the completed wiring board of the decoder. If Teletext is not required, omit R53 ... R70, C29 ... C36, VR7 ... VR10, T6 ... T12, and D1 ... D4.

as the automatic colour control (ACC) signal which permits the gain of the chroma amplifier on pin 9 to be maintained at optimum value. The gated burst is also taken from pin 15, delayed by an external inductor and fed back into the TDA 1365 on pin 16 to form the input of the subcarrier phase control. The colour burst synchronizes a phase-locked loop to the 4.4336 MHz colour subcarrier frequency providing a reference phase for the demodulation process. The alternating phase of the burst signal is compared with the burstgate pulse: with the line flip-flop, PAL switch, and ident killer, this allows the ident phase to be corrected.

A colour killer threshold voltage of 6.2 V at pin 13 ensures colour kill on a very noisy signal.

The blanking pulse input at pin 2 is used to blank the outputs in the line and frame flyback periods. As this is a fast blank input it can also be used with Teletext for character blanking.

The chroma output at pin 9 is demodulated to the R, G, and B output signals.

To produce the U and V signals an external transistor, T2, is used.
Figure 3. Circuit diagram of the colour decoder with Teletext inputs.

Parts list

If Teletext is not required, omit R53, R70, C29, C36, VR7, VR10, T6, T12, and D1, D4.

Resistors:
- R1 = 22 k
- R2 = 680 k
- R3, R6, R29, R67 = 1 k
- R4, R68 = 680 k
- R5, R70 = 15 k
- R7, R23, R25, R56, R58, R52 = 1 k
- R8, R10, R66 = 8 k
- R9 = 56 k
- R11, R12, R40 = 2 k
- R13 = 820 k
- R14 = 68 k
- R15, R26, R27 = 27 k
- R16, R17 = 47 k
- R18 = 120 k
- R19 = 68 k
- R21 = 220 k

Capacitors:
- C1, C5, C8 = electrolytic 10 μF/16 V
- C2 = 22 p
- C3 = 68 p
- C4, C30, C32, C34 = 180 p
- C7 = 18 μF
- C9, C10, C35 = electrolytic 2 μF
- C9, C20, C22, C38 = 10 n
- C11 = electrolytic 1 μF/16 V
- C12 = electrolytic 470 n
- C13 = 100 p
- C14, C18, C19, C36 = 47 p
- C15, C17 = 22 n
- C16 = electrolytic 4 μF
- C21 = 39 p
- C23 = 100 n
- C24 = electrolytic 22 μF/16 V
- C25 = electrolytic 47 μF/16 V

R22 = 470 k
R24, R30, R31, R32 = 220 k
R26 = 1 k
R33, R34, R35 = 3 k
R36 = 390 k
R37, R38 = 150 k
R39 = 82 k
R41, R45, R49 = 12 k
R42, R46, R50 = 47 k
R43, R51, R69 = 1 k
R44, R52, R60 = 270 k
R47 = 330 k
R48, R57, R59, R65 = 4 k
R53 = 50 k
R54, R63 = 180 k
R55, R61, R64 = 10 k
R70 = 33 k
VR1 = 2 k
VR2, VR10 = 4 k
VR3, VR5 = 100 k
VR4, VR6, VR11, VR12, VR13 = 10
VR7 = 470 k
VR8, VR9 = 470 k

Capacitors:
- C26, C27, C28 = 680 p
- C29, C31, C33 = 330 p
- C37 = 100 n

Inductors:
- L1 ... L4 = see figure 3
- L5 = 33 μH

Semiconductors:
- T1 = BC 237
- T2 = BC 337
- T3, T4, T5 = BF 258
- T6 ... T11 = 2N3904
- T12 = 2N3906
- D1 ... D4 = 1N4001

Miscellaneous:
- XT1 = 4,43 MHz
- Luma delay line = Valvo 817 V5400/1
- Chroma delay line = Mullard DL700 S8451
- Colour decoder IC = Plessey TDA 1355
to drive a PAL delay line of 64 µs. The delayed line (line N-1) is added to, and subtracted from, line N to produce 2 V and 2 U signals. These signals are fed to pins 24 and 25 which are the inputs to the R-Y and B-Y demodulators respectively. The G-Y signal is produced internally by adding together proportions of the R-Y and B-Y signals. The luma signal at pin 5 is fed through the contrast control and then black-level-clamped to provide a brightness control. This luma signal 'Y' is then added to the R-Y, B-Y, and G-Y signals to produce the R, B, and G outputs at pins 26, 27, and 28 respectively. The colour outputs are then amplified to over 80 V by three single common-emitter amplifiers, T3 ... T5, and then fed to the TV tube to produce a clear colour picture.

Pins 4, 7, and 8 provide controls for brightness, contrast, and colour respectively. They require only a small d.c. voltage (divided down from the user control pots) to provide a wide control range.

**Alignment**

**Colour circuit.**
- Set VR1 ... VR13 to centre of range.
- Connect blanking and burst gate pulses.
- Apply a 2 Vpp composite video signal (negative-going sync pulses) to the video input.
- Adjust the chroma band-pass coil for maximum chrominance on pin 11. The burst amplitude at this point should be 150 mVpp.
- Adjust the chroma trap coil for minimum chrominance on luminance at pin 5. The luma amplitude at this point should be 800 mVpp.
- Short out R20 and connect a 470 n capacitor from pin 16 to earth. Adjust the APC control, VR2, for 4.43 MHz at pin 20. Remove capacitor from pin 16.
- With the contrast and saturation at maximum, apply a 2 Vpp chroma subcarrier to the input of the circuit, and adjust L3 for maximum subcarrier at pin 25.
- With two x10 probes on pins 24 and 25, adjust VR1 for maximum on pin 25 and minimum on pin 24. The amplitude at pin 25 should be 200 mV.

**Output stage.**
- Adjust L4 for further minimum at pin 26.
- Remove short-circuit from R20 and re-apply composite video signal to input.

**Teletext set-up.**
- Select Teletext clock cracker page.
- Adjust VR10 until tinted text appears.
- Adjust VR8 and VR9 until all tint is removed from text.
- Adjust VR10 for optimum character brightness. Note, however, that if character brightness is set too high, flyback lines will be seen on picture.
- Adjust VR7 for optimum reduction in contrast when the set is switched from TV to mixed picture.
The accurate measurement of a tape run requires monitoring the length of tape that passes a point in a given period. The only realistic method is counting the revolutions of a free-running idler wheel in the tape path. Several designs have been published for digital tape counters which display true elapsed time, but to the best of our knowledge all have the serious disadvantage of requiring a very-high-tolerance pulley. In the present design this is not required, because any size pulley can be electronically 'tailored' to work accurately: the deviation can be kept to within half a second per hour.

The modest role of the tape counter sometimes creates the impression that it is a superfluous device. This is, of course, not so because it is virtually impossible to find a particular passage on the tape without the counter. Determining the duration of a recording, or how much tape is left on the spool, cannot, however, be done accurately with the usual tape counter. This is because the counter is usually belt-driven by one of the spools (normally the left-hand one) to count the revolutions. Unfortunately, the number of revolutions is not only dependent on the tape-speed, but also on the spool diameter and how much tape is left on the spool. The less tape is left, the faster the counter will run. A counter which indicates, in real time, how much tape has passed is, of course, much more useful. Regrettably, the amateur recorder fitted with such a counter has, to the best of our knowledge, yet to be made. Fortunately, this is a deficiency which can be cured easily with a soldering iron, some electronic equipment and components, and a little mechanical dexterity.

There are two ways to realize a real-time counter. Firstly, you could measure the speed of the two tape spools and then calculate the real-time lapse. This method does not, however, get rid of the dependence on the inner-spool diameter and the amount of tape left on the spool. Moreover, errors may be caused by slip if there is slack in the tape. The second, and much more suitable method is the use of a free-running idler wheel in the tape path. The number of revolutions of this wheel tells you exactly how much tape has passed. A look at the selected tape speed and the calculation of lapsed time becomes child's play. Unfortunately, the idler wheel used in the
second method has to be machined to very high tolerances because the error in indicated time is directly proportional to these tolerances. For instance, for an error of not greater than one second per hour, the diameter of the idler wheel must be within 0.03 per cent. Clearly an impossible task, even if you have a lathe.

The present design also uses an idler wheel (pulley) but with the facility of an electronic correction factor. The requirements of the idler wheel are therefore far less stringent and, moreover, deviations in tape speed can be compensated.

Before we get involved in the intricacies of the circuit, here is a summary of the characteristics of the timer:

- dimensions and tolerances of the tape pulley are (relatively) immaterial;
- no modifications to the tape machine required;
- automatic up/down counting with reference to tape movement direction;
- automatic count reversing below zero, that is, 3, 2, 1, 0, -1, -2, -3, and so on;
- accuracy greater than 0.5 second/hour;
- apart from the tape pulley, inexpensive, readily available components are used.

The basic set-up
The pulley, which is driven by the tape, is mechanically coupled to an aluminium or plastic disc with segments cut out as required (see figure 1). More segments than shown may be used, and this will make the correcting more accurate. It is, however, recommended that not more than 3 or 6 be used to ensure satisfactory switching at high speed. Two opto-couplers are used to determine the direction of rotation and the speed of the disc. An adjustable divider divides the incoming pulses so that the pulse rate (pulse repetition frequency) at its output is 1 Hz (tape machine in position “playback”). The divider is followed by another (+2) which is coupled to the tape speed selector.

The pulse repetition frequency (p.r.f.) at the output of the adjustable divider will never be precisely 1 Hz. Deviations are caused by tolerances in the dimensions of the pulley and small variations in the tape speed. The diameter of the pulley should therefore be chosen to give a p.r.f. of just above 1 Hz. An adjustable correction circuit ensures that after a certain number of pulses one pulse will be suppressed. This arrangement enables the timer to be set with very high accuracy.

The 1-second pulses are fed to an up/down counter which in its turn drives a BCD-to-7-segment decoder.

The circuit
Apart from a handful of discrete components, the circuit comprises eighteen CMOS-ICs, which are all readily available and not expensive (see figure 2).
The signals from the photo transistors in the opto-couplers are first 'embellished' in Schmitt triggers, N1 and N2. A D-type flip-flop, FF1, detects the direction of rotation of the pulley: its output, Q, is logic high when the tape runs forward. The pulses from N2 are also fed to a decade counter, IC5, which is here used as an adjustable n-divider. The value of n is dependent on the diameter of the pulley and the number of pulses per revolution of the disc. To allow for the two tape speeds of 19 and 9.5 cm (4.75 cm is rarely used nowadays), a divide-by-two stage is connected between points 1 and 2 (see figure 3). At the lower tape speed,
P becomes logic high which disables the by-two divider. When the higher speed is selected, P goes low, and the divider negates the doubling of the p.r.f. by the disc.

A 12-stage binary counter, IC6, forms the correction circuit mentioned earlier. It is clocked by the pulses from the disc and ensures, in conjunction with gates N13...N16, that after X number of pulses ($X \leq 4096$) one pulse is suppressed. This is done to ensure that the average pulse rate of the signal fed to the up/down counters is exactly 1 Hz. The suppressing of the single pulse is effected by the CE input (pin 13) of IC5. At a given instant IC6 will have counted to X. The Q outputs relevant to X are then logic high and consequently pin 13 of N13 will also be high. The flip-flop consisting of N13 and N14 is set and the output of N14 (pin 10) also goes high. Counter IC6 is then reset for the next cycle and the flip-flop formed by N15 and N16 is set. The output of N16, pin 3, becomes logic 1 and suppresses the next clock pulse emanating from the disc and intended to be fed to IC5. This clock pulse will none the less reset the flip-flop formed by N13 and N14. When the clock pulse decays, output QO of IC6 goes high and flip-flop N15/N16 is reset which completes this cycle of events.

The 1 Hz pulses are fed to cascade counters IC10...IC13. The most noteworthy feature of this chain is the preset facility of IC11. This stage counts the tens of seconds and is therefore arranged to ensure that a 5 is followed by a 0, not by a 6 (count-up mode), and that a 'carry out' is generated for the minutes counter. The same is done in the count-down mode: a 0 is then followed by a 5, not by a 9.

The counters drive the BCD-to-7-segment decoders, IC15...IC18, directly. The latch inputs of these decoders are used to realize a hold function. When one of the hold keys is pressed, the counters continue counting, but the displayed value is held.

The shaping of the UP/DOWN signal is effected by IC2...IC4. Whether this signal is high or low depends on the direction of rotation of the pulley (translated into a signal on pin 2 of FF1) and whether 00:00 has been passed. The latter is communicated via the clock input (pin 11) of FF2. When the counter goes through zero in the count-down mode, the output of IC2b (pin 12) goes high. This results in the counters being reversed via IC4 to the count up mode (U/D goes high) and an indication being given via N17...N20 that counting below 0 is taking place. This minus indication is effected by two alternately flashing LEDs (see figure 2) to avoid the necessity of using a fifth 7-segment display of which only the 'g' segment would be utilized. Two other arrangements for the minus indication are shown in figure 4: a directly driven, and therefore constantly lit, LED, and a single flashing LED. Take your pick!

Construction

To allow for the great variety of machines into which the timer may be fitted, we decided against producing a printed-circuit board. If you use vero or similar board, you need about 4 cm² if the ICs are fitted close together.

Connections are simply made with enamelled copper wire, but of the Q outputs of IC5 and IC6 only QO and Q2 of the former and 01 of the latter should be connected at this stage.

As mentioned earlier, the diameter of the pulley is not critical which means it may be possible for you to acquire a suitable pulley and bearing assembly from a discarded machine. Alternatively, you may find it necessary to either make a pulley yourself, or to get a machine-shop to turn one to order. The avoidance of high tolerances should make the latter a lot easier and cheaper. The pulley should have a diameter of not less than 13 mm.
Figure 5. The separate mains power supply (a). The counter indication may be retained by a battery back-up of dry cells (b) or NiCd cells (c).

This will help to improve tape contact and will achieve better matching to the parameters of this design. The use of a ball-bearing is strongly recommended to keep friction to an absolute minimum. The risk of slippage of the tape against the pulley is reduced by laying a rubber band over the pulley to aid grip (see figure 6). The pulley itself should be made of a non-ferrous metal, preferably aluminium, which will keep the moment of inertia small and this also aids prevention of slippage.

As regards the diameter of the pulley, consider the following example. Assume that the tape speed is 9.5 cm/s and that the disc generates two pulses per revolution. If the diameter of the pulley is 15 mm (circumference = \( \pi d = 47.12 \text{ mm} \)), the pulley will make 2.016 rev/s. As two pulses are generated per revolution, the pulse rate is 4.03 Hz or just above 4. The \( n \)-divider (IC5) should therefore be a \( \frac{1}{4} \) divider (see figure 7) which is effected by connecting its Q4 output (pin 10) to its reset input (pin 15). As IC5 is a decade counter (that is, it has ten decoded outputs Q0 ... Q9), \( n \) can be chosen anywhere between 1 and 10. However, to ensure reliable operation of the circuit, \( n \) should be at least 2. Furthermore, to be able to choose a precise correction factor, it is necessary to arrange for the disc to give a small fraction more than a whole number of pulses per second.

The values of resistors R1 and R2 have to be determined empirically; the voltage jump at the collector of the phototransistor should be as large as possible. The phototransistors, as is usual in this type of application, are positioned 90° out of phase with one another. This means that when one is just crossing from light to dark, the other is in the centre of a (light or dark) field.

The only electrical connection with the tape machine is point P (logic high at 9.5 cm/s and low at 19 cm/s). Perhaps the tape speed selector switch has a free contact? If the speed is selected mechanically, it may be possible to place a micro-switch somewhere along the mechanism.

The current consumption of the circuit is 260 mA, which is rather too much to tap from an existing supply. A circuit for a suitable mains supply is therefore given in figure 5a. If required, this may be supplemented with a dry-cell battery back-up (5b) or a NiCd battery back-up (5c). When the mains is switched off, all LEDs are off, but the remainder of the circuit remains operative so that the counter position is retained. The current consumption is then a mere 0.6 mA.
Alignment and operation

In the first instance, only output Q1 of IC6 is connected (to pin 1 of N16); all other outputs, Q0 and Q2...Q11, should be left free. Connect pin 13 of N13 temporarily to earth. In this way the CE input of IC5 is logic low.

Now run a tape for exactly one hour. On weekdays, readers in the U.K. may conveniently record BBC Radio 4 Long Wave from the 1 p.m. G.T.S. immediately preceding 'The World at One' to the 2 p.m. G.T.S. after the shipping forecast (note that the 2 p.m. G.T.S. is not given on VHF). For overseas readers, the World Service of the BBC broadcasts a G.T.S. before each news bulletin on the hour, most hours round the clock. There are only four times when this does not happen: see your local 'London Calling' for details and frequencies.

If everything has gone all right, the timer will indicate a little more than 60 minutes. If we again assume a pulley with diameter of 15 mm, and a tape speed of 9.5 cm/s, the disc will have made 7287.5 revolutions in the hour, resulting in 14,515 pulses. This number was quartered by IC5 so that the counters were fed with 3629 pulses. This will result in a reading of 59:29, in other words, 29 seconds too long. To compensate for these 29 seconds, IC6 has to be set for the correct (= earlier mentioned 'X') number of pulses, after which one pulse is suppressed. From the above, X = 3629/29 = 125 which is equivalent to the binary number 1111101. Starting with Q0, connect as many 0 outputs of IC6 as there are '1's in this binary number (in this example: six) to pin 13 of N13 via a diode (see figure 7b) after the temporary earth on this pin has been removed. Ignore the binary zeros! When IC6 has counted to the set number, all connected Q outputs will be high so that pin 13 of N13 is also high. This results in a disable of the next clock pulse to IC5. As this happens after every 125 pulses, the counters will register exactly 3600 after one hour resulting in a display of 60:00 — real time indeed!

The larger X, the more accurately the timer can be set. If X tends to be small, the diameter of the pulley should be made slightly smaller.

As IC5 is only capable of counting up, errors will be introduced if the tape is continually wound backwards and forwards, as during editing. This might have been prevented by using an up/down counter in place of the 4017, but this was considered unnecessary because the read-out will drift anyway during the editing process. This happens even on professional studio machines, requiring the tape to be retimed from the beginning after a lot of editing.
New portable digital thermometer

A new portable digital thermometer has been launched in the UK for only £55.00 by Portec Instrumentation, Luton, Bedfordshire. Designated the PI-8208, the new instrument provides 1°C resolution and 0.4% accuracy throughout its -30°C to +750°C measurement range and carries a two-year guarantee.

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Portec Instrumentation Limited,
3-5 George Street West,
Luton,
Bedfordshire.

Telephone: 0582.32613

(2731 M)

Calculator-style DMM

The first new Simpson calculator-style digital multimeter is now available in the U.K. from Bach-Simpson (UK) Limited.

Features of the 470 include: - Twenty five ranges including 1000 volts DC, 750 volts AC and 10 amps AC/DC and all voltage and resistance ranges being protected against transients up to 6 kV at 100 microseconds. Convenient recessed ‘human-engineered’ thumbwheel knobs control ranges and functions. An audible tone feature on the 2000 ohm range provides fast checks for shorts and continuity. A diode test provides quick, good-bad checks of semiconductor junctions. The easy-to-read, high-contrast, 3-1/2 digit, 7 segment LCD display also features a ‘low battery’ indicator - battery life being a year with average use. The high-impact, sealed case is 1.8 x 3.4 x 7.1” and a two-way fold-out stand provides for convenient benchtop use or for hanging in an upright position. Total weight is less than 1 lb.

The 470 is supplied complete with UL-recognised, colour-coded test leads with screw-on crocodile clips, 9 V battery and instruction manual. Optional accessories include a Simpson Amp-Clamp AC current adapter, as well as temperature, RF and high voltage probes, and Simpson universal test lead system.

Bach-Simpson (UK) Limited,
Tranent Estate,
Wadsbridge,
Cornwall PL27 6HD,
Telephone: 020-881.2031

(2733 M)

Desk top XY recorder

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Environmental Equipment (Northern) Limited,
Envirion House,
Welsh Row,
Nantwich,
Cheshire, CW5 5ES,
Telephone: 0270.625115

(2745 M)

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Charles Square,
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(2732 M)
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