ELECTRONICS
The Maplin Magazine

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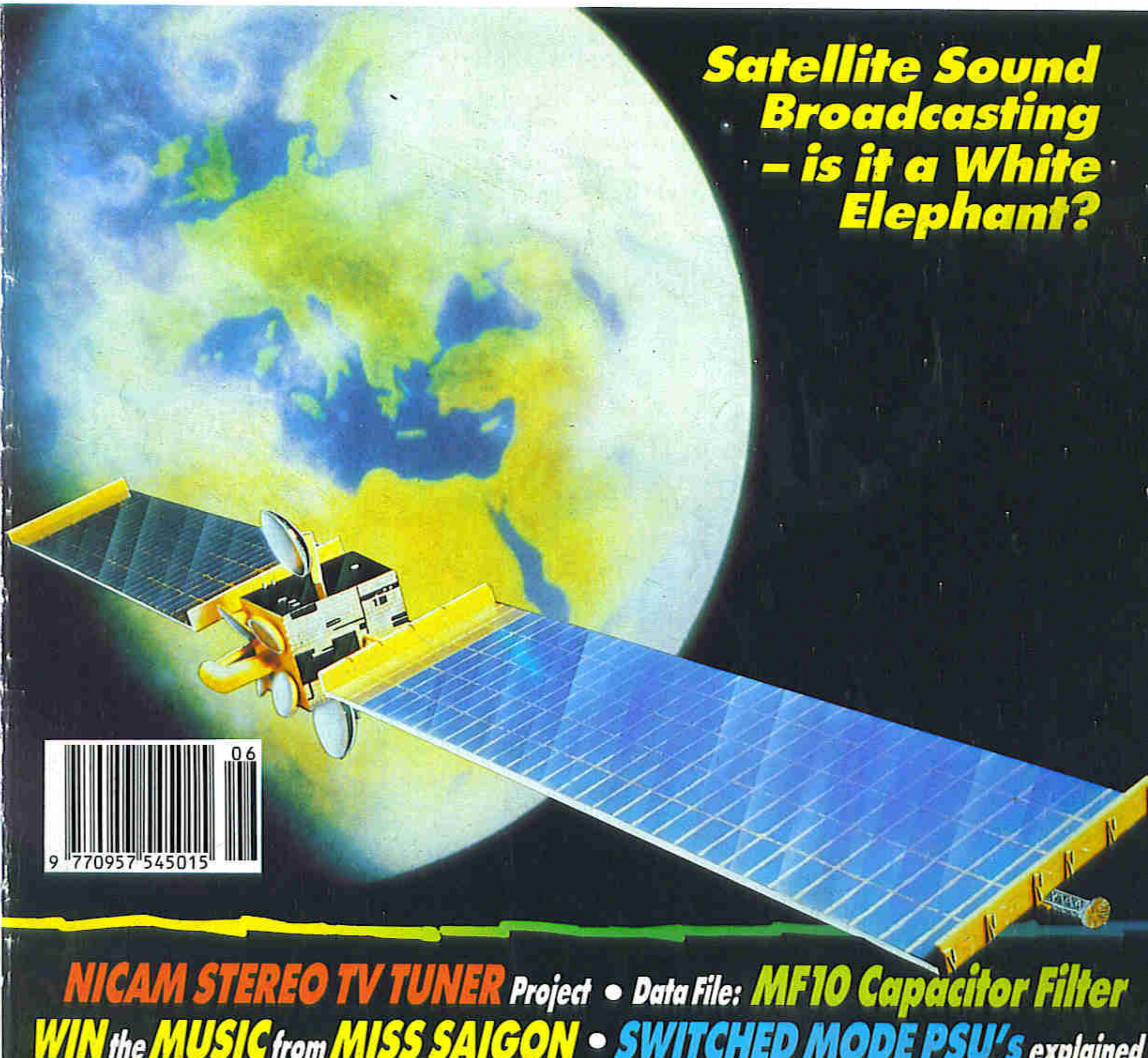
Satellite Sound Broadcasting – is it a White Elephant?



NICAM STEREO TV TUNER Project • Data File: **MF10 Capacitor Filter**

WIN the **MUSIC** from **MISS SAIGON** • **SWITCHED MODE PSU's** explained

Build a **SYNTOM Drum Synthesiser,** an **AUDIO SWITCH** and a **TIMER!**

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JUNE TO JULY 1990 VOL.9 No.38

EDITORIAL

In this issue of 'Electronics – The Maplin Magazine' there's a broad spectrum of projects and features for you to read and digest. Starting this issue is a two-part project; a stand alone NICAM Stereo TV Tuner Unit. There's a feature article on direct radio broadcasting via satellite; what will the future hold for the world of radio? Two handy little projects are the Audio Controlled Switch and the 1/300 Timer, which can be used separately or together. Our series on Switched Mode Power Conversion continues to reveal more secrets of this taboo area of electronics. This issue's Data File deals with the versatile MF10 Switched Capacitor Filter IC. Our ever-on-the-move roving reporter visits the new London stage show 'Miss Saigon', there's also a competition to win . . . well read the article and you'll find out! A popular project over the years has been the Syntom, it was first published way back in 1981 and since then there have been a few improvements, so here it is again in a new guise. Computers in the Real World looks at man/machine interfaces. Square One, our beginners series, continues by dealing with current, series and parallel circuits, attenuators and amplifiers. Of course there are all the usual regulars and also details of catalogue price changes. So now you know what's in store why not read on and enjoy!

R.T. Smith

Editor Roy Smith **Technical Editors** Dave Goodman, Chris Barlow, Gavin Cheeseman, Tony Bricknell, Allan Williamson.
Technical Author Robert Ball.
Consultant Author Alan Simpson.
Technical Artists John Dudley, Lesley Foster, Paul Evans, Ross Nisbet.
Art Directors Peter Blackmore, Jim Bowler.
Art Assistants Eugene Francis, Phillip Fey, Mick McGurk.
Print Co-ordinators Brian Lauezzari, Martin Needs, Ken Wakefield, Paul Owen.
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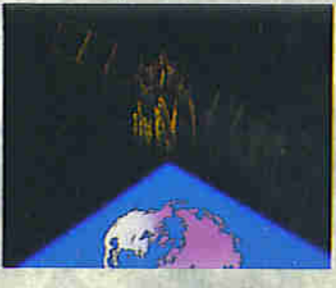

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REGULARS

CORRIGENDA

In the text accompanying the NICAM Television Tuner Project published in February – March '90 Issue No. 36, a test voltage was printed incorrectly. Page 39, right-hand column: IC1 pin 11 1.5V, this is incorrect and should read IC1 pin 11 11.5V.

Square One

A First Course in the Theory and Practice of Electronics

Part 2 by Graham Dixey C.Eng., M.I.E.E.

Electric Current

The prevailing concept of an electric current is that it is the flow of minute electrical particles called 'electrons'. These are assumed to have a 'negative charge' which, in practical terms, means that they will be attracted to 'positive charges'. This is based on the law that states that, 'opposite signs attract, like signs repel'. These ideas may be remembered from school science lessons and apply to what is called static electricity; they may also be applied to magnetism if we replace the positive and negative charges with North and South poles, respectively. Thus, in a circuit such as that of Figure 1(a), the flow of current is from the *negative* terminal of the battery round the circuit through the resistor towards the battery's *positive* terminal.

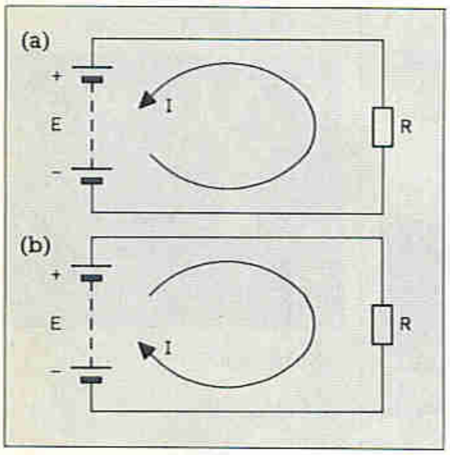


Figure 1. (a) Electron flow of current and (b) conventional current flow.

However, the Victorians, for whom electricity was becoming an increasingly practical reality, didn't appreciate the existence of the electron and assumed that current flowed from the positive terminal of a supply around to its negative terminal – Figure 1(b). This is called the 'conventional' direction of current, an idea that is still frequently used when describing how a circuit works. It doesn't actually matter that much which direction is assumed for current flow, though it can sometimes be awkward to describe the operation of semiconductor devices if the conventional flow is assumed.

Series and Parallel Circuits

Virtually any circuit diagram for a piece of equipment, no matter how simple or how complex, can be resolved into combinations of passive components, which are connected in series or in parallel, with or without the addition of active devices – transistors or IC's.

Figure 2 illustrates several important ideas. For a start, (a) is an example of what is called a 'series' circuit, (b) is a parallel circuit, while (c) is a series-parallel circuit, so called for obvious reasons.

Taking Figure 2(a) first, the statement that, 'the same current flows in all parts of the circuit', should be considered as reasonable. It would be difficult to explain anything else! Thus, the current I that leaves the positive battery terminal (notice the use of the old conventional direction) flows through R1, then through R2, and finally through R3 before re-entering the battery at its negative terminal. The value of this current depends upon the total resistance of the circuit. In a series circuit this is easy to calculate, since it is just the arithmetic sum of all the separate resistance values.

Therefore, 'total resistance' $R_T = R1 + R2 + R3$.
In the circuit shown, this equals
$5 + 15 + 10, = 30\Omega$.
The current in the circuit can be found using Ohm's law (explained in Part One).

Therefore, current I = voltage of battery/total resistance,
$= 15/30$,
$= 0.5A$.

Now Figure 2(b) can be considered. In this case the source of voltage E, known as the 'electromotive force' or EMF for short, is applied across three resistors in parallel. In this case, the voltage across each resistor is obviously identical but the total current I splits into three separate currents, I_1, I_2 and I_3, which each pass through one of the resistors, R1, R2 and R3 respectively, and then combine again at the other end of the parallel arrangement to become the total current I once more. It is quite easy to calculate each of these currents by using Ohm's law again.

The current $I_1 = E/R1$;
which equals $15/5 = 3A$.
The current $I_2 = E/R2$;
which equals $15/15 = 1A$.
The current $I_3 = E/R3$;
which equals $15/10 = 1.5A$.
The total current I obviously equals
$I_1 + I_2 + I_3$,
$= 3 + 1 + 1.5$,
$= 5.5A$.

Unlike the series circuit, the total resistance of the three parallel branches is not given by a simple sum of the resistors, but by a formula that involves their 'reciprocals' (the reciprocal of a number is 'ONE divided by that number'; e.g.

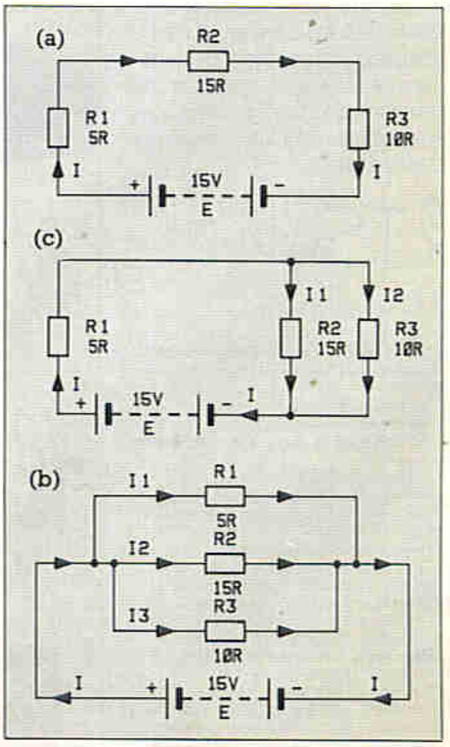


Figure 2. (a) A series circuit (b) a parallel circuit and (c) a series/parallel circuit.

reciprocal of 5 is 1/5 = 0.2). This formula is as follows:

$1/R_T = 1/R_1 + 1/R_2 + 1/R_3 + \ldots\ldots\ldots$ for any number of resistors.

For the above circuit $1/R_T = 1/5 + 1/15 + 1/10$,
$= 0.2 + 0.0667 + 0.1$,
$= 0.3667$.

Therefore, $R_T = 1/0.3667$,
$= 2.73\Omega$ (approx).

This result can now be double-checked because, if the voltage E is divided by the current I, it ought to give the same result. That is, $15V/5.5A = 2.73\Omega$, which a calculator confirms as being true.

There is a useful simplification of the above formula for the total resistance of resistors in parallel, that can be used when there are only two resistors, say R1 and R2. The simplified expression is:

Total resistance $R_T = (R1 \times R2)/(R1 + R2)$.

This form of the expression avoids the need to take reciprocals.

Figure 2(c) combines the ideas of both the previous circuit types. The total resistance of the circuit consists of the value of the series resistor R1 added to the total resistance of R2 and R3 in parallel. It ought by now to be obvious that this total circuit resistance is given by:

$R_T = R1 + (R2 \times R3)/(R2 + R3)$,
$= 5 + (15 \times 10)/(15 + 10)$,
$= 5 + 150/25$,
$= 5 + 6$,
$= 11\Omega$.

The total current in the circuit = Total voltage/total resistance,
$= 15V/11\Omega$,
$= 1.364$ A.

The voltage across $R1 = I \times R1$,
$= 1.364 \times 5$,
$= 6.82V$.

The voltage across R2 & R3 = $I \times (R2 \times R3)/(R2 + R3)$ [as above],
$= 1.364 \times 6$,
$= 8.18V$.

It should be noted that the sum of these two voltages, 6.82 + 8.18 is equal to the applied voltage, namely 15V. This should be expected; it is entirely logical and follows Kirchhoff's Second Law (see Part One).

From this it follows that it wasn't really necessary to 'calculate' the voltage across the parallel resistors. All that had to be done was to subtract the voltage across R1 (6.82V) from the applied voltage E (15V) in order to obtain the required value (8.18V).

The above basic network theory is of the utmost importance since, although relatively easy to apply, it can reveal important aspects of circuit behaviour as well as being useful as a tool in the design of various electronic circuits. Time and again when it is necessary to estimate the likely voltage or current in a circuit under normal operating conditions (for example, so as to be able to compare it with the value found under fault conditions), the only analytical methods used will be along the lines employed above.


The 'table top' stereo system being tested; it works!

For comparison, the corresponding formulae for series and parallel combinations of capacitors and inductors are shown in Figure 3. No further reference will be made to these at the moment, though they will be used as we progress further.

Amplification and Attenuation of Signals

Amplification (also known as gain) is the process of increasing the amplitude of a signal. The need for it is readily understood by considering a commonplace example. See Figure 4, which shows the block schematic diagram for a hi-fi amplifier with a magnetic pick-up input.

The signal generated by the magnetic (moving coil) pick-up is likely to be about 1 – 2mV only. At the other end of the chain, the level of signal required to drive the loudspeakers to reasonable volume is of the order of volts. Roughly 9V RMS is required to produce a power output of 10W into an 8Ω speaker. The signal level must, therefore, be raised by between 4500 and 9000 times. Where do these figures come from?

If the pick-up produces 1mV of signal, the amplification needed is going to be 9V/1mV, i.e. 9/0.001 = 9000 (since 1mV = 0.001V). If the pick-up develops 2mV of signal, the amplification required instead is going to be 9/0.002 = 4500 times. Hence, the figures quoted above.

This leads to a formal definition of

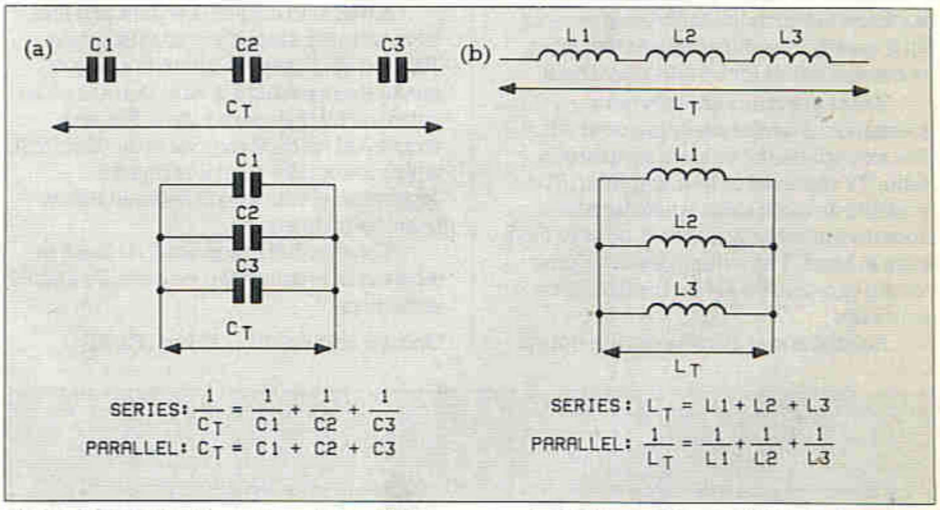


Figure 3. Formulae for series and parallel arrangements of (a) capacitors and (b) inductors.

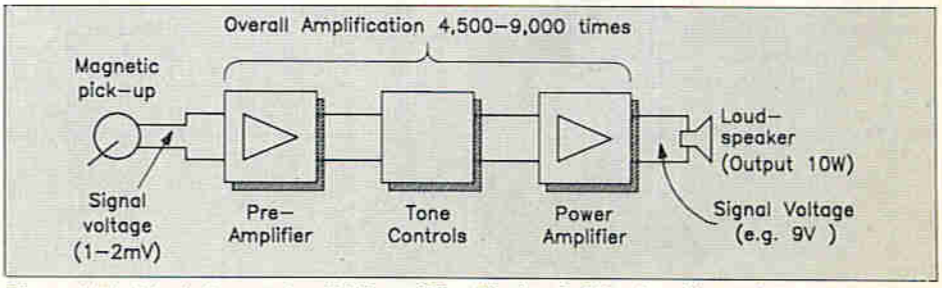


Figure 4. The block diagram for a hi-fi amplifier. The level of the signal is small at the pick-up and must be amplified before being used to drive the loudspeaker.

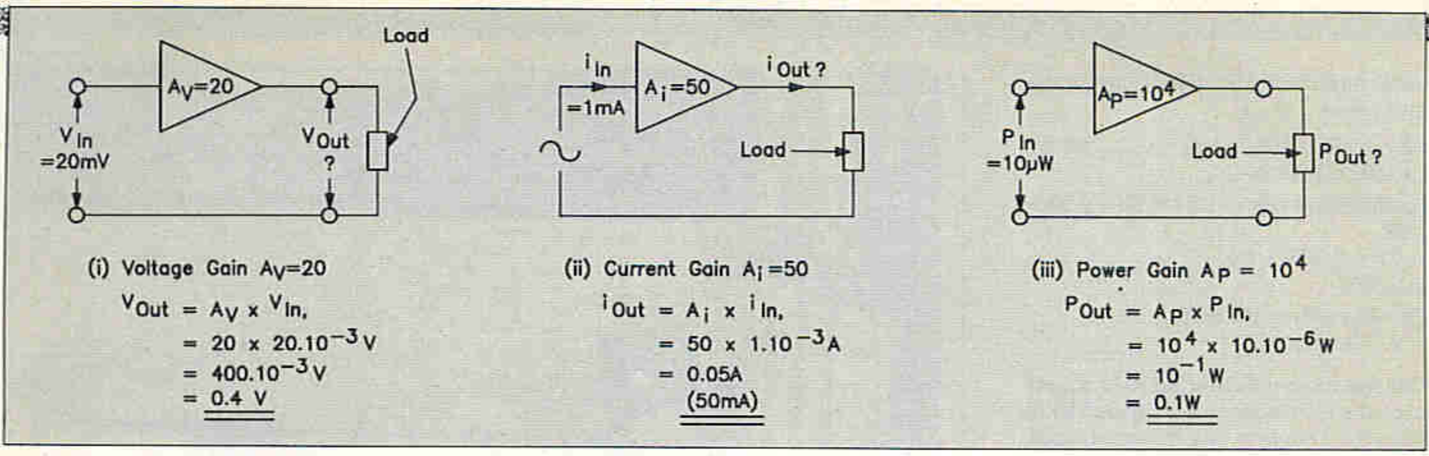


Figure 5. Three examples to illustrate the idea of amplification.

amplification:

Amplification (symbol A or G) = output/input.

It is important that both input and output are expressed in the same units e.g. both in volts, both in amps, both in millivolts, etc. Because it is just a ratio, amplification has no units. While it is possible to have devices in which the input is a voltage and the output is a current, these should be considered as special cases, outside the present discussion.

Figure 5 shows three examples to illustrate the idea of gain further. The symbol used in these examples is the general one for an amplifier.

Attenuation is complementary to amplification; another term is 'loss', so this obviously implies a reduction in the size of the signal. It is a result that may be associated with some other process, the signal loss that results being undesirable but unavoidable. Taking the case of the hi-fi amplifier of Figure 4 once more, the block marked 'Tone Controls' is usually considered essential to tailoring the response to suit individual requirements, but it usually introduces losses that must be compensated for by additional gain.

There are many cases where attenuation is deliberately introduced. One example is the volume control of a radio, TV receiver or hi-fi amplifier. The available amplification is usually a lot more than is actually needed, so as to have some in hand. The setting of the volume control can then be set for the listener's own taste.

Attenuation is also the ratio of output to input, both being in the same units. Again it has no units. If attenuation is expressed in this way, the result will be a fraction.

For example, if the input to an attenuator was 2.5V and the output was 0.5V, the ratio would be 0.5/2.5 = 0.2.

An alternative, and perhaps more meaningful, way of expressing attenuation is by reversing the process and putting input over output. In the case just quoted, this would give the result, 2.5/0.5 = 5, which would be written as 5:1.

The simplest type of attenuator is shown in Figure 6(a). It consists of just two resistors and is known as a potential divider. The loss is given by the ratio R2/(R1 + R2). The potentiometer of Figure 6(b) is nothing more than a continuously variable version of the potential divider, where the sections of track on either side of the wiper position correspond to R1 and R2.

The Decibel (dB)

It was said earlier that gain and loss have no units, since they are just ratios. This is true. However, there is a way of giving them particular units that are often more useful than pure ratios. The unit employed for this purpose is the 'decibel', which is actually what is termed a 'logarithmic' unit, as will be seen below from the formulae.

The decibel is correctly defined in terms of the ratio of two powers, P1 and P2, as follows:

Gain (or loss) in dB = 10log (P2/P1).

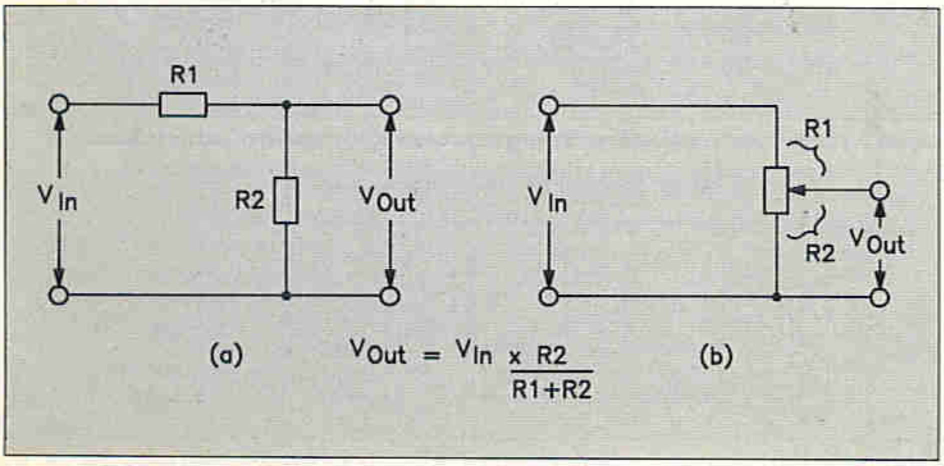


Figure 6. (a) A potential divider (b) a potentiometer.

For example, if the input power P1 to a device was 10mW and the output power P2 from the device was 1W, then:

Gain = 10log (1/0.01),
[since 10mW = 0.01W]
= 10log 100,
= 20dB.

With the ready availability of inexpensive scientific calculators, the working out of problems with logarithms in them is quite easy. Just divide P2 by P1 first; then use the 'log' key (not $\log_e$ or ln) on this result and multiply the result obtained by 10. The answer is in decibels.

The decibel can also be used to express the ratio of two voltages or currents, as follows:

Gain or loss in dB = 20log (V2/V1) for voltages;
or 20log (I2/I1) for currents.

It should be noted that the coefficient of the expression is now 20.

Strictly speaking, the above expressions for voltages or currents are only correct if the two quantities, input and output, are measured at points where the resistance is identical. This isn't always true. The resistance at the input of an amplifier (usually referred to as its input impedance) may well be quite different from the resistance at the output of the amplifier (the load impedance). However, the decibel has been found to be so convenient for expressing gains and losses that such restrictions are simply ignored. What really matters in the end is understanding what is implied by values expressed in this way. Some common ratios for power and voltage (or current) and the corresponding decibel values are as follows:

Ratio	No. of dB (power)	No. of dB (voltage or current)
2	3	6
10	10	20
100	20	40
1000	30	60
10,000	40	80

It is worth noting that the number of decibels required to express a particular ratio of voltages or currents is twice that for the same ratio of two powers. This has confused people in the past into believing that there are two different types of dB – one for power and another for voltage. There aren't! To take an example, 20dB is

20dB whether referring to voltage or power. What *is* different is the *numerical ratio* that these numbers of decibels represent, being 100 for power and only 10 for voltage, which arises from the fact that power is proportional to the *square* of voltage ($10^2 = 100$).

Gains and Losses in Series

Figure 7 is included to show how useful the decibel is for calculating the overall gain or loss of a series connected system. If ratios are used, a chain of multiplications is involved; using decibels it comes down to simple addition and subtraction.

The Decibel (dB) and the dBm

The decibel is not absolute in expressing magnitude. It is perfectly alright to say that an amplifier has a gain of, say, 40dB – this merely means that the voltage gain is 100 and the power gain 10,000. But it is nonsense to say that the 'output' of the amplifier is 40dB; the output can only be expressed in absolute units, such as volts, amps or watts, while the decibel is merely a relative unit, relating one level to another. It is usual to talk about a level as being 'so many dB above or below' another level (in popular jargon, 'so many dB up or down'). For example if the actual output of an amplifier is 10W, the decibel could be introduced by comparing this level to some agreed reference, such as 1mW. Thus, it becomes possible to say that 10W is '40dB up on 1mW' since 10W/1mW = 10,000 which, as has been seen, corresponds to 40dB. In telecommunications it is standard practice to refer power levels to 1mW and to use the unit dBm, which is a shorthand way of writing 'the power level in dB relative to the reference level of 1mW'. So, finally, the problem of the amplifier output is solved by saying, not that the output is 40dB (which is now known to be nonsense), but that it is +40dBm (which is correct!).

Amplifying Devices

Apart from thermionic valves, which have only very specialised uses nowadays, the active device used for amplifying signals will usually be either some form of transistor or an integrated circuit (IC or 'chip'). Transistors may either be of the 'bipolar' type (known as Bipolar Junction Transistors or BJT's) or of the 'unipolar' type (known as Field Effect Transistors or FET's). The term 'unipolar' is rarely used, so will now be dropped and FET used instead. These two types sub-divide into further classifications. In this article the BJT will be explained as far as is necessary to understand its use in circuits that follow later.

The Bipolar Transistor or BJT

BJT's fall into two types, known as PNP and NPN; the latter is the more numerous type these days, though it wasn't always so. The semiconductor material now used almost exclusively is Silicon (Si), although it is still possible to buy Germanium devices (Ge). The symbols for the two transistor types are shown in Figure 8.

The meanings of the letters 'N' and the 'P' in the terms NPN and PNP tend to be a little obscure without diving into specific details of semiconductor physics and device manufacture, a move that would be neither popular nor wise. There are numerous text books that cover the topic more formally. It isn't at all vital to understand such physics in order to be able to apply or appreciate the usefulness of these devices. Little more is needed than a working knowledge of the voltage and current relations, as is given below, and much can be done and understood with this alone. All that will be said here about the subject is that these letters refer to pure silicon (or germanium) semiconductor material that has been 'doped' to give it particular properties. The transistor is then formed of a sandwich of alternate N and P layers in either configuration, NPN or PNP. The 'junctions' formed between these layers give the transistor its name.

This figure also shows (i) the names of the three electrodes, (ii) the voltages that appear between the electrodes, and (iii) the currents that flow to/from the electrodes. For the purposes of the following discussion, the 'input' and 'output' of the transistor have also been indicated.

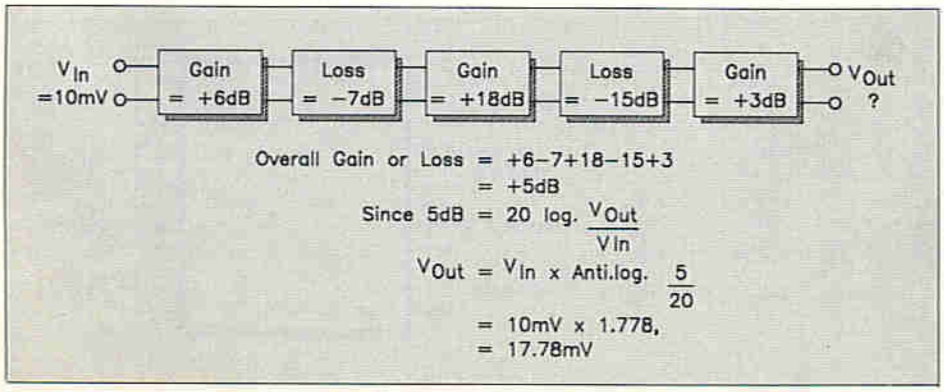


Figure 7. The use of the decibel for gains and losses in series.

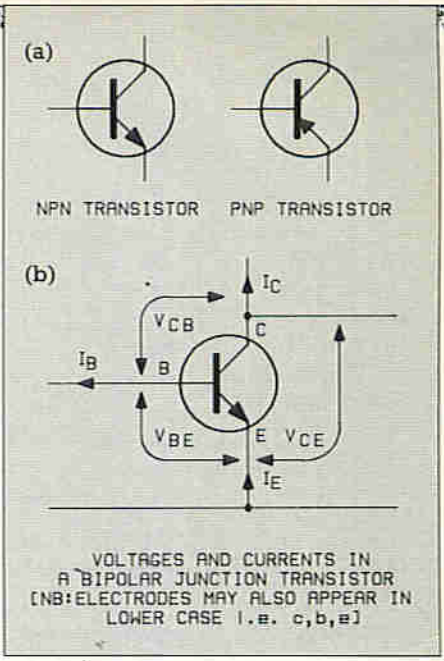


Figure 8. (a) Circuit symbols for NPN and PNP junction transistors (b) voltages and currents in a BJT.

Taking the electrode names first, the current may be assumed to start (that is be 'emitted' from) the emitter and flow through the material to the 'collector' (where, logically, it is collected); the base is used to control the flow of current through the device. As a result, a small current also flows in the base lead. In fact this latter current, known as I_B, is the difference between the other two currents. Obviously then, the emitter current equals the sum of the collector and base currents.

That is, $I_C + I_B = I_E$

The convention used for identifying the various voltages and currents should be noted. Since a voltage exists between 'two points', these points are used as suffixes after the general symbol for voltage, V. Thus, the voltage between base (B) and emitter (E), for example, is known as 'V_{BE}'. Since a current flows into or out of an electrode, the suffix used is the symbol for that electrode. Thus, the collector current (the current flowing out of the collector) is known as 'I_C'.

There is a subtle variation on this convention that caters for the separate cases of 'd.c. values' and 'a.c. values'. For the d.c. case the suffix used is 'upper case' letter/s; for the a.c. case either the symbol itself is 'lower case' and/or the suffix will use 'lower case' letter/s. Thus the voltage V_{CE} is the d.c. value between collector and emitter, while the voltage V_{ce} (or v_{ce}) is the a.c. value. The two values are invariably quite different so the distinction is important.

There are two relationships between some of these voltages and currents that should be known, one being rather more useful than the other. They are known by the name of the 'h parameters', which shouldn't put anyone off, since they are quite simple to appreciate.

The first of these parameters is known as the 'current gain' h_{FE} (d.c. value) or h_{fe} (a.c. value). It is nothing more than the ratio of collector current to base current. In the d.c. case it is the ratio of the d.c. values of collector and base currents, while in the a.c. case, it is the ratio of the a.c. values of these currents. It takes

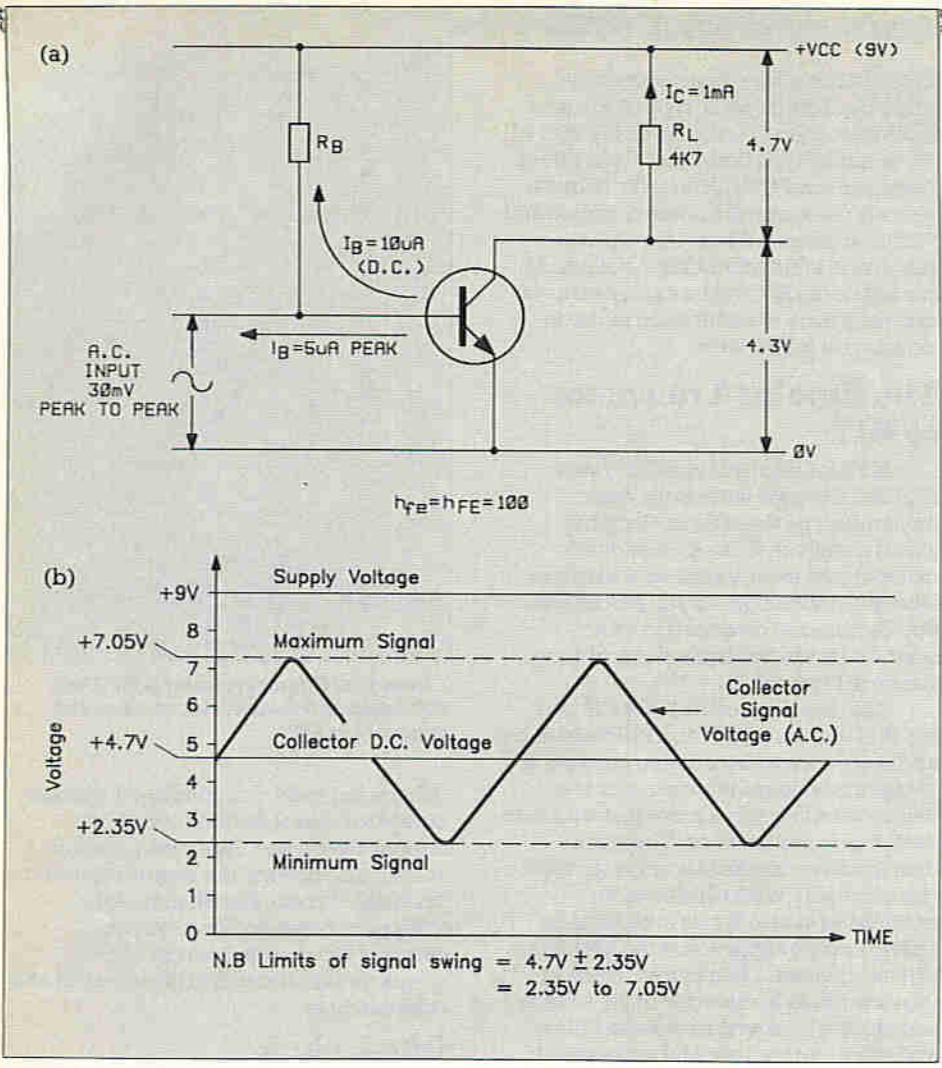


Figure 9. (a) Circuit of a simple BJT amplifier, showing current and voltage relationships (b) graph of collector voltages with time, when amplifying a sinewave signal.

longer to describe it than to understand it!

In symbols: $h_{FE} = I_C/I_B$; while $h_{fe} = i_c/i_b$.

The importance of this parameter is that, since it expresses the ratio of 'current out' for 'current in', *it is a measure of the ability of the transistor to amplify.*

The other h parameter is h_{ie}. It is probably a relief to realise that, for practical purposes, it only has an a.c. value, which is the ratio of V_{be}/i_b. Since it is the input 'voltage' over the input 'current', it is obviously a 'resistance'. It is, in fact, known as the 'input resistance' of the transistor.

Typical values of h_{fe} are almost always available for any given transistor, but the value of h_{ie} hardly ever is. It is not too difficult to estimate it, however.

The d.c. and a.c. Conditions

The beginner to electronics can be forgiven at this point for wondering why the currents in a transistor should have both d.c. and a.c. values. After all, the function of the device is to amplify signals (which are a.c. variations), so why bother with d.c. as well? Figure 9 may go some way towards explaining this.

Figure 9(a) shows a very simple single-stage transistor amplifier, while Figure 9(b) is a graph of voltage against time. Everybody is aware that electronic equipment needs power, often in the form of a battery. In both diagrams, the voltage referred to as $+V_{CC}$ is this supply voltage, assumed to be +9V. Other assumptions made are that the collector current, I_C, is 1mA (this being d.c. supplied by the battery) and the resistor in the collector lead, marked as R_L, has a value of 4.7k. If the product $I_C \times R_L$ is taken (Ohm's law), the result will be 4.7V. It is useful to remember that:

"the product 'milliamps x kilohms' equals 'volts'."

This voltage of 4.7V that has been calculated is the voltage drop (also known as the 'potential difference' or just p.d.) across the 'load resistor' R_L. If this drop is subtracted from the supply voltage (9 − 4.7 = 4.3V), the answer is the voltage between the collector and the 0V line. This value is marked as a horizontal line in Figure 9(b) since it is a voltage that is constant with time – until a signal is applied, also shown. Notice that this signal – a sinewave in this case – varies equally above and below the steady 4.3V line. This illustrates that a d.c. voltage and an a.c. voltage can exist across the transistor at the same time. It should be noticed, also from Figure 9(a), that the h_{FE} of the transistor is 100, so that the corresponding steady value of the base current, I_B, is $1mA/100 = 10\mu A$. This current flows from base to supply through the resistor R_B; it is known as the 'base bias current'.

So what we have are a number of steady voltages and currents (known collectively as the d.c. conditions of the transistor) and a number of alternating voltages and currents (the signal), as follows:

(i) In the base lead there is a steady bias current ($10\mu A$ in this case); when a signal voltage is applied where shown, an alternating base current is superimposed on this. The steady voltage between base and emitter, known as V_{BE}, is about 0.6V for silicon transistors.

(ii) In the collector lead (hence in R_L also) there are two currents, a steady value (1mA in this case) which is h_{FE} times the steady base current, and an alternating value which is h_{fe} times the alternating base current. Suppose that the alternating base current had a peak value of $5\mu A$ and h_{fe} was 100, then the peak value of collector signal current would be $100 \times 5\mu A = 0.5mA$.

(iii) The flow of collector current through the resistor R_L produces a voltage drop across R_L. The steady d.c. value of I_C gives the drop of 4.7V already calculated. The alternating value, i_c,

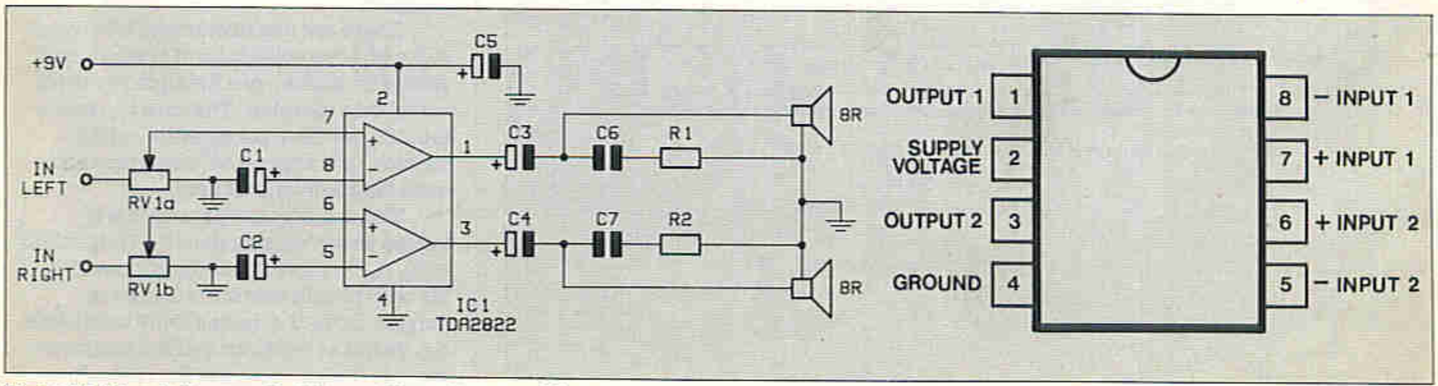
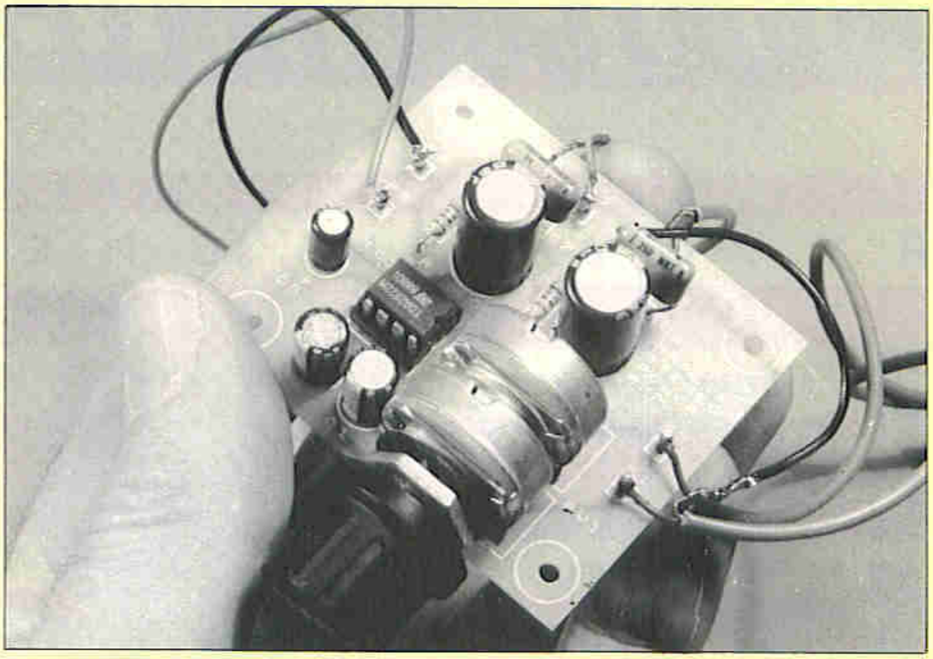


Figure 10. Circuit diagram for this month's project, an add-on stereo power amplifier for a personal stereo.

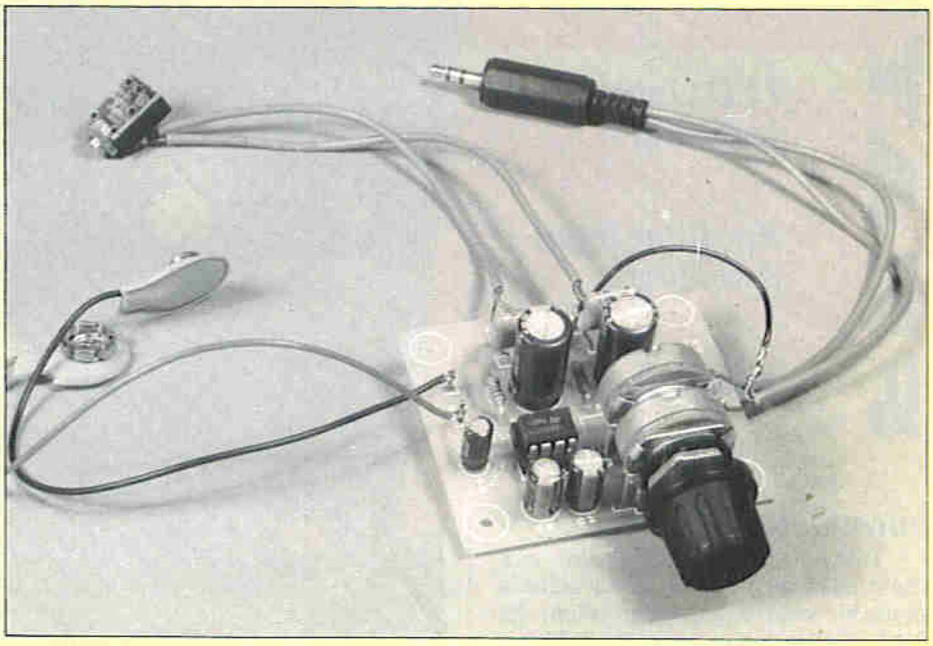
gives a 'peak' drop of 0.5mA x 4.7k = 2.35V. This is the peak value of the signal output from the amplifier.

Because the alternating input voltage required between base and emitter to produce the alternating base current is very much less than the output voltage just calculated, the transistor has obviously performed the process of amplification. Taking an arbitrary input voltage to illustrate the point, suppose that it had a peak-to-peak value of 30mV then, writing the output voltage as a peak-to-peak value also, gives 2 x 2.35V = 4.7V. Voltage gain is equal to output/input, which equals $4.7/(30 \times 10^{-3}) = 157$.

It may be necessary to read the above through several times carefully but, in the end, the basic idea of how a bipolar junction transistor is able to amplify a signal should become obvious. In the next part of this series the amplifying action of the Field Effect Transistor (FET) will be described. In essence the action is similar, in fact a little simpler. Both of these devices can be 'integrated', and so the amplifying action of IC's will then also be understood.



Close-up of the assembled stereo power amplifier, built on the custom PCB, as described in the text.



External connections to the stereo amplifier PCB: at left, the PP3 9V battery connectors; top left, speaker outputs via 3.5mm stereo jack socket; top, 3.5mm jack plug connector to the 'Walkman' unit phones socket.

This Month's Project

This article has been largely to do with amplification. It is, therefore, appropriate that the project should be on the same subject. There are any number of possibilities, not all of them of particular interest or practicability. However, the one chosen, it is hoped, will have the most appeal. A project that, once built, can be seen (or as in this case, heard!) to do something positive, will be more rewarding than one that does not do anything that is of immediate benefit. In this instance, all those who own a 'Walkman' type of personal stereo can, by building this quite simple and inexpensive circuit, turn their 'personal' system into a table-top hi-fi, a sometimes more convenient alternative to the isolation that wearing headphones forces one to accept. It is not a substitute for a true hi-fi stereo system – in fact the term hi-fi is used a little tongue in cheek – the output power is quite modest but still useful. It is certainly quite adequate for general listening.

The circuit for the stereo power amplifier is shown in Figure 10. It is based upon the TDA2822, an 8-pin DIL IC that will give 1W per channel into 8Ω loudspeakers. This costs a mere £1.10; the component count is low – a stereo potentiometer, two resistors and seven capacitors, plus a few items of hardware. This design also has a PCB available, although there is no reason why it shouldn't be built on a small piece of Veroboard instead. The stereo input jacks directly into the 'headphone socket' of the personal stereo, using the standard size 3.5mm connector. Power for the stereo power amplifier can be taken from a PP9 battery, which could easily be housed in a small plastic box together with the amplifier and an on/off switch. The precise arrangements for housing the circuit and battery are left to the individual builder, as is the choice and method of connection of the speakers. The latter should be 8Ω types with a rating of not less than 1W, unless one restricts the power output. Photographs show the layout of components on the PCB as well as the complete system connected up.

PARTS LIST

RV1a/b	47k Dual Log, Pot.	(FX11M)
R1,R2	4·7Ω Dual Log	(M4R7)
C1,C2	100μF 10V Elect	(FB48C)
C3,C4	470μF 16V Elect	(FB72P)
C5	10μF 25V Elect	(FB22Y)
C6,C7	0·1μF Polyester	(BX76H)
IC1	TDA 2822	(UJ38R)
	Stereo O/P PCB	(GE11M)
	DIL Socket 8-Pin	(BL17T)
	3·5mm Stereo Jack	(HF98G)

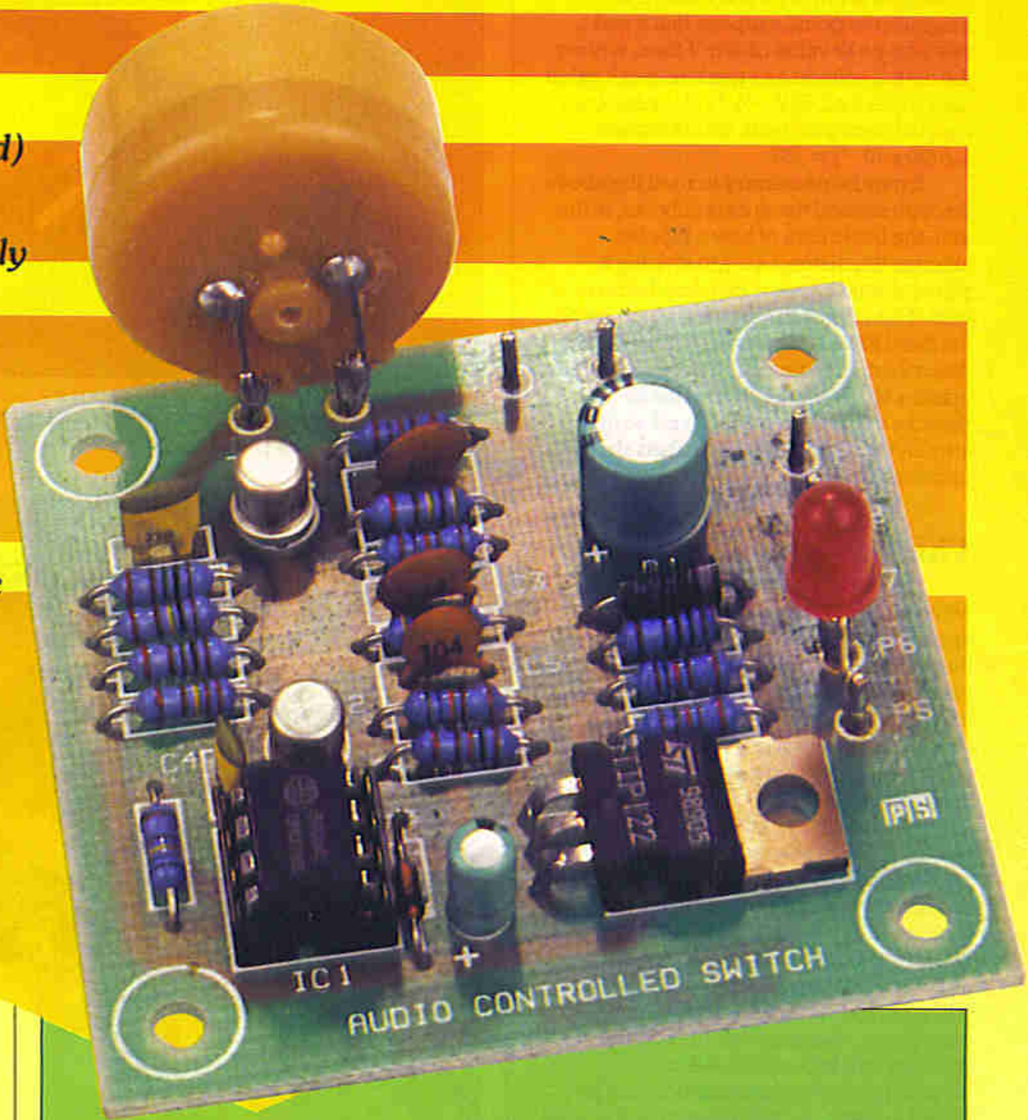
Suitable Speakers are (YT25C) 3·5" SPK, 8Ω (1·5W Rating)

AUDIO CONTROLLED SWITCH

BY GAVIN CHEESEMAN

FEATURES

- ★ *Easy Operation (Whistle Operated)*
- ★ *Wide Power Supply Voltage Range (3V-14V)*
- ★ *Switches up to 500mA*
- ★ *LED Output State Indicator*
- ★ *Sensitive Input Amplifier*
- ★ *Fibreglass PCB*



Introduction

The Audio Controlled Switch is a sound operated switching circuit suitable for use in a wide variety of applications. An open collector output is provided which is capable of driving relays, sounders, etc. up to a maximum current of 500mA. Provision is made for an LED, to show the output status. For increased flexibility the audio controlled switch is designed to operate over a wide range of power supply voltages between 3V and 14V. The module is usually triggered by whistling but will respond to any tone approximating a sine wave at a frequency within the capture range of the circuit.

Circuit Description

The circuit is based around the UM3763 Voice Control (Whistle) IC, the pinout of which is shown in Figure 1. As can be seen from Figure 2, the IC contains everything necessary for an effective audio operated switching circuit. The IC basically compares the frequency of the incoming signal with the frequency of an internal clock oscillator and switches the output to its complimentary state when the signal is

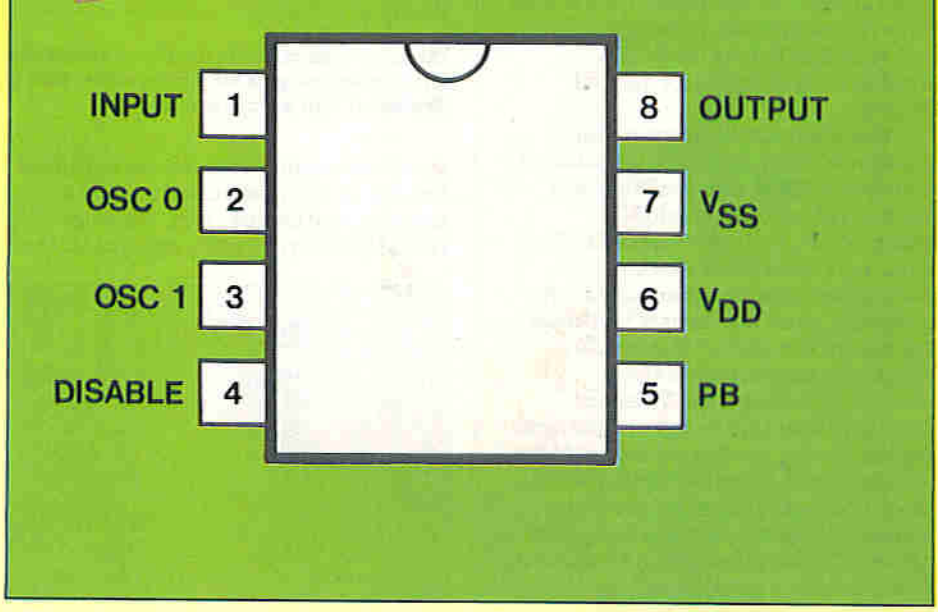


Figure 1. UM3763 Pinout.

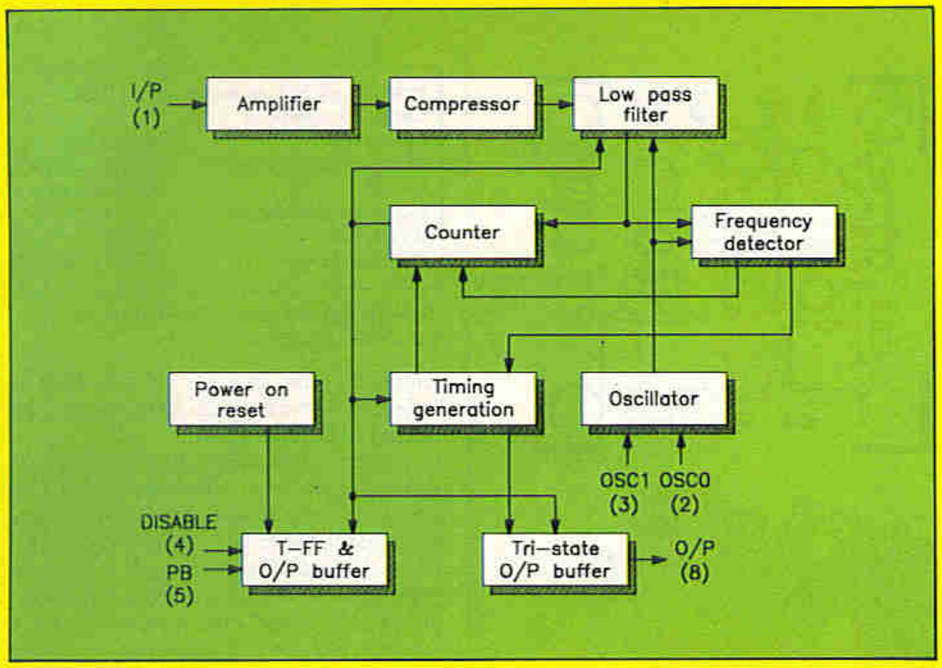


Figure 2. UM3763 Block diagram.

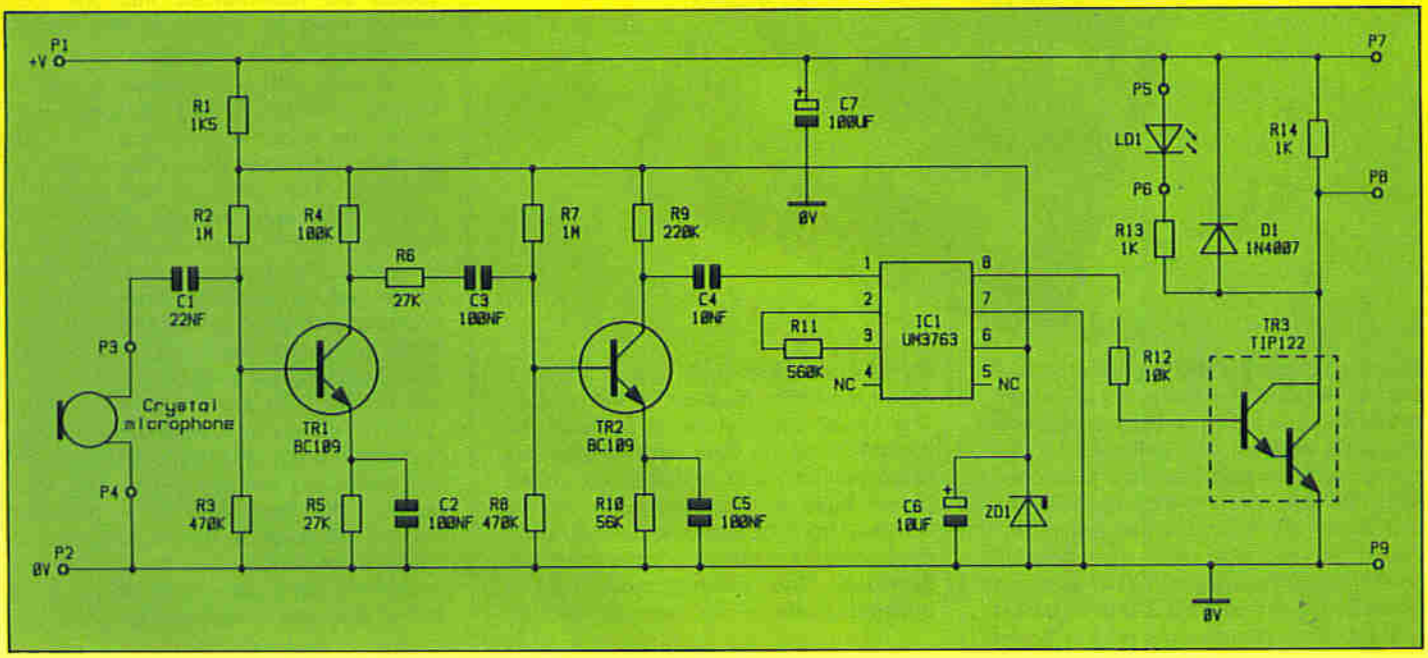


Figure 3. Circuit Diagram.

within the capture frequency range of the circuit. Although the UM3763 is designed to be triggered by whistling, the device will respond to virtually any sinusoidal tone within its capture range as long as the amplitude is sufficient.

Quite an effective whistle control circuit can be built around the IC alone; however, it was decided that a more sensitive arrangement using additional front end amplification would be more useful as this would effectively increase the control distance. With this concept in mind a simple 2-stage audio amplifier is used to boost the amplitude of the incoming signal.

Referring to Figure 3, it can be seen that a crystal microphone is used as a transducer. Initial amplification is performed by transistors TR1 and TR2. The signal from the crystal microphone is fed to the base of transistor TR1 via capacitor C1 which serves as interstage coupling, isolating the microphone from the DC bias voltage on the base of the transistor. Capacitors C3 and C4 perform a similar function in other parts of the circuit, isolating the different DC voltages in each stage while allowing AC signals to pass unhindered. Resistors R2, R3, R5, R7, R8 and R10 are bias resistors for the transistor amplifier stage and C2 together with C5 provides a low impedance earth return for AC signals. R4 and R9 are collector load resistors for TR1 and TR2 respectively. The output from TR2 is fed to the input (pin 1) of integrated circuit IC1.

To allow for operation over a wide range of power supply voltages it is necessary to provide a stabilized supply for IC1 as the device requires a supply voltage of between 2.7V and 3.3V to operate. Zener diode ZD1 provides the necessary regulation to hold the IC supply voltage within the required range and also provides a stable supply voltage for the front end amplifier. Resistor R1 limits the current through ZD1 and C6 decouples the zener diode to prevent the introduction of noise onto the supply rail.

The capture frequency of the IC is determined by the value of R11 and this is set for a frequency range of approximately 1.5kHz - 2.2kHz. The output from the IC is fed to output switching transistor TR3 via R12 which limits the current to the base of the device. A darlington type power transistor is used in the output switching stage, as this provides a superior switching characteristic to most single bipolar transistors and requires a comparatively small base current to switch on. Light Emitting Diode LD1 gives an indication of the output state and illuminates when TR3 is switched on. The current through the LED is limited by R13 and D1 prevents any high voltage spikes which may be produced when driving inductive loads, from damaging TR3. Resistor R14 provides a load for TR3 when the module is used to drive a high impedance load and resistors of different value may be fitted to suit different drive requirements. Capacitor C7 provides decoupling for the main supply rail.

Construction

Insert and solder the components onto the PCB referring to the legend (Figure 4), starting with resistors R1 - R14. The IC socket is fitted such that the notch at one end of the socket corresponds with that on the PCB legend. There are seven capacitors in the kit, two of which are of the electrolytic type. Electrolytic capacitors are polarised and must be inserted into the board observing the correct polarity; the negative lead, indicated by a minus (−) sign on the side of the capacitor case is positioned away from the positive (+) symbol on the PCB legend. Next insert PCB pins P1 - P9 and press them into position using a hot soldering iron. When the pins are heated in this way, very little pressure is required to push them into place. Once the pins are in position they can then be soldered.

Semiconductors (diodes, transistors and IC's) need special precautions when inserting; in particular, take care not to overheat the diodes and transistors during

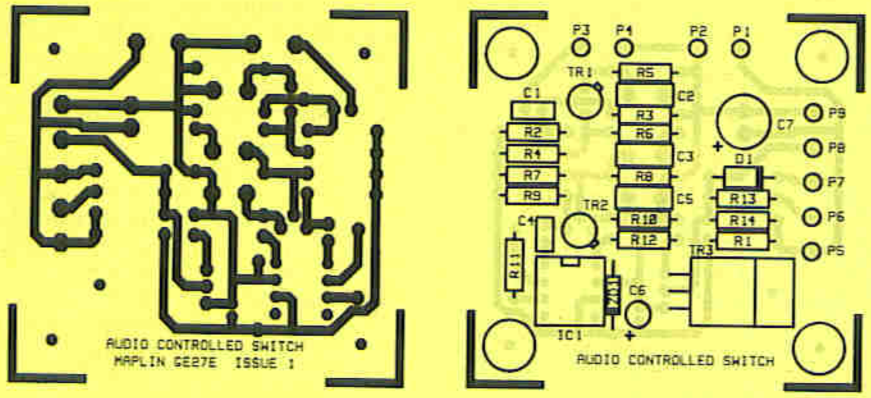
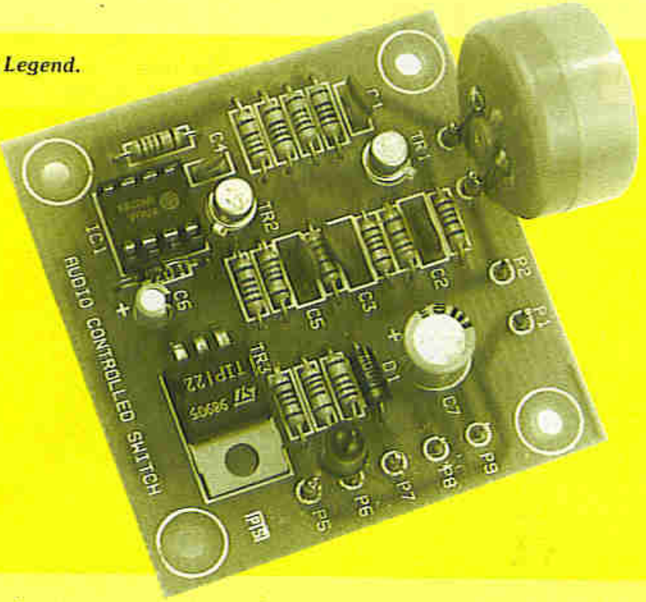


Figure 4. Track and Legend.



soldering. Polarity is also important with all semiconductors. The diodes are orientated so that the band at one end of the diode is at the same end as that indicated by the legend, and the transistors are positioned such that the case corresponds with the outline on the PCB. Please note: TR3 should be mounted with the heatsink bracket facing toward the PCB as shown in Figure 5. Do not install IC1 into its socket until all other components on the board have been fitted. When fitting the device make sure that the notch at one end of the IC corresponds with that in the socket. It may be necessary to bend the IC pins in slightly to allow the component to fit properly into the socket. For further information on soldering and constructional techniques, refer to the constructors' guide included in the kit.

Testing

Before applying power to the finished PCB it is a good idea to double check your work to make sure that the soldering is up to standard and in particular that there are no dry joints or solder short circuits. Figure 6 shows the wiring diagram for the module. The crystal microphone is soldered between P3 and P4. Care must be exercised when handling and soldering the microphone leads as they can easily become detached from the microphone body and if this happens the unit may be permanently damaged. Light emitting diode LD1 is soldered between P5 (anode) and P6 (cathode); the cathode of the LED is indicated by the flat side of the case and the shorter of the two leads.

Power Supply Voltage Range	3V-14V DC
Current Consumption (Quiescent)	6mA at 12V
Effective Trigger Frequency	1.5kHz - 2.2kHz
Output	Open Collector
Maximum Load Current (P7 and P8)	500mA
PCB Dimensions	57mm x 54mm

Table 1. Specification of Prototype Audio Controlled Switch.

A 3V - 14V supply that is capable of delivering at least 10mA is required to power the unit. Power supply connections are made between P1(+V) and P2(0V). If a mains derived DC power supply is used, it is important that it is adequately decoupled to prevent the introduction of low frequency ripple on to the supply rail as this may cause false triggering or unreliable operation. In addition, when choosing a power supply it should be remembered that the load current must be added to the current consumption of the module.

A tone with a frequency of approximately 1.5kHz - 2.2kHz is required to trigger the circuit and this may either be generated electronically or more usually by whistling. The state of the output is indicated by light emitting diode, LD1. Apply power to the module. If a multimeter is available, the current consumption of the circuit can be measured and should be approximately 6mA at 12V in the standby mode. In this state the output of the module (P8) should be high and LD1 should remain extinguished. On receipt of a tone of the correct frequency the output should change to the low state and LD1 should illuminate; the circuit will remain in this state until another tone burst (whistle) is received, when it will revert to the original state. In many cases it may not be practical or possible to generate a tone electronically and in this case whistling is probably the

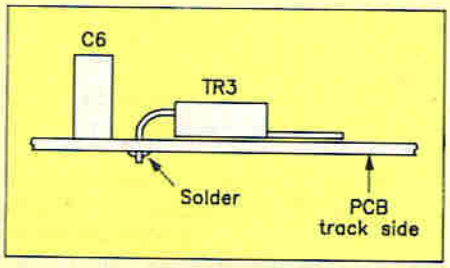


Figure 5. Mounting TR3.

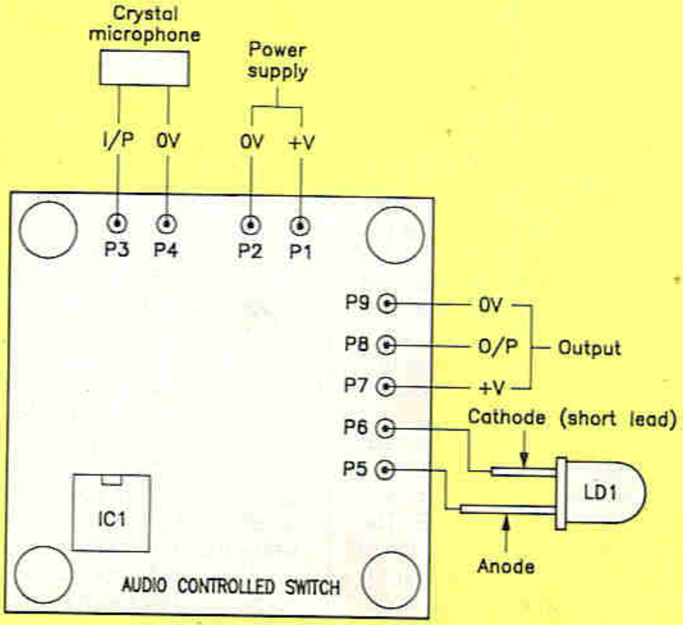


Figure 6. Wiring Diagram.

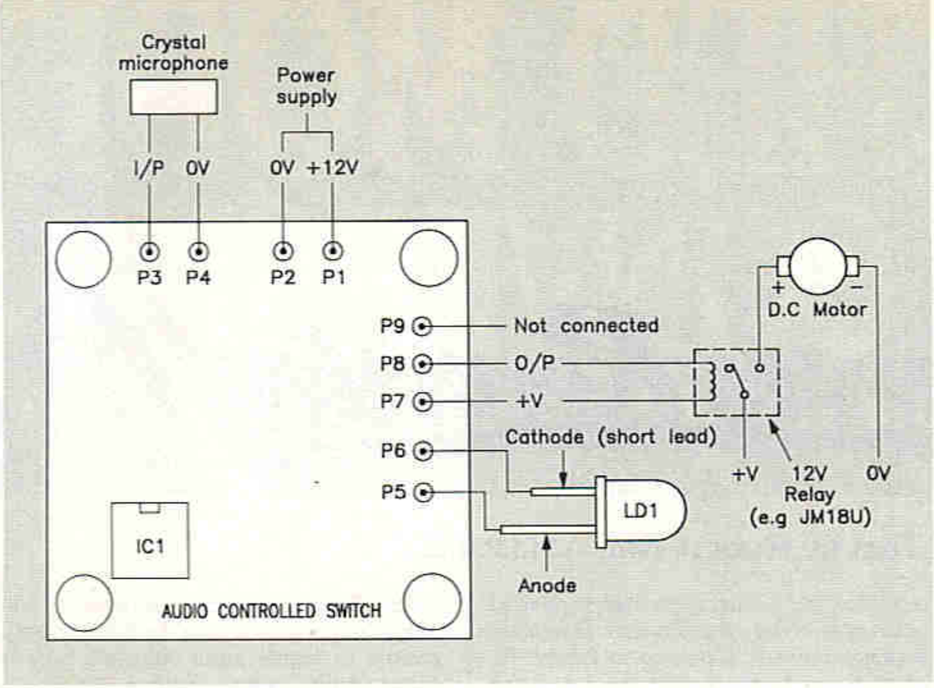


Figure 7. Switching a Motor using a relay.

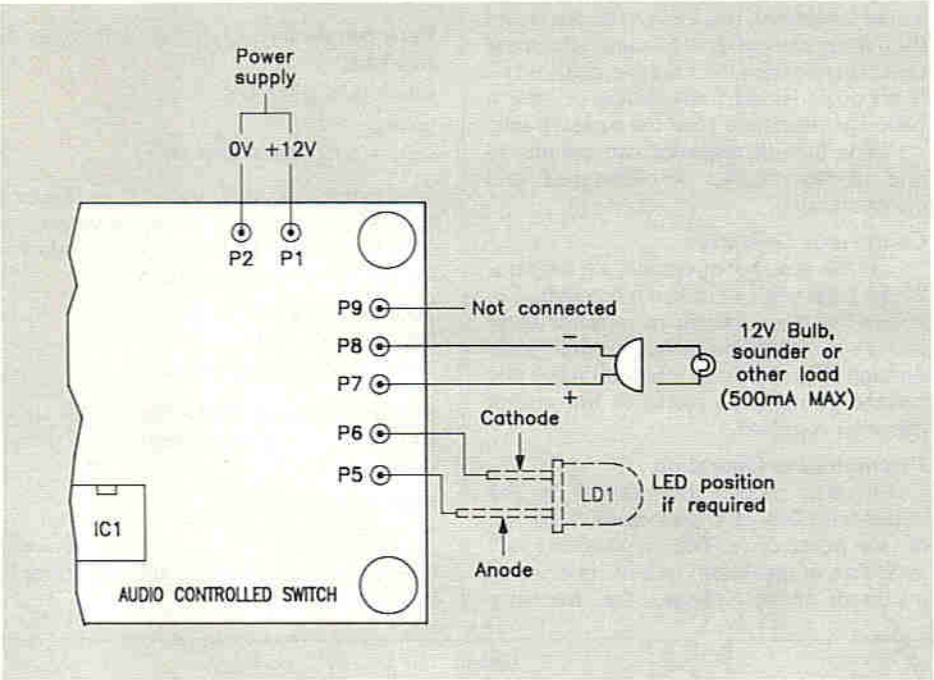


Figure 8. Switching a load directly.

best method of triggering the unit. Because many people may not be able to estimate the the correct frequency, initially some experimentation may be necessary but once you get used to the sort of tone required, operating the unit becomes easy. It should be possible to operate the device from several metres away with a whistle of average volume.

Using the Module

The audio controlled switch is suitable for a wide range of switching applications and can make a useful alternative to other control media. For example the unit could be used to switch lighting on and off; using this method of switching you no longer have to find the switch to turn on the light in a darkened room. Sound operated switching of this type can also be useful for turning equipment on and off when your hands have to be free to perform another task. Another idea would be to use the module to drive motors or similar equipment for opening and closing doors or curtains. Figure 7 and Figure 8 give some examples of different applications using the module.

If the equipment to be switched operates at a voltage or current level outside the drive capability of the audio controlled switch circuit a relay may then be used to provide an intermediate stage of switching. With its open collector output, the module is ideal for switching relays and when used in this configuration a suitable relay should be chosen for the supply voltage in use. For example, if a 12V power supply is used to power the audio controlled switch circuit then a relay with a coil suitable for 12V operation should be used. A suitable general purpose relay for 12V operation is Maplin stock code JM18U.

The circuit could be used to operate a simple timer; this can be useful for lighting and similar applications where it is desirable for the equipment to switch off automatically after a short period. The 1/300 timer kit (stock code LP30H) can be used in conjunction with the audio controlled switch to provide time delays up to around 5 minutes. For longer delays a more complex timer is required. Finally, Table 1 shows the specification of the prototype Audio Controlled Switch.

AUDIO CONTROLLED SWITCH PARTS LIST

Resistors: All 1% 0.6W Metal Film			
R1	1k5	1	(M1K5)
R2,7	1M	2	(M1M)
R3,8	470k	2	(M470K)
R4	100k	1	(M100K)
R5,6	27k	2	(M27K)
R9	220k	1	(M220K)
R10	56k	1	(M56K)
R11	560k	1	(M560K)
R12	10k	1	(M10K)
R13,14	1k	2	(M1K)
Capacitors			
C1	22nF Ceramic	1	(WX78K)
C2,3,5	100nF Minidisc	3	(YR75S)
C4	10nF Ceramic	1	(WX77J)
C6	10μF 16V Minelect	1	(YY34M)
C7	100μF 16V Minelect	1	(RA55K)
Semiconductors			
IC1	UM3763	1	(UJ47B)
TR1,2	BC109	2	(QB33L)
TR3	TIP122	1	(WQ73Q)
D1	1N4007	1	(QL79L)
ZD1	BZY88C3V0	1	(QH01B)
LD1	LED Red	1	(WL27E)
Miscellaneous			
P1-9	Pins 2145	1 Pkt	(FL24B)
	Crystal Mic Insert Plastic	1	(LB93B)
	DIL Socket 8-Pin	1	(BL17T)
	PC Board	1	(GE27E)
	Constructors Guide	1	(XH79L)

A complete kit of parts is available:
Order As LP29G (Audio Cntrl Switch) Price £5.95
The following item is also available separately:
Aud Contrl Sw PCB **Order As GE27E Price £2.45**

SWITCHED MODE POWER CONVERSION

The Secrets Revealed!

Part Two by Robert Ball A.M.I.P.R.E.

Resumé

In part one we started by looking at power supply fundamentals and covered the basic principles of both linear and switched mode power supplies, and concluded by looking at the forward regulator. In part two we shall examine the operation of the flyback regulator and boost regulator, and then take a look at isolated power converters.

Flyback Regulator

The circuit in Figure 4a is that of a flyback regulator, and essentially it contains the same components as the forward regulator, except that they are arranged differently. As before S represents a power transistor. This circuit differs in operation to the forward regulator in that it provides a regulated DC output, Vout, of *opposite* polarity to the DC input, Vin. The principal difference between a flyback and forward regulator is the way in which energy is delivered to the output capacitor. In the forward regulator, energy is provided continuously, whilst in the flyback regulator energy is pumped in a cyclic manner. The pumping action necessitates a higher value filter capacitor than with the forward regulator, this is due to the higher peak to peak value of the current pulses. Operation is straightforward. Referring to Figure 4b, when S conducts, current flows and the magnetic field in L expands. In Figure 4c, when S commutates, the magnetic field in L collapses and the polarity of the voltage across L reverses, this forward biases D and the current through L continues in the *same direction* releasing the stored energy into C. S conducts (either immediately or after a period of 'dead time') and the cycle repeats.

The flyback regulator can operate in one of two modes – continuous and discontinuous.

Continuous Operation

In this mode of operation, a (comparatively) large value of inductor is required to ensure that the current in the inductor never falls to zero. Although the current flows through the inductor continuously, the current through the diode to the output capacitor is pulsed.

Discontinuous Operation

In this mode, the current in the inductor is allowed to fall to zero at the end of each pump cycle. The circuit is designed such that, at maximum output current and minimum input voltage, the transistor switch starts conducting as soon as the diode stops conducting. At lower output current or higher input voltages, there is 'dead time', when neither device is conducting. The differences in operation can be seen from the current waveforms in Figure 5.

Peak current through the inductor when S conducts

Ipk = (Vin x Ton) / L

where:

Ton = conduction time of S

S commutates and voltage is induced across L, D1 conducts and energy stored in L is transferred to C and load. Inductor current falls to zero linearly

Tdon = (Ipk x L) / Vout

where:

Tdon = conduction time of D

Power delivered to load equals peak energy stored in L and the frequency of pump cycles.

$$\begin{aligned} \text{Pout} &= \text{Vout} \times \text{Iout} \\ &= 0.5 \times \text{L} \times \text{Ipk}^2 \times f \end{aligned}$$

Output current equals average current through D.

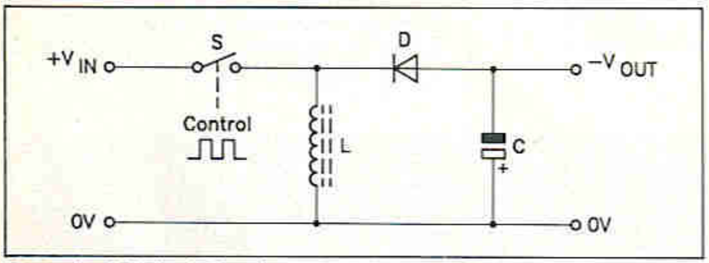


Figure 4a. A Flyback Regulator.

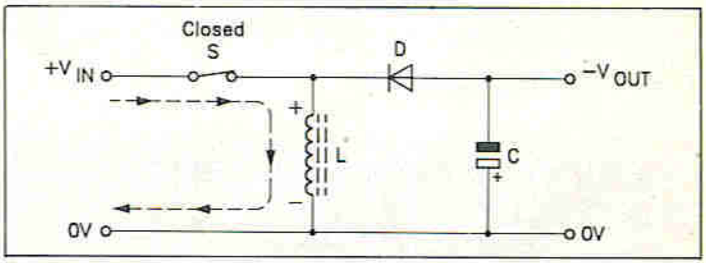


Figure 4b. Current Flow in Flyback Regulator – S Closed.

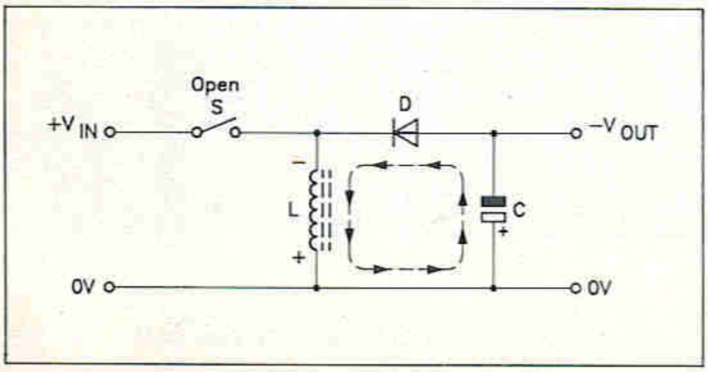


Figure 4c. Current Flow in Flyback Regulator – S Open.

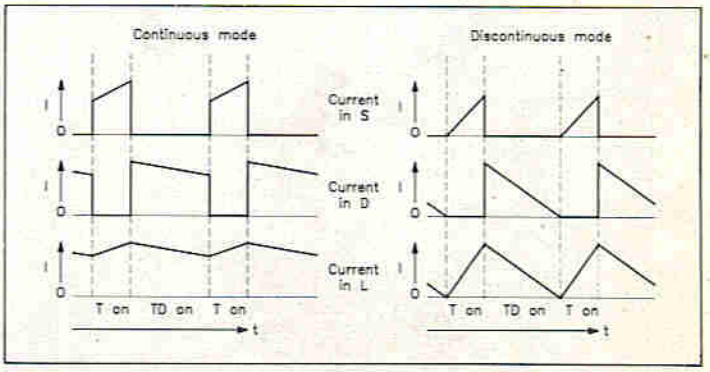


Figure 5. Current Waveforms in Flyback Regulator.

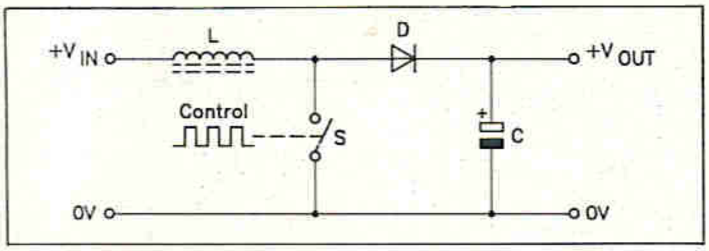


Figure 6a. A Boost Regulator.

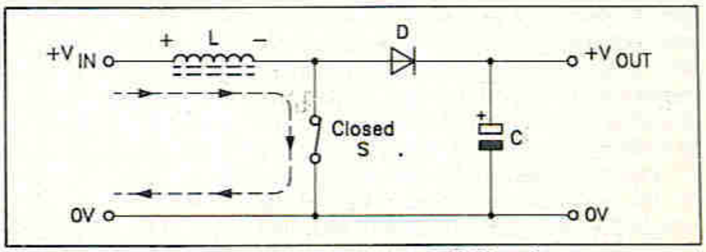


Figure 6b. Current Flow in a Boost Regulator – S Closed.

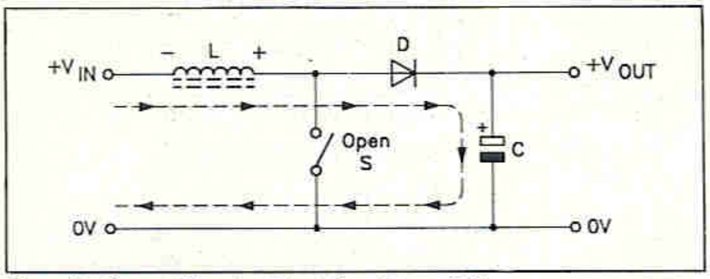


Figure 6c. Current Flow in a Boost Regulator – S Open.

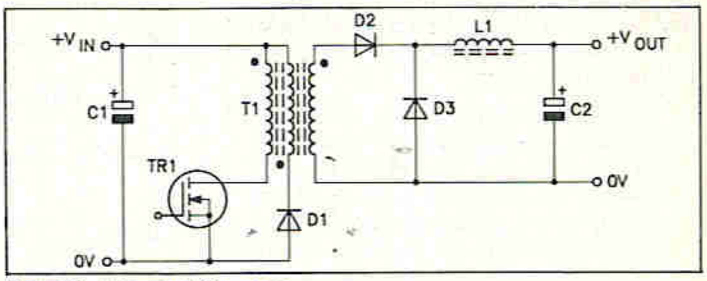


Figure 8. A Forward Converter.

$\text{Iout} = (\text{Ipk} / 2) \times (\text{Tdon} / \tau)$
$\quad = (\text{Ipk} / 2) \times \text{Tdon} \times f$

where:
$\tau = 1 / f$

Output Voltage (opposite polarity to Vin) may be determined as follows:

$\text{Vout} = \sqrt{(\text{Pout} \times R_L)}$
$\quad = \text{Ipk} \times \sqrt{((L \times f \times R_L)/2)}$

where: R_L = Load Resistance

The output voltage of the circuit can be regulated by operating the circuit at a fixed frequency and varying the transistor duty cycle. However, because of the pumping action, the output voltage sags while the transistor switch is on and rises when the transistor is off. This makes the circuit difficult to control in a fixed frequency manner. A better approach to controlling the flyback converter when operating in the discontinuous mode is to have a fixed peak current in the inductor and hence fixed diode conduction time. The transistor switch 'on' time can then be varied inversely to any changes in the output voltage. This gives rise to the circuit having variable frequency of operation.

Boost Regulator

The circuit in Figure 6a is that of a boost regulator. The boost regulator provides a regulated DC output, Vout, of higher voltage than the DC input and of the same polarity as Vin. This circuit, as with the flyback converter, pumps energy to the output capacitor in pulses. Referring to Figure 6b, when S conducts, current flows and the magnetic field in L expands. In Figure 6c, when S commutates, the field in L collapses and the polarity of the voltage across L reverses, this voltage adds to the supply voltage and forward biases D. The current in L continues in the same direction releasing the stored energy into C. Additional energy is transferred from the input directly to the output during the diode conduction time. S conducts and the cycle repeats.

The pumping action that the boost regulator exhibits is similar to that of the flyback regulator, for this reason it is desirable to operate it in the discontinuous mode with a fixed peak current through the inductor. However in the boost regulator, unlike the flyback regulator, the diode conduction time is not fixed, but varies with the input voltage. Waveforms associated with the boost regulator are shown in Figure 7.

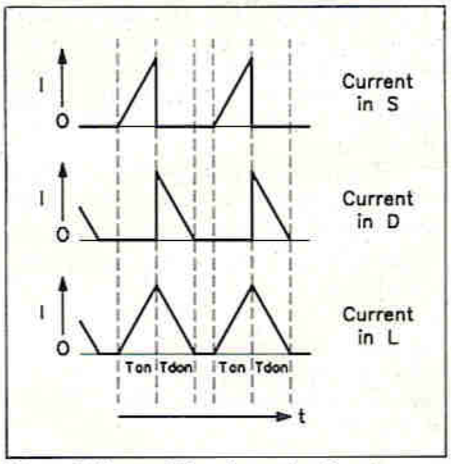


Figure 7. Current Waveforms in a Boost Regulator.

$\text{Ipk} = 2 \times \text{Iout}_{max} \times (\text{Vout} / \text{Vin}_{min})$

$\text{Tdon} = (L \times \text{Ipk}) / (\text{Vout} - \text{Vin})$

Output voltage is regulated by controlling the duty cycle.

$\text{Vout} = ((\text{Ton} / \text{Tdon}) + 1) \times \text{Vin}$

Ripple voltage is directly proportional to diode conduction time.

$\text{Tdon max} = (L \times \text{Ipk}) / (\text{Vout} - \text{Vin}_{max})$

Switched Mode Converters

So far we have dealt with switched mode regulators which, although they have high efficiency, do not provide input to output isolation. Isolation is required in applications that use the 240V AC mains supply, or in other instances where this is a design requirement. In a linear power supply, isolation is provided by a low frequency (50Hz) power transformer. The transformer provides an isolated AC output on one or more secondaries, from an AC mains primary input. The stepped down (or stepped up) secondary voltage is rectified and then passed to a linear regulator. However by using switching principles it is possible to combine isolation, high efficiency and regulation in one, and this is achieved by using a transformer that operates at high frequency (25kHz to 250kHz). The construction of such a transformer is very different to that of a mains power transformer in that, for a given power through-put, the high frequency transformer will be smaller and lighter. Transformers of this type have ferrite dust cores as opposed to laminated iron cores and comparatively fewer turns in the windings than that of a mains power transformer.

The forward regulator and the flyback regulator have their transformer equivalents, the forward converter and flyback converter. Additionally there is the push-pull converter, the half bridge converter and the full bridge converter. There are some other types, but we shall not deal with these here.

Since we have covered the fundamental principle of using a power transistor as a switch, the figurative use of the switch will be omitted and replaced by the transistor itself. It will be seen that the circuits use a power MOSFET transistor, this is in keeping with the current trend of MOSFET use. However, conventional bipolar power transistors may be used with a few circuit differences, namely in the drive circuitry.

These circuits are shown with DC inputs, but may be used with AC by the inclusion of a rectification circuit prior to the input capacitor.

Forward Converter

Referring to Figure 8, C1 is the input reservoir capacitor, serving as an energy store. T1 is the high frequency ferrite cored transformer. The primary and secondary are connected in the same phase, but note the extra 'middle' winding, which is connected in opposite phase. When TR1 switches on, current flows through the primary winding of T1, the magnetic field in T1 expands causing a current to be induced in the secondary winding. The voltage across the secondary winding is such that D2 conducts, charging the output capacitor C2 via energy storage inductor L1. When TR1 turns off ('blocks'), the magnetic field in T1 collapses ('flyback'). At this point several things happen:

1. The polarity of the voltage across the 'middle' demagnetisation winding of T1 is such that D1 conducts. This allows the magnetic field in T1 to collapse in a controlled manner, thus ensuring that the net magnetisation of T1, at the start of the next conduction phase of TR1, is zero. If this were not the case, then after a few cycles the transformer core would magnetically saturate, causing the primary current to rise excessively, destroying TR1.
2. The voltage across the secondary of T1 is such that D2 is reverse biased. The magnetic field in L1 starts to collapse, and the voltage across it reverses, D3 conducts and maintains current flow through L1 and so continuing to charge C2. This behaviour is known as flywheel action and explains why D3 is commonly referred to as a 'flywheel diode'. TR1 conducts and the cycle repeats.

Waveforms associated with the circuit are shown in Figure 9.

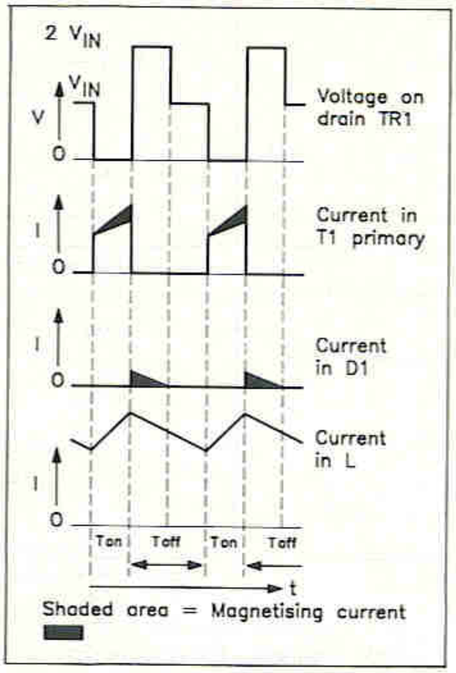


Figure 9. Current Waveforms in a Forward Converter.

The output voltage Vout equals the average of the waveform applied to the LC filter.

$Vout = Vin \times (n2 / n1) \times (Ton / \tau)$

where:
$n2$ = secondary turns on T1
$n1$ = primary turns on T1
Ton = conduction time of TR1
$\tau = 1 / f$

The control circuit monitors Vout and controls the duty cycle of the drive waveform to TR1.

Duty cycle $\alpha = Ton / \tau$

If Vin increases, the control circuit will reduce the duty cycle α accordingly, so as to maintain a constant output. Likewise if the load is reduced and Vout rises, the control circuit will act in the same way. Conversely, a decrease in Vin or increase in load will cause the duty cycle to be increased.

$Vout = Vin \times (n2 / n1) \times \alpha$

Flyback Converter

Referring to Figure 10, C1 as before serves as the input reservoir capacitor, T1 is the transformer, but note that this time the secondary is *oppositely* phased to the primary. When TR1 turns on, current flows through the primary of T1 and the magnetic field in T1 expands, storing energy in T1. The voltage induced across the secondary of T1 is such that D1 is reverse biased. When TR1 turns off ('blocks'), the magnetic field in T1 collapses ('flyback') and the voltage across T1 secondary reverses, forward biasing D1. The energy stored in T1 is released into C2. TR1 turns on again and the cycle repeats. A demagnetisation winding is not required as the magnetisation of T1 returns to zero during the flyback phase by the action of D1, which uses up the energy.

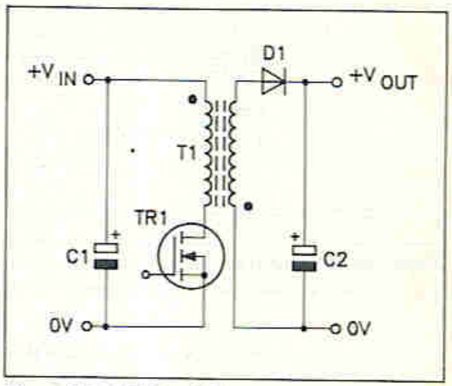


Figure 10. A Flyback Converter.

The output voltage for a flyback converter (trapezoidal current flow operation) may be calculated as follows:

$Vout = Vin \times (n2 / n1) \times (Ton / \tau) \times (1 / (1 - (Ton / \tau)))$

where:
$n2$ = secondary turns on T1
$n1$ = primary turns on T1
Ton = conduction time of TR1
$\tau = 1 / f$

The control circuit monitors Vout and controls the duty cycle of the drive waveform to TR1, as before.

Duty cycle $\alpha = Ton / \tau$

If Vin increases, the control circuit will reduce the duty cycle accordingly, so as to maintain a constant output. Likewise if the load is reduced and Vout rises, the control circuit will act in the same way. Conversely, a decrease in Vin or increase in load, will cause the duty cycle to be increased.

$Vout = Vin \times (n2 / n1) \times \alpha \times (1 / (1 - \alpha))$

It can be seen that the output voltage changes when the duty cycle α is changed. However the relationship between the output voltage and duty cycle is *not* linear, as was the case with the forward converter, but instead it is a hyperbolic function.

The current flow in a flyback converter can have either trapezoidal or sawtooth characteristics, this can be seen in Figure 11. The trapezoidal current characteristic is due to the switching transistor turning on again before the secondary current has dropped to zero. Whilst the sawtooth characteristic is due to the secondary current falling to zero and there being a period of 'dead time' when there is no current flow in either secondary or primary.

Winding Up

In part two we have covered operation of flyback and boost regulators and then dealt with isolated forward and flyback converters. In part three we will examine operation of the push pull, half and full bridge converters.

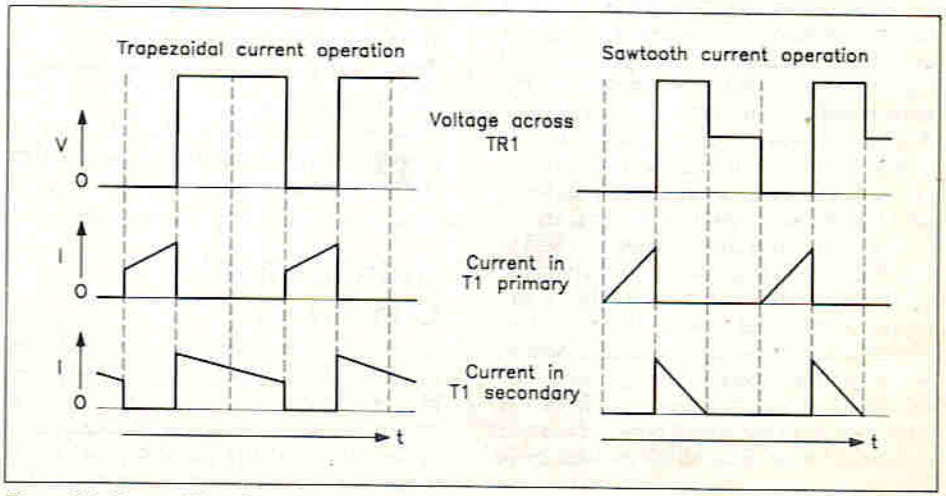


Figure 11. Current Waveforms in a Flyback Converter.

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NICAM STEREO TV TUNER UNIT

Part One by C.S. Barlow

Features

- ★ Power input protection
- ★ Voltage synthesis tuning system
- ★ SCART, DIN and Phono sockets
- ★ Push-button function switches
- ★ LED indicators
- ★ Superbly finished case
- ★ Infra-red remote control expandable

Foreword

In Part One of this Two Part article, we examine in detail the circuit operation of the NICAM Stereo Tuner Accessory Kit.

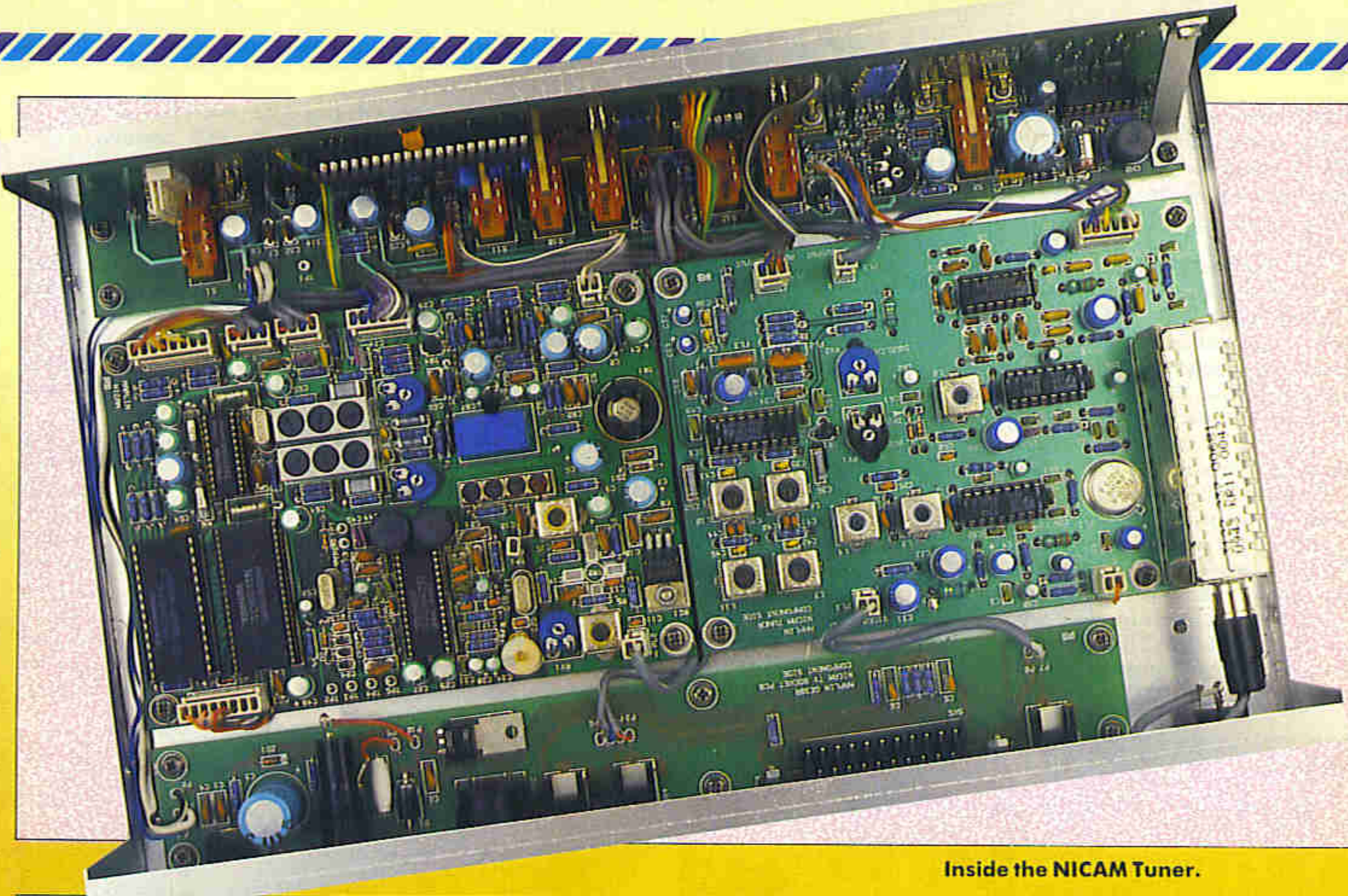
Introduction

The accessory kit is designed for use with the Maplin NICAM tuner and decoder projects (stock code LP09K and LP02C), see 'Electronics – The Maplin Magazine' December '89 – January '90 Issue Number 35 (XA35Q) and February – March '90 Issue Number 36 (XA36P). Three circuit boards are used to link up and provide the optimum working environment for the tuner and decoder PCB's. The socket PCB has a selection of audio/video connections for SCART, DIN and Phono with the DC entering the power input protection circuit via a 2·5mm socket. On the display PCB a voltage synthesis tuning system with a non volatile 16-channel memory supports the tuner board. In addition to the function switches on the switch PCB a voltage generator IC is used to provide the +25V read and write memory supply. The system has the potential for an infra-red receiver to be added giving remote control of station selection and audio output level.

The circuit boards are housed in a specially manufactured metal case, to a very high standard. To power the unit a regulated 12V DC mains adaptor capable of providing up to 600mA must be used (stock code YZ21X). With its variety of sockets the tuner system can be connected to a wide range of home entertainment equipment and the SCART connector is compatible with most modern single, or twin speaker (stereo) televisions.

Specification of Prototype

Power supply input voltage:	11V to 13V
Current at 12V:	130mA 530mA with NICAM tuner and decoder
Input protection (crowbar)	
Over-voltage:	+15V
Reverse polarity:	−0·6V
Fuse rating:	1A
Tuning system (M491B)	
Station memory:	16-channel
Memory type:	Non volatile (ten-year data retention)
Memory supply voltage:	+25V (μA78S40 switching regulator)
Channel display:	7-segment LED
Voltage synthesizer:	13-bits (8192-steps)
Clock oscillator:	455KHz
Keyboard matrix:	Channel, Tuning UP/DOWN and Store
Remote control input:	PCM signals
Push-button switching:	Power ON/OFF Audio tune NICAM/FM UK/Continental M1+M2 M1 M2
Sockets	
Stereo audio output:	SCART, DIN and Phono
Composite video output:	SCART and Phono
DC power input:	2·5mm



Inside the NICAM Tuner.

Circuit Description

In addition to the circuits shown in Figures 1, 3 and 4 a block diagram is detailed in Figure 2. This should assist you when following the circuit description or fault finding in the completed unit.

To reduce the amount of wiring in the project all the connectors (SK1 to SK6) are mounted directly on to the socket PCB. The DC power for the circuit is applied to SK1 and must be within the range of 11V to 13V with the positive supply on the centre pin. The input voltage is decoupled by C2 to C4 and further decoupling is provided at regular intervals on the other two PCB's. If the supply is reversed, diode D1 will conduct, blowing the 1A fuse FS1, this will also happen if the supply voltage exceeds 15V. Over-voltage protection is provided by a thyristor TH1 with a 15V zener diode ZD1 feeding its gate. Finally, the decoupled and protected positive supply appears on P2 with its ground return, 0V1, on pin 1.

The stereo audio output from the NICAM decoder (stock code LP02C) is connected to the socket PCB as follows:

P3 – decoder PL6 pin 1 (right channel)
P4 – decoder PL6 pin 2 (0V2 screen)
P5 – decoder PL6 pin 3 (left channel)
P6 – decoder PL6 pin 4 (0V2 screen)

The audio output then appears on the sockets as follows:

Right – phono SK4 (full output)
Right – SCART SK5 pin 1 (full output)
Right – DIN SK2 pin 5 (attenuated output)
Left – phono SK3 (full output)
Left – SCART SK5 pin 3 (full output)
Left – DIN SK2 pin 3 (attenuated output)
0V2 – phono SK3 and SK4
0V2 – SCART SK5 pin 4
0V2 – DIN SK2 pin 2

The video output (PL3 pin 1) from the NICAM television tuner (stock code

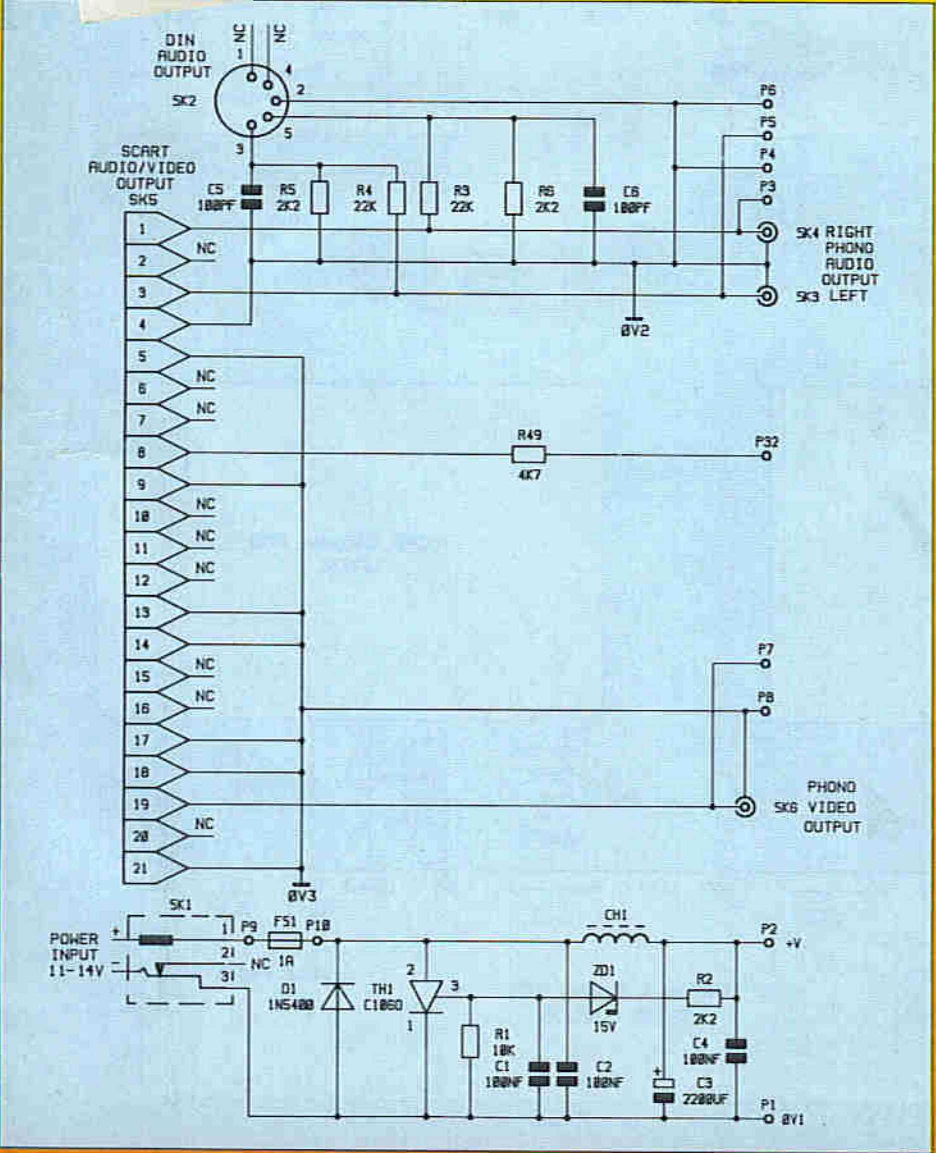


Figure 1. Circuit 1 Socket PCB.

LP09K) is connected to P7 then fed to the phono socket SK6 and pin 19 of the SCART connector SK5. The tuner 0V3 video screen (PL3 pin 2) connects to P8, SK6 and pins 5, 9, 13, 14, 17, 18 and 21 of SK5.

Pin 8 of the SCART socket SK5 is used to switch the function of the television from broadcast (logical '0') to SCART peritelevision reproduction (logical '1'). This is achieved by applying +12V to P32 on the socket PCB from P31 on the switch PCB when the power is switched on.

The +12V supply from P2 on the socket PCB connects to P2 on the switch PCB with the 0V1 ground return on P1. Switch S1 is used as the power on/off control for the accessory circuits and the NICAM boards which are connected in the following manner:

P3 – decoder PL1 pin 1 (positive supply)
P4 – decoder PL1 pin 2 (0V2 ground)
P5 – tuner PL1 pin 2 (positive supply)
P6 – tuner PL1 pin 1 (0V3 ground)

Two additional positive supplies are required by the voltage synthesis tuning system, IC2, located on the display PCB. The first is a simple +5V regulator, RG1, used to power the chip. The second more complex switching regulator, IC1, generates the +25V required to read from, or write to the non-volatile memory contained in IC2. A preset resistor, RV1, is used to set the output of IC1 to exactly +25V.

The interconnections between the switch and display PCB's is made by the correspondingly numbered 'PP' pads on the circuit boards. TR3 on the switch PCB is controlled by the Automatic Frequency Control (AFC) defeat output from pin 16 of IC2 on the display board via PP3. This output is normally high resulting in TR3 being turned on and its collector voltage will remain low until the AFC line changes. Each time a channel button is pressed the collector will go high and a half second delay is added when the button is released. If the button is held in, the channels are stepped up or down every half second and the collector of TR3 remains high. However, when the tune up or down button is used a one second AFC defeat will be added after the button is released. The collector voltage from TR3 is used to control TR4 and also passes through S2 to control the audio muting on both the NICAM tuner and decoder PCB's. The collector of TR4 is connected via P11 to PL5 pin 1 on the tuner PCB and when TR4 is turned on (AFC defeat low) the AFC action is switched out.

When changing channel or tuning in a TV station the ordinary FM and the NICAM digital stereo sound is muted. This is done to reduce any spurious noises to a minimum, especially when tuning across a station. The normal tuning procedure is to tune for the best quality picture at which point the sound should also be properly tuned in. However, if you do not have a TV or video monitor and you are only listening to the audio from a stereo system this function

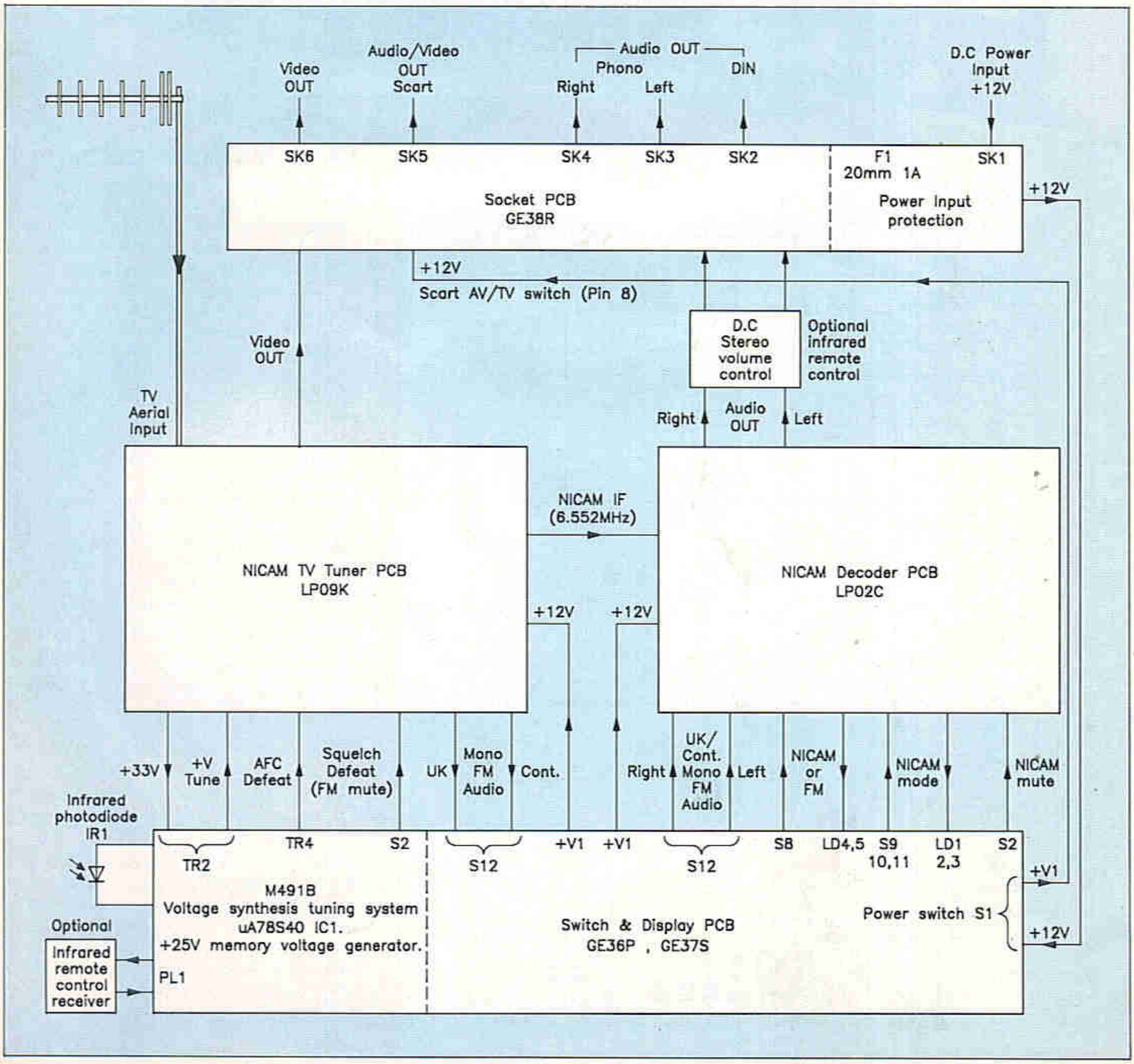


Figure 2. Block Diagram.

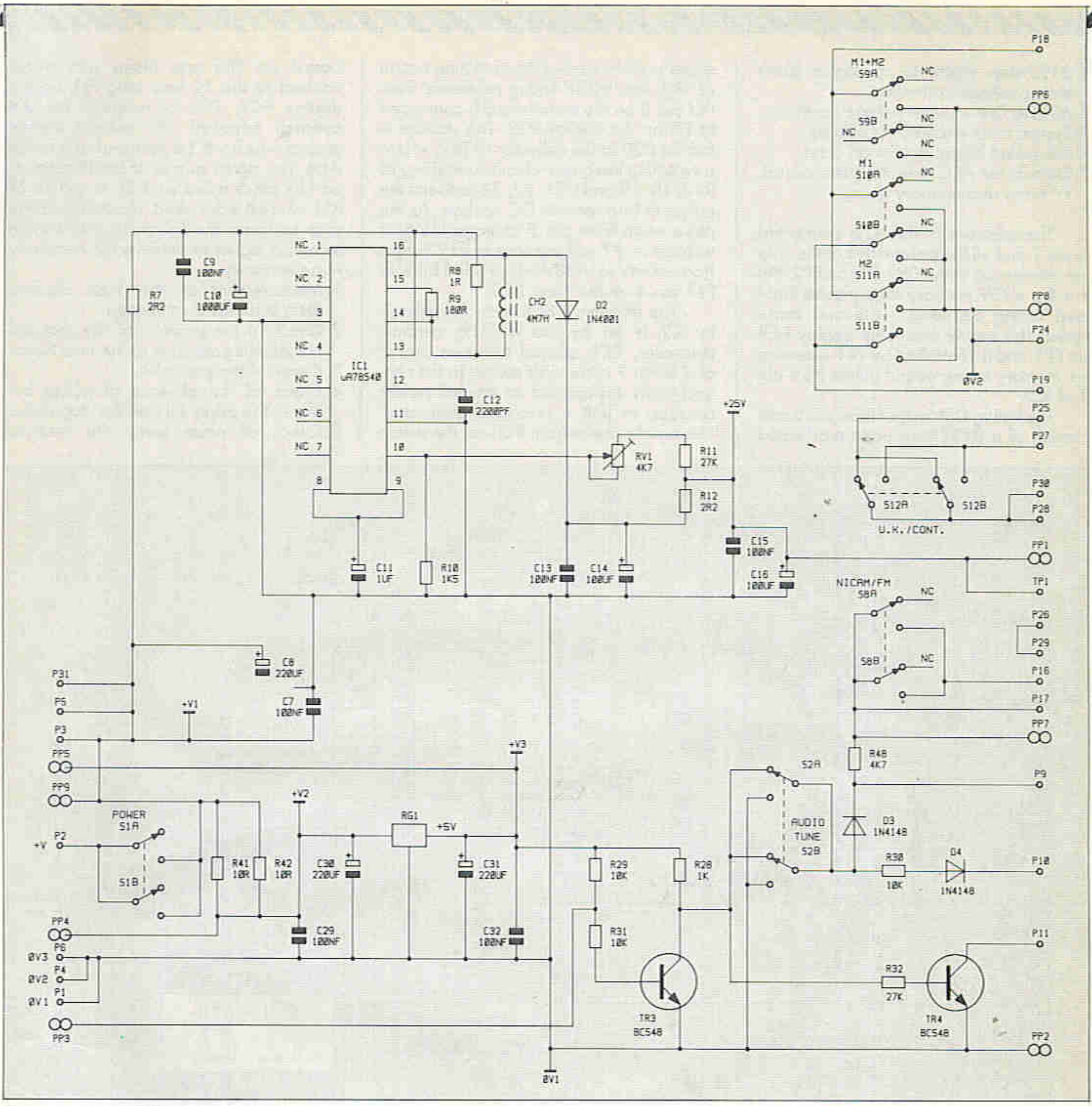


Figure 3. Circuit 2 Switch PCB.

must be overridden. This is accomplished by pressing in the audio tune switch S2 which removes the AFC defeat voltage from the junction of D3 and R30. When the AFC defeat voltage is present it passes through R30 and D4 on to P10 which is connected to PL1 pin 6 on the NICAM tuner board. When this positive bias voltage is applied, the FM squelch circuit becomes active and mutes the sound. To mute the NICAM audio the AFC defeat voltage passes through D3 on to P9 which is connected to PL4 pin 6 on the decoder. In addition, the NICAM mode is automatically deselected by the same voltage passing through R48 on to P17 which is connected to PL7 pin 2. The NICAM mode can also be manually switched out at any time by pushing in S8, and pin 1 of PL7 supplies this voltage to P16 which then passes through S8 back to P17.

When the NICAM audio is deselected the ordinary FM signal is switched through the decoder board. However, the tuner is equipped with a dual FM demodulator for both the 6MHz UK and 5·5MHz continental sound system. When in its out position S12 on the switch PCB selects the UK sound, or the continental sound when pushed in. The connections to and from this switch are as follows:

P25 – tuner PL4 pin 1 (6MHz FM audio)
P26 – tuner PL4 pin 2 (0V3 screen)
P27 – tuner PL4 pin 3 (5·5MHz FM audio)
P28 – decoder PL5 pin 3 (external input left)
P29 – decoder PL5 pin 2 and 4 (0V2 screen)
P30 – decoder PL5 pin 1 (external input right)

A group of three interlocking push switches S9, 10 and 11 are used to select the M1 or M2 options when the NICAM two channel mono mode is received. The logic '1' (+5V) input for the switches comes from PL3 pin 1 on the decoder board which connects to P15 on the display PCB. This voltage then passes through R47 and PP6 returning back to the switch assembly. The logic '0' (0V2) input is connected via P24 to PL4 pin 8 on the decoder. The switches have two output lines which are connected to the NICAM decoder as follows:

P18 – decoder PL4 pin 3 (select 1)
P19 – decoder PL4 pin 4 (select 2)

Mounted on the display PCB is IC2 a M491B TV tuner voltage synthesis tuning system, see Figure 5 and Table 1. The M491B is a monolithic N-MOS LSI chip which has several different types of circuits included in its construction:

1. 16-channel station memory.
2. 7-segment LED station display.
3. Keyboard matrix.
4. PCM control input (Infra-red remote control).

5. 8192-step digital to analogue (D/A) tuning voltage converter.
6. 63-step D/A volume voltage converter.
7. System clock oscillator (455kHz).
8. Integrated digital power on reset.
9. Outputs for AFC defeat, power on/off, TV band and memory timing.

The substrate of this IC is connected to pin 1 and all the parameters of the chip are referenced to the 0V1 line on PP2. Pin 2 is the +25V memory supply pulse input used during the read, write and erase cycles. This supply enters the display PCB via PP1 and is controlled by TR1 receiving the memory timing output pulses from pin 3 of IC2.

The tuning D/A output is on pin 5 and consists of a 8192-step pulse modulated signal used to control the switching action of TR2. The +33V tuning reference from PL1 pin 3 on the tuner board is connected to P8 on the display PCB. This voltage is fed via R20 to the collector of TR2, where a switching integrator circuit comprising of R17, 18, 19 and C21, 22, 23 converts the pulses in to a smooth DC voltage. As the pulse width from pin 5 changes the tune voltage on P7 will increase in 8192-steps from +0·4V to +30V which is fed back to PL1 pin 4 on the tuner PCB.

The frequency of the clock oscillator in IC2 is set by the 445kHz ceramic resonator, CR1, placed between pins 7 and 8. Pin 9 is the +5V supply to the chip and when it is applied an internal power on reset of half a second is generated. This supply comes from RG1 on the switch board via PP5 and along with others connect to the 12-way plug PL1 on the display PCB. PL1 is reserved for the optional infra-red (IR) remote control project which will be released at a future date. The signal output of the IR receiver on PL1 pin 5 is fed via C20 to pin 11 of IC2 where it is decoded. This section of the chip performs the following tests on the incoming signal to achieve the necessary noise immunity:

1. Measurement of the pulse distance (time base synchronization).
2. Check of the position of the received bits opening window at the time bases.
3. Check of the parity bit.
4. Check of the absence of pulses between the parity bit and the stop pulse.
5. Check of noise level; the receiver

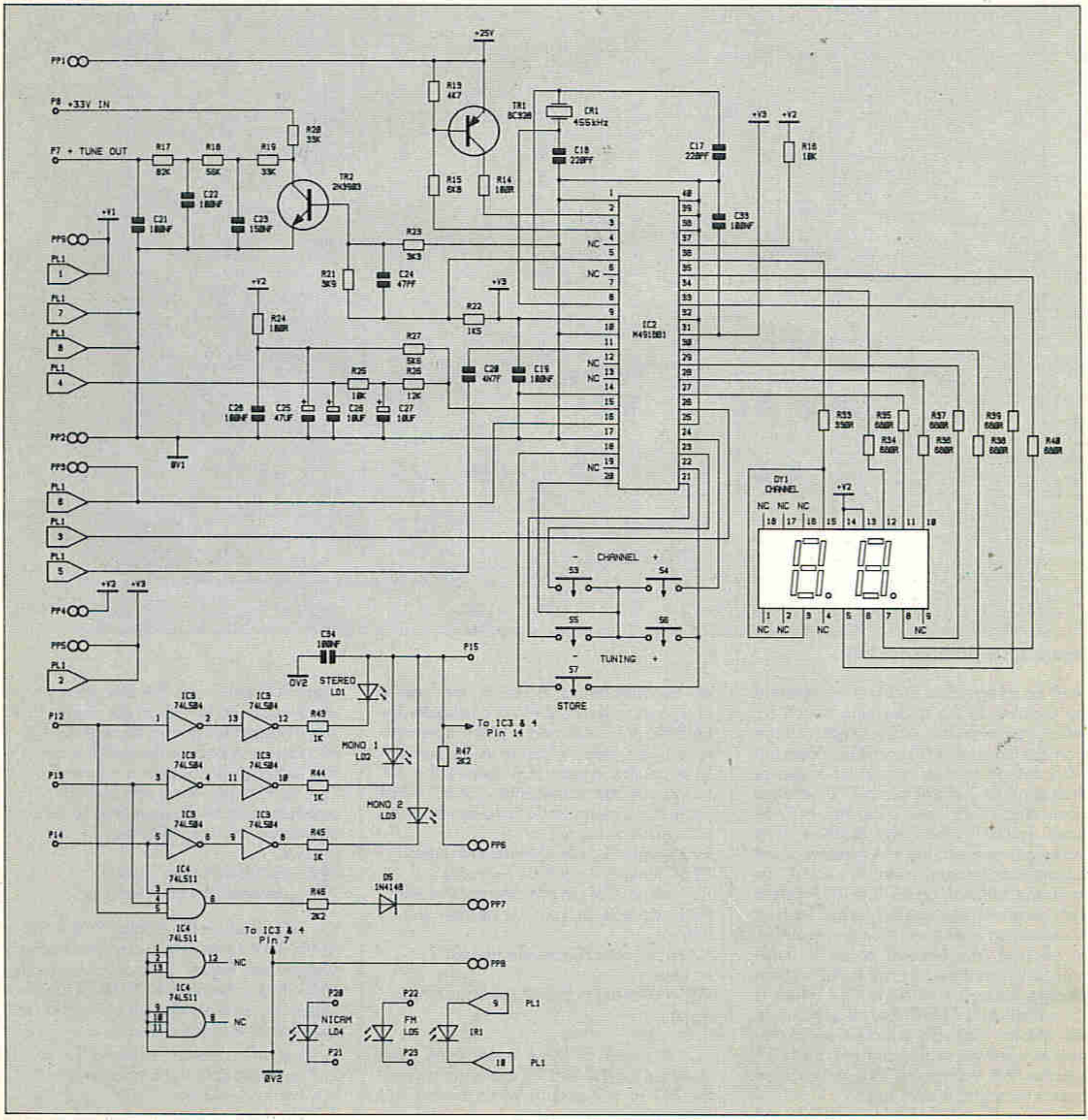


Figure 4. Circuit 3 Display PCB.

checks parasitic transient inside and outside the time windows.

If the test conditions are not fulfilled the received command is rejected. However, if the received signal is acknowledged as valid it is stored and decoded. The end of transmission will be acknowledged by receiving the end of transmission code or by means of an internal timer if the transmission remains interrupted for more than approximately 550ms.

Included in the design of the optional IR receiver is a DC voltage controlled stereo signal attenuator. The DC control is generated by the 7·8kHz square wave signal from the D/A volume output on pin 15 of IC2. This signal has a 63-step variable duty cycle and in the case of a continuous command changes at the rate of approximately one step every 100ms. This signal is converted by R25, 26 and C26, 27 into a smooth DC voltage which is directly proportional to the duty cycle. This DC output on PL1 pin 4 can be reduced to a minimal level and reset to the previous setting by means of the mute on/off command. The volume is also muted for about one second at each power on/off command and half a second for each change of channel. Pin 16 of IC2 is the AFC defeat output which is connected to PP3 and controls the switching action of TR3 on the switch PCB as previously described.

The keyboard matrix on pins 18 to 24 will accept a command if the corresponding contact has been closed for a minimum time of 30ms. If a complete IR command has been received the keyboard inputs are blocked until the command has been executed and the end of transmission code is generated. Only some of the keyboard commands have been implemented so the full matrix is not

STOP PRESS ... STOP PRESS

A ready-built version of the NICAM decoder board will be available from June 1990. **Order code AM00A, price £129.95.**

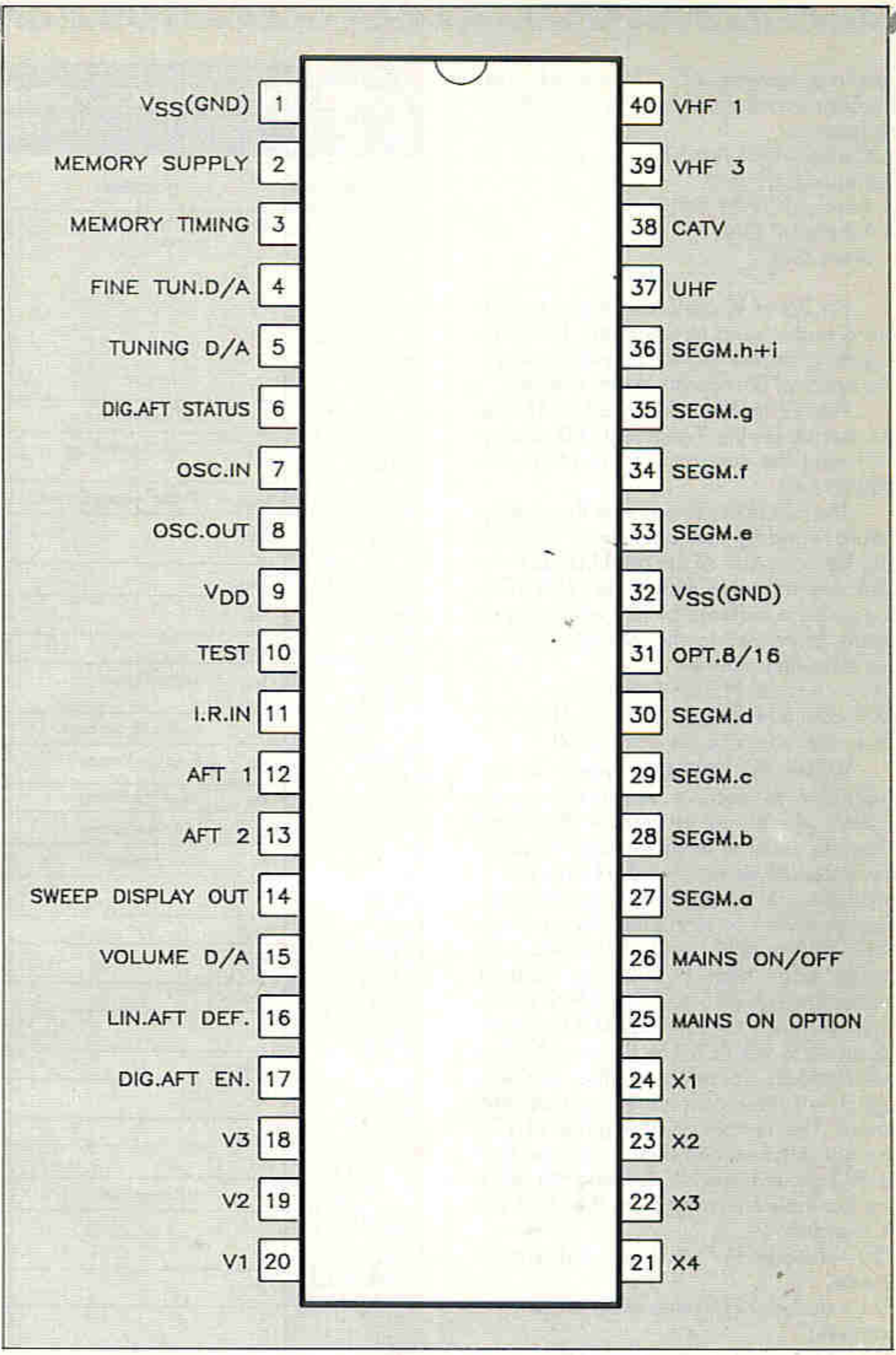
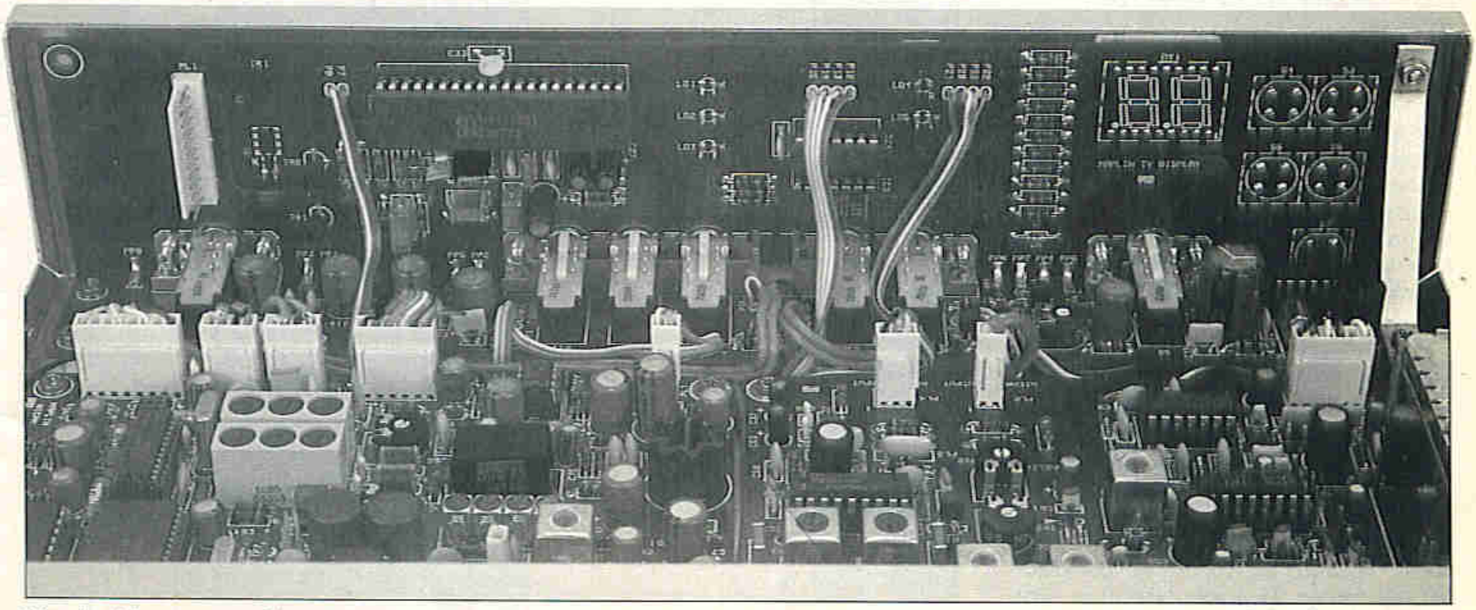


Figure 5. M491B Pin-out.



View inside rear panel.

required leaving pin 19 unused. The keyboard commands used by the unit are as follows:

1. Channel DOWN (S3)
2. Channel UP (S4)
3. Tuning DOWN (S5)
4. Tuning UP (S6)
5. Store (S7)

Pin 26 of IC2 is brought out to PL1 pin 3 and is used to signal the TV/video switching on the SCART connector when the optional IR receiver board is fitted.

Pins 27 to 30 and pins 33 to 36 are the outputs for the 7-segment LED display DY1 and the connections are made via R33 to R40.

The rest of the circuitry on the display board is mostly concerned with controlling the condition of the red LED's LD1 to LD5. The three NICAM mode LED's LD1, 2 and 3 are buffered by IC3 which has its inputs connected to the decoder PCB in the following manner:

P12 – decoder PL3 pin 8 (Stereo)
P13 – decoder PL3 pin 6 (Mono 1)
P14 – decoder PL3 pin 4 (Mono 2)

Within the NICAM system is the capability to receive non-audio information where one, or both of the sound channels could in future be used to carry this data. When no sound information is available LD1, 2 and 3 will not light up. This condition is monitored by a three input AND gate IC4 and when it occurs its output goes high (+5V). The voltage passes through R46 and D5 to PP7 which connects back to the NICAM/FM switch S8 on the switch PCB. This has the effect of automatically deselecting the NICAM signal in preference for the normal FM sound. The remaining two gates of IC4 are not required and their inputs are tied to 0V2 ground. The NICAM and FM LED's are controlled directly from the decoder PCB as follows:

P20 – decoder PL7 pin 5 (NICAM LD4 anode)
P21 – decoder PL7 pin 6 (NICAM LD4 cathode)
P22 – Decoder PL7 pin 3 (FM LD5 anode)
P23 – Decoder PL7 pin 4 (FM LD5 cathode)

The remaining opto device IR1 is an infra-red photodiode which has the speed and sensitivity required for remote control applications. Its anode and cathode are connected to pins 9 and 10 of PL1 which is reserved for the optional IR remote control receiver. IR1 is included in the accessory kit as it simplifies the later installation of the receiver board.

Next Time

In the next edition of 'Electronics - The Maplin Magazine' August - September '90 Issue Number 39 (XA39N), we present Part Two of this article which gives full constructional details. There is also a special offer for a complete kit of all the parts required to build the complete NICAM Stereo TV Tuner Unit at a very special price.

Table 1. M491B STATIC ELECTRICAL CHARACTERISTICS
(T_{amb} = 0 to 70°C, V_{DD} = 5V unless otherwise specified)

Pins	Parameter		Test conditions		Values			Unit
					Min.	Typ.	Max.	
2-Memory 2-Supply	I_{pp}	Memory Supply Current	$V_{pp}=26V$					
			Write	Peak Average			42 12	mA mA
			Erase	Peak Average			9 5	mA mA
			Read	Peak Average			8 2.5	mA mA
	R	Pull down resistor					25	KΩ
3-Write Timing 3-Out	V_{OL}	Output Low Voltage	$V_{DD}=4.75V$	$I_{OL}=2.5mA$			8	V
	$I_{O(off)}$	Output Leakage Current	$V_{DD}=4.75V$	$V_{OUT}=26V$			100	µA
4-Fine Tuning 4-D/A	$I_{O(off)}$		$V_{DD}=5.25V$	$V_{O(off)}=13.2V$			50	µA
5-Tuning D/A	V_{OL}		$V_{DD}=4.75V$	$I_{OL}=5mA$			1	V
6-Digital AFT 6-Out	V_{OL}		$V_{DD}=4.75V$	$I_{OL}=20mA$			1.5	V
	$I_{O(off)}$		$V_{DD}=5.25V$	$V_{O(off)}=13.2V$			100	µA
9-Power 9-Supply	I_{DD}	Supply Current	$V_{DD}=5.25V$				100	mA
11-I.R. Input	V_{IPP}	Peak to peak voltage			0.5		13.2	V
12-AFT 1 13-AFT 2	V_{IL}	Input Low Voltage	$V_{DD}=5.25V$				1.5	V
	V_{IH}	Input High Voltage	$V_{DD}=5.25V$		3.5			V
	I_{IL}	Input Low Current	$V_{DD}=5.25V$	$V_{IL}=1.5V$			−0.4	mA
	R	Pull-up resistor				30		KΩ
14-Display 14-Out	V_{OL}		$V_{DD}=4.75V$	$I_{OL}=20mA$			1.5	V
	$I_{O(off)}$		$V_{DD}=5.25V$	$V_{O(off)}=13.2V$			100	µA
15-Volume 15-D/A	V_{OL}		$V_{DD}=4.75$	$I_{OL}=4mA$			1	V
	$I_{O(off)}$		$V_{DD}=5.25V$	$V_{O(off)}=13.2V$			50	µA
16-Linear AFT 16-Out	V_{OL}		$V_{DD}=4.75V$	$I_{OL}=1mA$			0.4	V
	$I_{O(off)}$		$V_{DD}=5.25V$	$V_{O(off)}=13.2V$			50	µA
17-Digital AFT 17-Enable	V_{IL}						0.8	V
	V_{IH}				2.0			V
	I_{IL}		$V_{DD}=5.25V$	$V_{IL}=0.8V$			−0.4	mA
	R	Pull-up resistor				30		KΩ
18-19-20 V3 V3 Keyboard In V2 V2 V2 V1	V_{IL}						1.5	V
	V_{IH}				3.5			V
	I_{IL}		$V_{DD}=5.25V$	$V_{IL}=0.8V$			−0.4	mA
	R	Pull-up resistor				30		KΩ
21-22-23-24 X4 X3 Keyboard X2 Out X1	V_{OL}		$V_{DD}=4.75V$	$I_{OL}=1mA$			0.4	V
	$I_{O(off)}$		$V_{O(off)}=5.5V$				25	µA
25-Mains on Enable	V_{IL}						0.8	V
	V_{IH}				2.4			V
	I_{IL}		$V_{DD}=5.25V$				−0.4	mA
	R	Pull-up resistor	$V_{IL}=0.8V$			30		KΩ
26-Mains 26-On/Off	V_{OL}		$V_{DD}=4.75V$	$I_{OL}=100µA$			0.4	V
	I_O		$V_{DD}=4.75V$	$V_O=0.7V$	−1.6			mA
27-28-29-30 33-34-35 Display Out	V_{OL}		$V_{DD}=4.75V$	$I_{OL}=20mA$			1.5	V
36-Display Out	V_{OL}		$V_{DD}=4.75V$	$I_{OL}=30mA$			1.5	V
31-Memory	V_{IH}				2.0			V
	V_{IL}						0.8	V
37-UHF B 38-CATV A 39-VHFIII N 40-VHFI D	V_{OL}		$V_{DD}=4.75V$	$I_{OL}=1mA$			3	V
	V_{OH}		$V_{DD}=4.75V$	$I_{OH}=-150µA$	2.4			V
	V_{IL}						0.3	V
	V_{IH}				3			V
	$I_{O(off)}$		$V_{DD}=5.25V$	$V_{O(off)}=13.2V$			50	µA

Air your views!

A readers forum for your views and comments. If you want to contribute, write to the Editor, 'Electronics – The Maplin Magazine', P.O. Box 3, Rayleigh, Essex, SS6 8LR.

Pinless Chips

Dear Sir,

As one who dabbles in the hardware side of computers, I read with great interest the article by Mr Dixey in your No.37 issue on data transmission. It was very informative, but alas falling into the same trap as most other literature, in after describing particular chips and not giving the pin-outs of them. The most difficult thing to obtain is information – especially that which enables one to actually use a chip. May I respectfully request that all authors include pin-outs when mentioning chips in their articles. As I am now retired, and on a limited budget, my own projects mostly centre around recovered chips from scrapped computers which I have collected over the years – how about some knowledgeable person writing articles on chips, not the run-of-the-mill 74 or 40 series, but on the 24 to 40 pin chips that are/have been used in electronics. Incidentally, I find your catalogue very useful but limited in this respect as it describes only current chips. However, I look forward to Mr Dixey's next article.

N. J. Tubb, Crawley, Sussex.

The article in question explains how various forms of data transmission work, and gives examples of various interface IC's. Printing the pin-outs of these IC's alone would not help anyone to use them as pin-outs in isolation from timing diagrams, specifications and pin designations are not much use. If we printed the necessary information and diagrams, the magazine would be an 80 page data-sheet! For information on specific interfacing to particular computers, our range of books is the best solution. But did you know we offer a Data Sheet service? For 40 pence, we can supply you with data on any IC that we stock, generally these data sheets contain application circuits and useful information on how the device can be used. The Data File series of articles has and will continue to deal with many different kinds of analogue and digital IC's. I hope you will enjoy reading the next part, Computers in the Real World on page 58.

Picture Problems

Dear Sir,

The caption to photo 9 on page 24 of April's M.M. should read "the power connections are made to the pins at the bottom: 0V left and 5V right". The photo shows the transistor BC212L wrongly positioned. A pity it is a course for beginners.

J. W. Biggs, Hertford.

On your first point, you are quite correct, the picture was printed upside down so the pins were at the bottom instead of the top! So your caption is correct. On the second point, the BC212 in the picture is correctly orientated, as it is not an L suffix device. However we only sell L suffix devices, the pin-out of which is given in Figure 6.

Oh No Not Those Old Projects Again!

Dear Sir,

I have received my copy of the April/May 1990 issue of your magazine and have noticed that four out of the six projects featured are merely revamps of old projects. Two of the four are very little different to the original, and in my opinion, none of them merit a full reprint. One of the other projects is very simple, though an excellent teach project for those new to the hobby. However, I am glad to see that you are introducing your readers to the very rewarding area of video electronics with the TV line-up chart generator.

M. Ellis, Kingston-upon-Thames, Surrey.

The reason for reprinting the Car Digital Tachometer and the Car Battery Monitor is that they were published in 'Best of E&MM' this publication is now out of print. These two projects were originally published in issues 1 & 2 of E&MM way back in 1981. So congratulations for being a 'founder' reader of both 'E&MM' and 'Electronics'! Since 1981 we have gained many thousands of readers and new readers would completely miss out on two extremely popular projects if we didn't reprint. After all, 9 years between repeating a project is not bad going, many other magazines cannot boast the same! The Digital Logic Tester and the ADA Echo updates are tried and tested readers modifications, it was thought that people who have built these projects would like to know ways of improving them. If anyone else has further comments or suggestions about reprints and updates, please write in, after all it is your feedback that helps us include the projects and features that you want to see.

Fast Dealings

Dear Sir,

What can I say? I wrote to you about the non arrival of 'Electronics – The Maplin Magazine', No.36, posted letter on Monday and HEY PRESTO, on the following Thursday it arrived from you in a large brown envelope, nicely addressed. No mistake could be made by our Postal Service. Then in magazine No.37 an article about your address system of the magazine called "Addressing the Problem", by another unhappy customer, seems that I was not the only one. But like your pun in your reply, that you are aware of the problem and that you will be able to address it. "Ha Ha", very good. Thanking you all for such a prompt reply to my letter.

T. K. Currie, Chigwell, Essex.

★★★★★★★★★★★★★★★★★★★★

STAR LETTER

This issue Mr F. Thomas from Dyfed in Wales receives the Star Letter Award of a £5 Maplin Gift Token for his letter on... Well read-on and you will find out!

Feline Frolics

Dear Sir,

This is a letter of contentment, in particular, where three semi-feral cats are concerned. What on earth has a trio of felines got to do with an electronics book? I shall explain. In total, I have purchased four of your Outdoor PIR units (XG96E) which have been installed on various properties, most of which are in somewhat isolated areas. The third one caused a problem, in so far that it would trigger on and off for no definable reason. So I wrapped it up and returned it to your service department as per warranty. Back it came, flea in ear notation, unit is fully functional. After due examination, I decided the system was being triggered by an upward flow of warm air. Changed the location and problem ceased. The fourth all but broke my heart. Had installed the PIR, the property was about as accessible as the dark side of the moon. Owners were delighted with the system as they now felt more secure. About a week later, the phone rang, and I was told the unit was useless, since it would not turn off after the hours of darkness. Spent so much time toing and froing, my marital life was on the line. Decided to go out to the place where the problem was together with my dearly beloved, the idea being to sit in the car at dusk and await the onset of darkness. Eventually we were rewarded. Three magnificent cats arrived, sat in a circle totally silent, bathed in a pool of perpetual moonlight. The moment the house door was opened, they scarpered! This was two and a half years ago. My reward from the householders was a present of a beautiful kitten. (Most deals in Wales are on a barter basis.) We had her spayed, just as well, she is also feral, yet great fun in the radio shack. No mice around and the life of a fly is measured in micro seconds. Guess what, called her KATHODE, she has a black band across her eyeline. Excellent magazine which maintains an even presentation of general interest. Would like to see a write-up of Alan Dower Blumlein. A chap named Thompson was to have published a biography of the great man.

Perhaps we should have sent you £5's worth of 'Whiskas' cat food instead of a Maplin Gift token!

★★★★★★★★★★★★★★★★★★★★

Where's Bob's Mini Circuits?

Dear Sir,

After being introduced to Maplin through a friend, I have bought several kits and components from you, also I got a few back issues of the Maplin magazine. I was so impressed I decided to take out a subscription with you, then the other day I received my first up-to-date issue (37), turning the pages I discovered to my horror no 'Bob's Mini Circuits', what ever happened to Bob? Is he on holiday, or did he resign? This was my favourite feature in the magazine with such easy to build and useful circuits. Will we see a return of Bob's mini circuits, if not what about one of your other technical designers doing a similar feature!

You can be rest assured that Bob will be returning with some more of his Mini Circuits in the very near future.

Hot Line is Not so Hot!

Dear Sir,

I normally purchase at one of your shops. Having recently moved I decided to use your 'same day credit card hotline'. I 'phoned at 4pm and the lady extracted all the information from me and then told me the order would be sent on Monday – my reply – "forget it, I can purchase locally". If this is a reflection of your 'hot line' service you get 0 out of 10 and to think I went along with the praise recently given to you in P.W. I only wanted a 27128 EPROM. I doubt if this kind of complaint gets printed in your Electronics Magazine.

H. Andrew, Norfolk.

Brenda Crickmar, Customer Services Manager Replies:

Unfortunately on the day you tried to place your order our computer was down from 3pm onwards. This is a rare occurrence, but when it happens we are powerless to do anything about it and this is why we were unable to dispatch your goods for you on this occasion. We consider that being able to dispatch goods up to 5pm on the same day as ordered by phone is an extremely good service. This is our normal service and if from time to time there is an abnormal circumstance which prevents us from doing so, as on the day you tried to place your order, we can only apologise and assure you we do our very best to live up to our speedy reputation.

DATA FILE

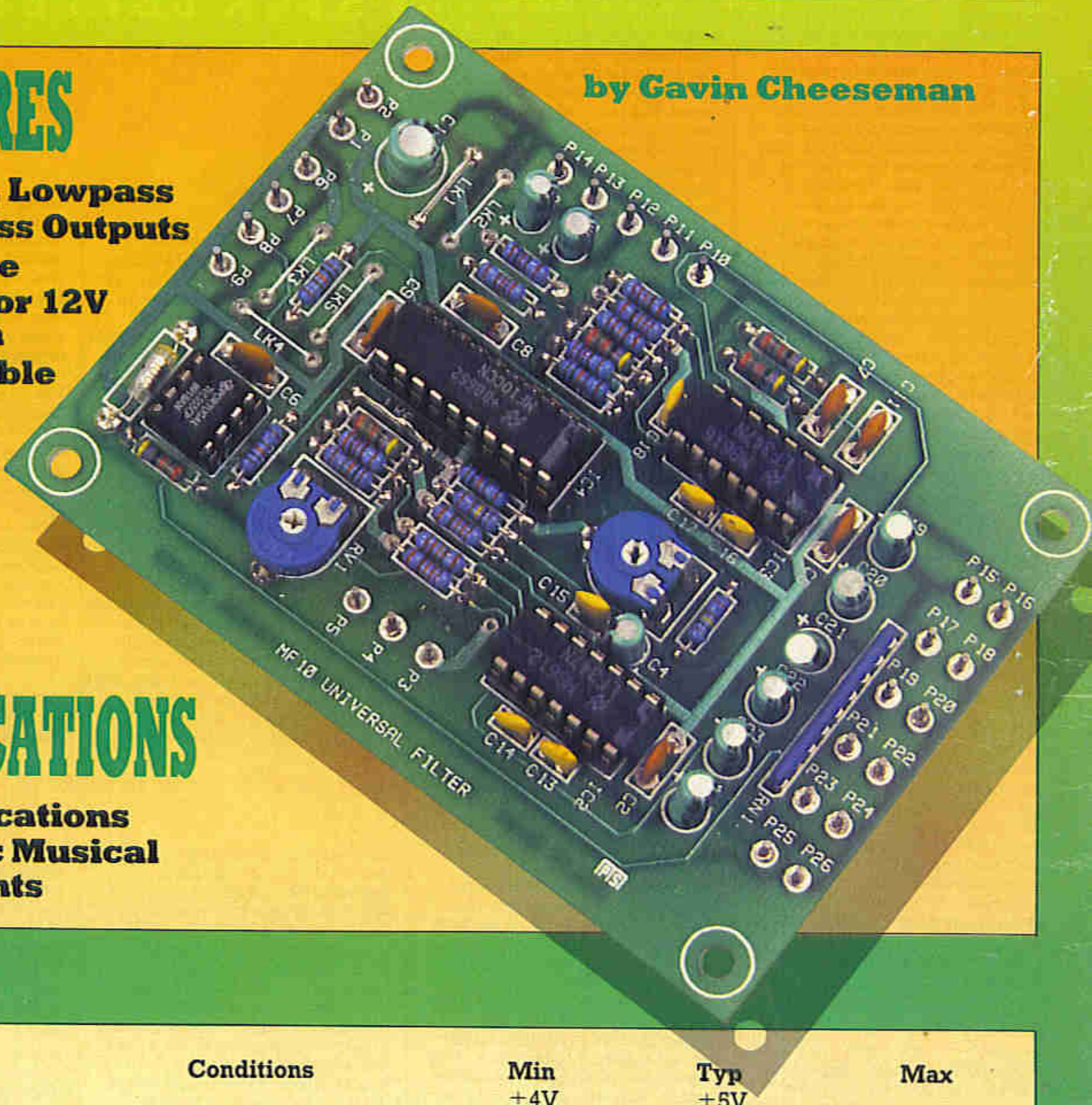
MF10

UNIVERSAL SWITCHED CAPACITOR FILTER

by Gavin Cheeseman

FEATURES

- ★ Highpass, Lowpass & Bandpass Outputs
- ★ Easy to Use
- ★ Suitable for 12V Operation
- ★ Kit Available



APPLICATIONS

- ★ Communications
- ★ Electronic Musical Instruments

Parameter	Conditions	Min	Typ	Max
Supply Voltage		±4V	±5V	
Absolute Maximum				±7V
Supply Current			8mA	10mA
Maximum Clock Frequency		1MHz	1.5MHz	
Clock Feedthrough			10mV	
Crosstalk			50dB	
Operating Temperature	Absolute Maximum	0°C		70°C
Storage Temperature	Absolute Maximum			150°C
Power Dissipation	Absolute Maximum			500mW

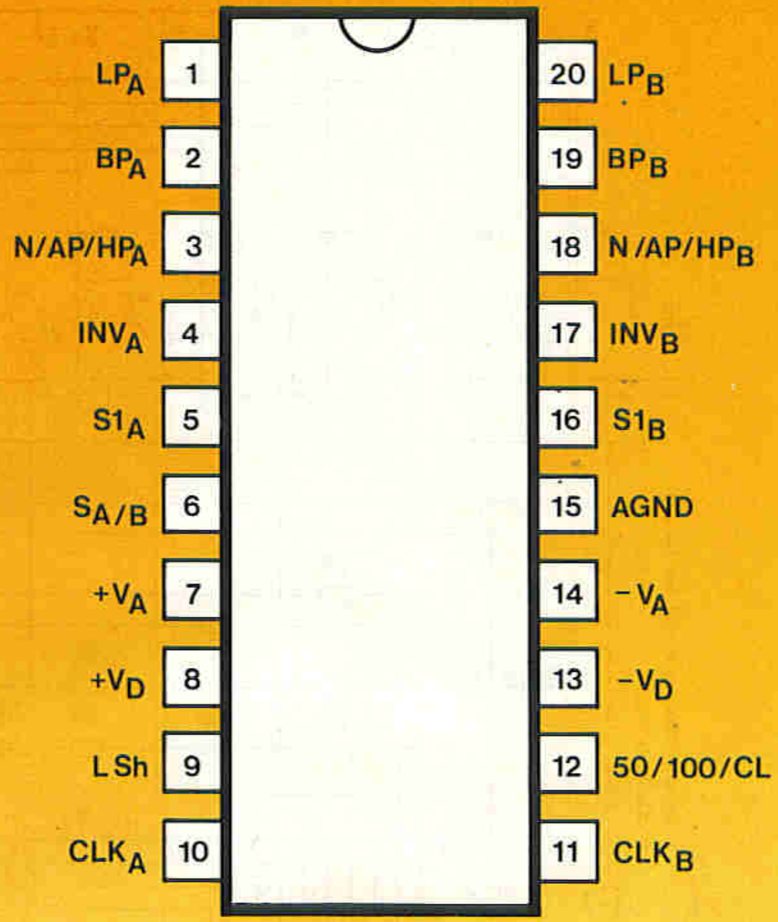
Table 1. MF10 Typical Electrical Characteristics.

Introduction

The MF10 effectively contains two CMOS active filter building blocks which can be configured with the addition of external components, to produce different second order functions (12dB/octave). It is possible to use either of the blocks individually or alternatively the two blocks may be cascaded to provide higher order functions. Figure 1 shows the IC pinout diagram and Table 1 lists some typical electrical characteristics for the MF10.

IC Description

The MF10 is supplied in a 20 pin DIL package which comprises two active filter blocks. Each block has 3 separate output pins: pin 1 (20) and pin 2 (19) provide lowpass and bandpass outputs respectively, whilst pin 3 (18) may be configured to perform either notch, highpass or allpass functions. The cutoff frequency of the filter is partially determined by the frequency of the clock and partially by external resistor ratios depending on the circuit configuration used. Both lowpass and bandpass outputs can be configured so that the cutoff frequency is a direct



Pin Description

LP, BP, N/AP/HP	These are the lowpass, bandpass, notch or allpass or highpass outputs of each 2nd order section. The LP and BP outputs can sink typically 1 mA and source 3 mA. The N/AP/HP output can typically sink and source 1.5 mA and 3 mA, respectively.
INV	This is the inverting input of the summing op amp of each filter. The pin has static discharge protection.
S1	S1 is a signal input pin used in the allpass filter configurations (see modes of operation 4 and 5). The pin should be driven with a source impedance of less than 1 kΩ.
$S_{A/B}$	It activates a switch connecting one of the inputs of the filter's 2nd summer either to analog ground ($S_{A/B}$ low to V_A^-) or to the lowpass output of the circuit ($S_{A/B}$ high to V_A^+). This allows flexibility in the various modes of operation of the IC. $S_{A/B}$ is protected against static discharge.
V_A^+, V_D^+	Analog positive supply and digital positive supply. These pins are internally connected through the IC substrate and therefore V_A^+ and V_D^+ should be derived from the same power supply source. They have been brought out separately so they can be bypassed by separate capacitors, if desired. Thy can be externally tied together and bypassed by a single capacitor.
V_A^-, V_D^-	Analog and digital negative supply respectivley. The same comments as for V_A^+ and V_D^+ apply here.
L Sh	Level shift pin: it accommodates various clock levels with dual or single supply operation. With dual ± 5V supplies, the MF10 can be driven with CMOS clock levels (± 5V) and the L Sh pin should also be tied either to the system ground or to the negative supply pin. If the same supplies as above are used but T^2L clock levels, derived from 0V to 5V supply, are only available, the L Sh pin should be tied to the system ground. For single supply operation (0V and 10V) the V_D^-, V_A^- pins should be connected to the system ground, the AGND pin should be biased at 5V and the L Sh pin should also be tied to the system ground. This will accommodate both CMOS and T^2L clock levels.
CLK (A or B)	Clock inputs for each switched capacitor filter building block. They should both be of the same level (T^2L or CMOS). The level shift (L Sh) pin description discusses how to accommodate their levels. The duty cycle of the clock should preferably be close to 50% especially when clock frequencies above 200 kHz are used. This allows the maximum time for the op amps to settle which yields optimum filter operation.
50/100/CL	By tying the pin high a 50:1 clock to filter center frequency operation is obtained. Tying the pin at mid supplies (i.e., analog ground with dual supplies) allows the filter to operate at a 100:1 clock to center frequency ratio. When the pin is tied low, a simple current limiting circuitry is triggered to limit the overall supply current down to about 2.5 mA. The filtering action is then aborted.
AGND	Analog ground pin; it should be connected to the system ground for dual supply operation or biased at mid supply for single operation. The positive inputs of the filter op amps are connected to the AGND pin so "clean" ground is mandatory. The AGND pin is protected against static discharge.

Figure 1. IC Pinout.

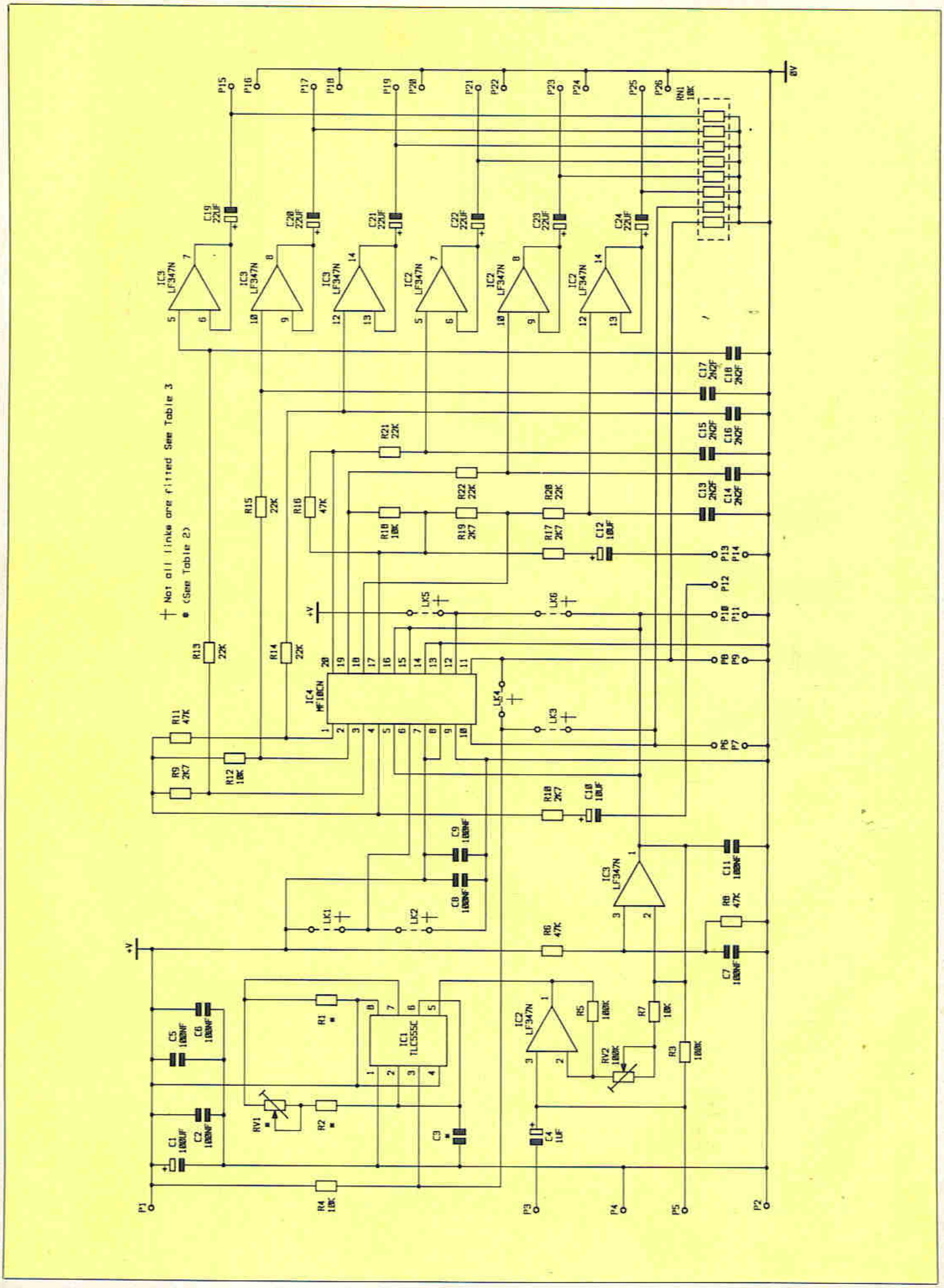


Figure 2. Circuit Diagram.

submultiple of the clock frequency. The centre frequency of the notch and allpass circuits is always directly dependant on clock frequency.

IC Power Supply Requirements

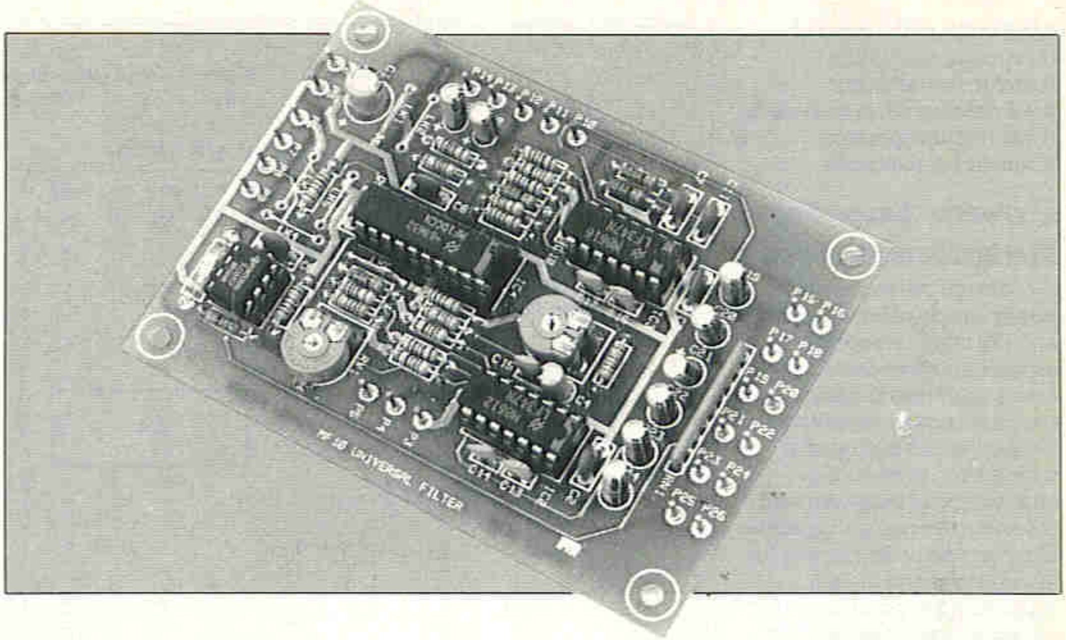
The MF10 requires a split rail power supply of typically ±5V at around 8mA. Separate pins are provided for analogue and digital supplies and separate supply rails should be used if minimal interaction between the analogue and digital sections of the circuit is to be achieved. Both the analogue and digital supplies should be decoupled individually; this is particularly important at high frequencies to prevent the clock from modulating the output.

Kit Available

A kit of parts including a high quality fibreglass PCB is available as an aid to constructors, for a general purpose application circuit using the MF10 switched capacitor filter IC. Figure 2 shows the circuit diagram of the module and Figure 3 shows the PCB legend.

The module has an on-board clock and 6 separate buffered outputs (3 for each filter block). Facility is provided for voltage control of the clock frequency and selectable clock/centre frequency ratio. The circuit caters for lowpass, bandpass and notch filter characteristics with the option for alternative highpass operation. If required the on-board clock may be disconnected to allow the use of an external clock oscillator.

Connection information is given in Figure 4. Inputs are connected between P11(0V) & P12(i/p) and P13(i/p) & P14(0V). Output signals are taken from P15 - P26. The frequency of the internal clock is adjusted by preset resistor RV2, the range of which is set by resistors R1 & R2 and capacitor C3. The kit contains the basic component values to allow the circuit to operate on any one of three different ranges and Table 2 shows the options available. It should be noted that the ranges shown are based on 100/1 clock/centre frequency ratio and apply to the basic notch/bandpass/lowpass mode only.



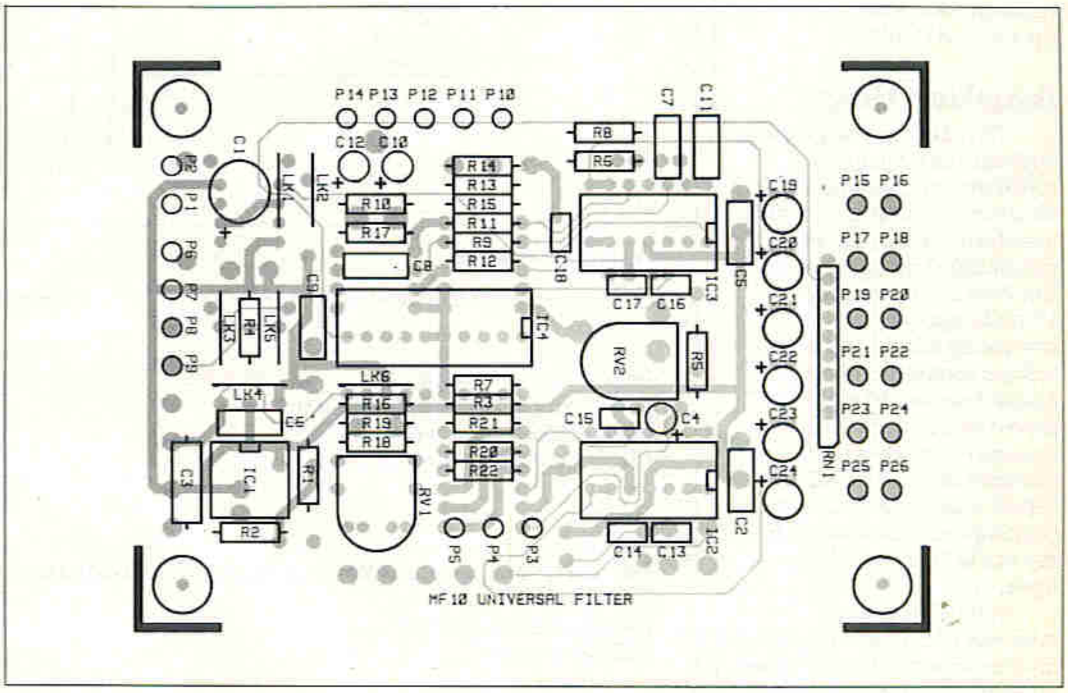


Figure 3. Legend.

Frequency Range	R1	R2	RV1	C3
10Hz – 150Hz	10k	47k	1M	1000pF
100Hz – 1.4kHz	10k	47k	1M	100pF
1kHz – 8kHz	1k	4k7	100k	100pF

Table 2. Approximate Frequency Ranges and Corresponding Component Values.

Clock frequency may also be adjusted by applying a voltage to the voltage control input (P3 - P5) and the sensitivity of this input is adjusted using preset resistor RV2.

Some of the facilities provided by the module are selected by fitting links. There are 6 links and Table 3 shows which of these must be fitted for each function. The links marked with a tick must be fitted when the function shown in the corresponding left hand column of the table is selected; those marked with an X symbol in the same column must be left out. In a typical example the module could be used to provide two sets of notch, bandpass and lowpass outputs using the on-board clock with a 100/1 clock/centre frequency ratio and in this case LK1, LK3, LK4 and LK6 only would be fitted.

If the internal clock oscillator is not required, then links LK3 and LK4 should not be fitted. An external clock signal may then be applied to P6(i/p) & P7(0V) and P8(i/p) & P9(0V). The maximum external clock frequency is typically 1.5MHz. It should also be remembered that output filter components C13 - C18, R13 - R15 and R20 - R22 limit the bandwidth, so the value of these components must therefore be taken into consideration when evaluating the maximum operating frequency of the circuit.

Power Supply Requirements

The circuit requires a power supply of between 8V and 12V which is capable of supplying at least 50mA. For optimum performance, a regulated power supply should be used, which is properly smoothed to prevent the introduction of mains derived noise into the system. Separate high frequency decoupling for the analogue and digital supplies is provided for in the circuit design. Power supply connections are made to P1(+V) and P2(0V).

Applications

The filter has many varied applications ranging from sound effect generation in electronic musical instruments to audio frequency filtering for communications equipment. The filter frequency may be swept by applying an alternating voltage to the voltage control input of the circuit, between P3 and P4. It should be noted that P3 is capacitively coupled and is therefore suitable for AC signals whereas P5 is directly coupled and more suitable for use as a DC control voltage input.

Typical frequency response characteristics, using the component values supplied in the kit are shown in Figure 5, Figure 6 and Figure 7. The responses shown are based on a centre frequency of 1kHz and

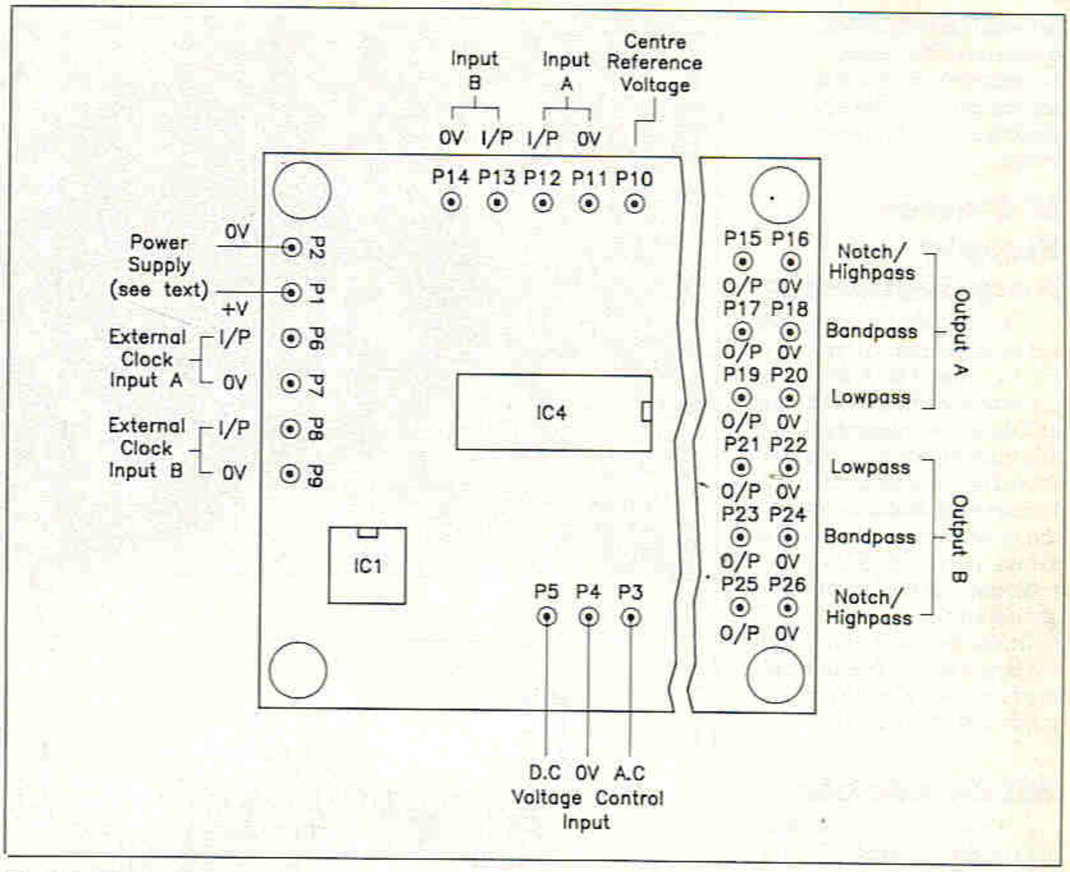


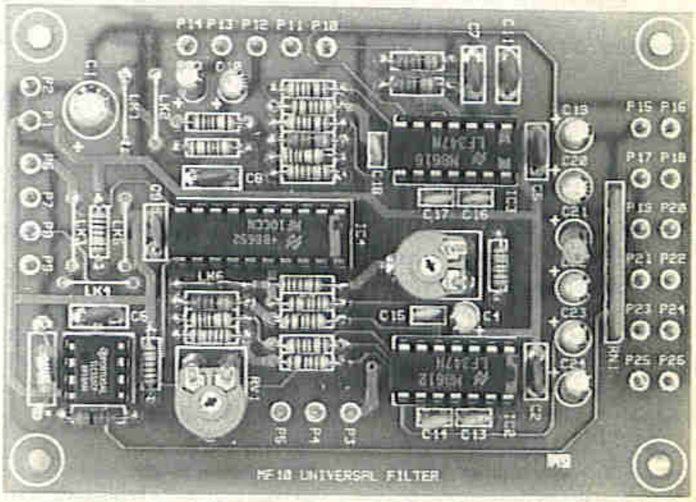
Figure 4. Wiring Diagram.

Power Supply Voltage	8V - 12V
Power Supply Current (quiescent)	29mA at 10V
Internal Clock Frequency Range	See Table 3.
Clock/Centre Frequency Ratio	Selectable 100/1 or 50/1 Except Highpass
Outputs	Notch, Bandpass, Lowpass with Highpass Option.
Maximum Voltage Gain (tested at 1kHz at peak of bandpass response)	10dB
Maximum Input Voltage	0.9V RMS
PCB Dimensions	73mm x 102mm approximately

Table 4. Specification of Prototype MF10 Filter Module.

Function	Link Number					
	1	2	3	4	5	6
Notch/Lowpass/Bandpass	✓	X	–	–	–	–
Highpass/Lowpass/Bandpass	X	✓	–	–	–	–
Internal Clock (Input A)	–	–	✓	–	–	–
Internal Clock (Input B)	–	–	–	✓	–	–
Clock/Centre Frequency ratio 50/1	–	–	–	–	✓	X
Clock/Centre Frequency ratio 100/1	–	–	–	–	X	✓

Table 3. Link Function Table.



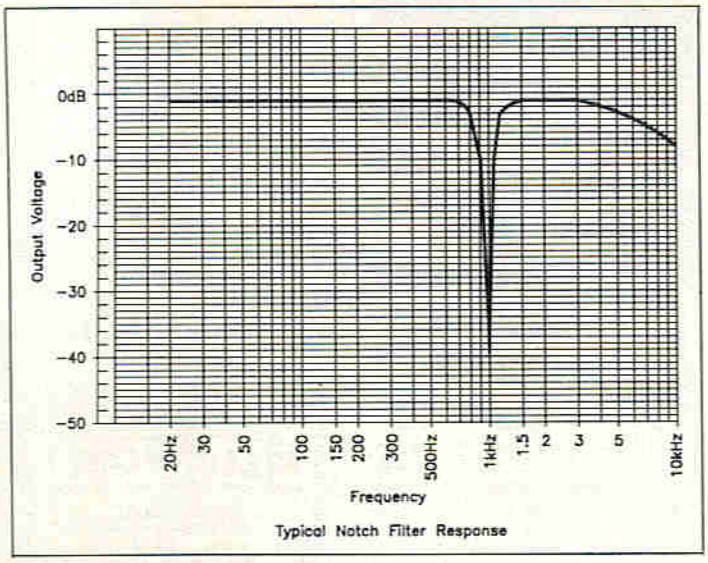


Figure 5. Typical Notch Filter Response.

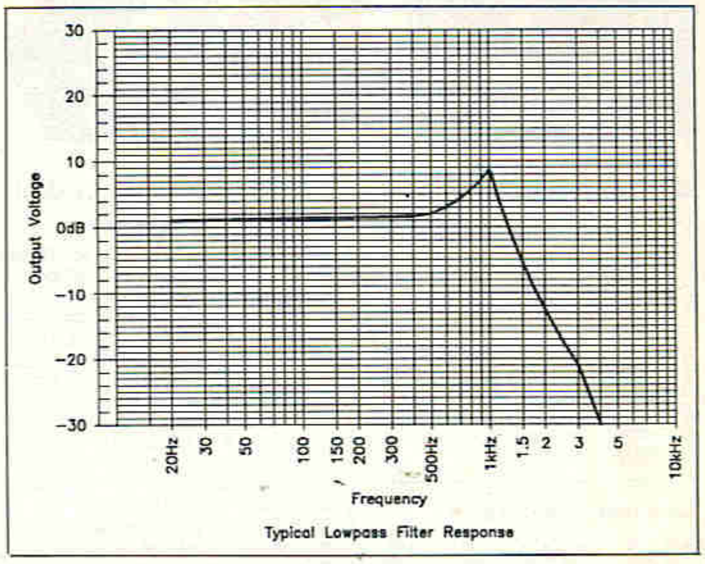


Figure 7. Typical Lowpass Filter Response.

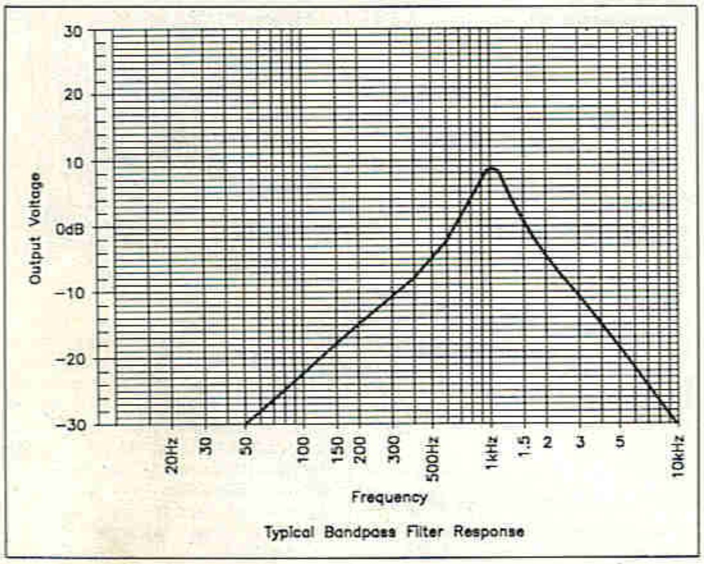


Figure 6. Typical Bandpass Filter Response.

an input level of 770mV. Variations in filter response may be obtained using different component values.

If a sharper cutoff characteristic is required than is possible with one filter then two or more filter blocks can be cascaded to produce a sharper response. If the same clock is used for both blocks then the filter cutoff frequencies should track relatively closely. Depending on the number of stages used, additional input attenuation may be required in front of one or more of the filter blocks to prevent overloading and in this case, the value of input resistors R10 and R17 can be increased. Alternatively an external attenuation network may be used for convenience.

Because the MF10 is based on a digital system, the output waveform is made up of a series of steps corresponding to the clock frequency. Although the on-board filter network removes most of the digital content of the signal it only provides very basic filtering and a higher level of distortion is therefore noticeable at low frequencies. If the filter is going to be used over a limited range, additional low pass filtering may be used to smooth the signal.

MF10 UNIVERSAL SWITCHED CAPACITOR FILTER PARTS LIST

Resistors: All 1% 0.6W Metal Film

R1,2	See 'Additional Parts' below		
R4,7,12,18	10k	4	(M10K)
R3,5	100k	2	(M100K)
R6,8,11,16	47k	4	(M47K)
R9,10,17,19	2k7	4	(M2K7)
R13,14,15,20,21,22	22k	6	(M22K)
RV1	See 'Additional Parts' below		
RV2	100k Hor. Encl. Preset	1	(UH06G)
RN1	10k SIL Array	1	(RA30H)

Capacitors

C1	100μF 16V Minelect	1	(RA55K)
C2,5-9,11	100nF Minidisc	7	(YR75S)
C3	See 'Additional Parts' below		
C4	1μF 63V Minelect	1	(YY31J)
C10,12	10μF 16V Minelect	2	(YY34M)
C13-18	2n2F Ceramic	6	(WX72P)
C19-24	22μF 16V Minelect	6	(YY36P)

Semiconductors

IC1	TLC555C	1	(RA76H)
IC2,3	LF347N	2	(WQ29G)
IC4	MF10CN	1	(QY35Q)

Miscellaneous

	DIL Socket 8-Pin	1	(BL17T)
	DIL Socket 14-Pin	2	(BL18U)
	DIL Socket 20-Pin	1	(HQ77J)
	PC Board	1	(GE42V)
P1-26	Pins 2145	1 Pkt	(FL24B)
	Constructors Guide	1	(XH79L)

Additional Parts (Included in Kit)

R1	1k	1	(M1K)
R1	10k	1	(M10K)
R2	4k7	1	(M4K7)
R2	47k	1	(M47K)
RV1	100k Hor. Encl. Preset	1	(UH06G)
RV1	1M Hor. Encl. Preset	1	(UH09K)
C3	100pF 1% Polystyrene	1	(BX46A)
C3	1000pF 1% Polystyrene	1	(BX56L)

All the above items are available in a kit:
Order As LP17T (MF10 Kit) Price £15.95
The following item is also available separately:
MF10 Universal Filter PCB **Order As GE42V Price £5.95**

NEWS REPORT

Digital Goes Green

The CT2 movement, variously known as Phonepoint, Zonephone or the poor man's cellular phone, is making steady progress with many units receiving that essential BABT green dot label. Ferranti says that it now has around 1500 base stations at over 1000 UK sites up and running while Mercury Callpoint has over 15,000 site agreements for base stations. Keeping out of touch seems to be getting more difficult every day.

Number Please

With the news that the French public videotex service Minitel has crashed through the 5 millionth user barrier, BT rather than following the French route and issuing free terminals as a replacement for telephone directories, are about to introduce a charge of about 50p for their directory enquiry service. At the same time, BT are looking to make better marketing use of its directories, cramming all the numbers on to a single CD-ROM with full sorting capabilities. Stand by for even more direct mail circulars.

ITV Moves Towards NICAM Sound

The IBA reports that the introduction of NICAM (Near Instantaneous Companded Audio Multiplex) is making good progress. As the authority replaces the original ITV transmitters installed about 20 years ago, program distribution networks for ITV and Channel 4 will increasingly incorporate digital stereo, using an all digital path from the studio through to your TV set. Good news for Maplin who were first in the field with a NICAM Decoder kit. (See Issue 35 of 'Electronics – The Maplin Magazine' for details.)

DOS is Well and Living in Your Computer

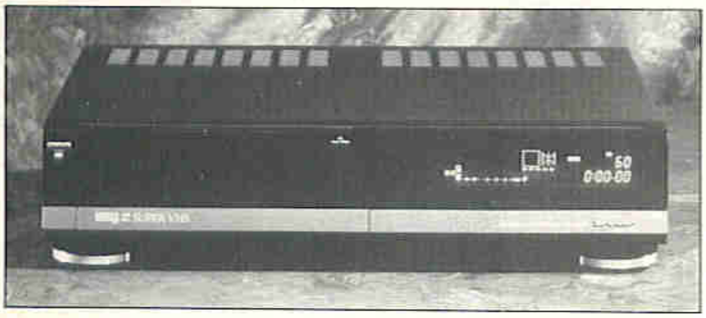
A recent survey finds that more than 9 out of 10 completely customised PC-based software packages, run under DOS. This finding should not surprise the computer industry says Michael Bernstein of North London management consultants Sterlings. "DOS has been the dominating operating system since the advent of the micro and this dominance looks like being continued well into the 1990's".

However when it comes to computer languages says Sterlings, BASIC is number one followed by COBAL (the clear leader in terms of code lines) with 'C' the third most popular language in Europe. Details, Tel: Sterlings 01-349-0261.

ITV told to Watch Its Language

The IBA gave itself a big pat on the back following the latest annual survey of public opinion. The vast majority of viewers said they have not been offended by anything they have seen. (What not even those tedious Party Political Broadcasts?) However complaints were up in respect of bad language, while over half thought that ITV was politically biased towards the labour movement.

The survey also reveals that virtually everyone has a TV set in the main living-room. In addition to a main set, 62% of viewers have a second set, with 24% claiming at least three sets. The most popular location for an extra TV set is the main bedroom, followed by a child's bedroom, and then the kitchen. The TV related home equipment league is headed by the video recorder – 70% of viewers; home computer 26%; and video camera – 3% of viewers.



Super Sharp VCR

Ready to meet the expected high demand for NICAM equipment, is the all new Super-VHS, remote control, two-speed Sharp VC-S1000H. Apart from featuring NICAM stereo sound, the video recorder has a full range of tape editing facilities.

The Sharp S-VHS system gives more than 400 lines horizontal resolution – and separate chrominance and luminance signal paths which virtually eliminates cross-modulation interference. As a result, picture quality of the unit is dramatically better than standard VHS which has a horizontal resolution of around 250 lines. The company also states that the quality of sound is close to that of compact disc. Audio specification includes a frequency response from 20Hz to 20kHz and a dynamic range greater than 90dB.

With an 8-event, 365-day programable timer, which includes a 100 year calendar (will we still be recording James Bond movies in the year 2090?) the system offers up to 4 hours standard play or up to eight hours in long play mode. Snags? Well the unit has a futuristic price to match its futuristic specification – £999 including VAT. Details, Tel: 01-836-1072.

Plain Fax

Canon have introduced a new plain paper facsimile model, the FAX-850 which operating at a rate of 6 seconds per page, is the fastest Group 3 A4 transmission time available. Perhaps not before time, Canon have reduced the price of thermal transfer paper, bringing the cost more into line with that of thermal paper. The new machine will operate in both thermal and thermal transfer mode for users with an existing stock of paper. A further plus point is that the Fax-850 operates in dual access mode, which means that if a message is being received users can still enter documents into memory to be sent out once the line becomes available. This then frees the operator from having to wait in order to send a fax. "The queue forms inside the machine, not beside it" says Canon. Details: 01-773-3173.

Rent a Lap

A highly innovative rental service has been introduced by Micro Rent for business travellers attending weekend functions away from their offices. Travellers can rent a laptop computer at a cost equal to two days rental. Time will show whether the travelling executive will prefer to take a laptop computer in place of the more familiar laptop companion. Details: 01-937 3595.

IBM Gets a Brain Wave

While running a computer model for studying the brain, those back-room boys at IBM unexpectedly produced electrical waves like those actually found in the brain itself. The computer model was designed to imitate 10,000 cells in the brain's hippocampus, an area that is essential for the formation of new memories and the origin of many epileptic episodes. Using the model, the scientists can simulate how the hippocampus works, and study in a controlled environment, some of the medical benefits that increased understanding of epilepsy could bring. This study may also suggest new ways for designing tomorrow's computers.

Perhaps the most startling aspect of the waves – technically known as population oscillations – is that no one understands precisely how they are generated either by the supercomputer model or by the brain. The fact that the waves spontaneously arose in the supercomputer model, however, gives the scientists potent evidence that their model is accurate in its simulation of brain activity. The next step is to use the model to discover the waves' cause and function. Details, Tel: IBM (0705) 321212.

Chips with Everything

IBM has also announced the production of a 16-Mbit computer memory chip on an existing semiconductor production line. The 16-Mbit dynamic random access memory (DRAM) chip has four times the storage capacity of today's most advanced memory chips. The chip can store the equivalent of about 1,600 pages of double-spaced typewritten text and operates at very high speed, accessing the first bit of data from one of its storage cells in 50 nanoseconds (thousand-millionths of a second) and subsequent bits at a sustained data serial rate of only 10 nanoseconds. At this speed, nearly all of the chip's 16,777,216 bits could be read in only 1/25 of a second, or several times faster than the blink of any eye.

At the same time, Apple has introduced three new display cards which serve to accelerate the responsiveness of all Macintosh applications, particularly graphics-intensive ones – up to 30 times. Details: 01-862-3028.

BT Fishing for Sales

If you want one of those much admired red telephone boxes, now being replaced by plastic boxes, then BT advises you to hurry. At £300 they are much in demand. Uses for the old boxes are varied, ranging from being converted into cocktail bars, birdcages, showers, bookcases and even aquaria. A case of fishing lines replacing telephone lines perhaps. Details: 01-356-6304.

Price Wars

British Telecom has come under fire, and not for the first time, over its high telephone usage charges. But suggestions that BT charges are amongst the highest in the world are nonsense says the company. BT insists that a true comparison needs to look at the overall 'basket' of charges and typical usage. Unfortunately for BT, the industry watch-dog quango OFTEL, has done just that and confirms that BT's relative position has worsened as a result of the price changes during 1989.

In fact BT's business phone charges are more expensive than those of France, West Germany and Italy confirms OFTEL, while in the residential league, the UK comes in last with the most expensive calls. The solution to high telephone bills is to move to France where call costs average 20% less.

Meanwhile, there can be little doubt that rival communications carrier Mercury Communications has been watching the BT pricing trends of generally falling long distance tariffs and rising local call charges. In their most recent announcement, Mercury were 'delighted' to make no price increases for their residential and small business customers.

Even so, BT appears not to have got the pricing message. From June this year, 2p and 5p coins will be phased out from their public payphones. 'Electronics' advice is to take a stop watch with you when making a phone call. BT calls are charged in 10p doses – just one millisecond over and you are into the next unit period – unlike that of Mercury where you pay the exact cost of the call.

Calling All Young Hams

Young radio hams are being offered the chance to win some government money. The Department of Trade and Industry is sponsoring 'The Young Radio Amateur of the Year Award' for 1990's outstanding achievement by a young radio enthusiast. For the DTI, young is being under 18 years old on the contest closing date 31st July 1990.

For the winner, the prize is The 1990 Award, plus £250 cash. The winner and runners up will win a visit to see DTI's Radio Monitoring Station at Baldock in Hertfordshire. The DTI will provide all entrants with a copy of the RSGB's Amateur Radio log book. Entrants are being judged on their balanced enthusiasm for the hobby with possible winning areas including:

★ an interest in amateur radio home construction

★ operating interests and skills, particularly teamwork for club contests

★ use of the hobby for the good of the community, such as RAYNET, St John's Ambulance, sponsored walk organisations, help for the disabled

★ the ability to spread the word – presentations or demonstrations at schools, clubs, scouts, guides

★ amateur radio in a school scientific project

Details, Radio Society of Great Britain. Tel: (0707) 59015.

Speak to Me

With European barriers set to tumble in 1993, the introduction of a portable five language translator that speaks to you perfectly, is timely. 'The Interpreter' stores over 13,000 phrases in each of five languages – English, French, Spanish, German and Italian – holding in total 65,000 phrases of versatile language database developed by UK software writers.

All you have to do is to type in a word on the keyboard and the unit will not only translate that word, but also create a useful selection of phrases around your chosen word. Push the required language button and the unit will immediately translate (there is a male or female voice option) speaking and displaying your phrase in whichever of the five languages chosen. The package which includes case, carrying strap, earphone, wrist strap, and multi-lingual instruction manual costs £133·90. Details: (0793) 514666.

Keeping In Touch at 30,000 Feet

British Airways hope that their Skyphone project which will enable passengers to 'phone home' from the skies, will take off this summer. The transmission will make use of an Inmarsat satellite and a series of groundstations spread around the world. But calling to tell Mary to organise the Chilli Con Carne and sparkling wine, will not be cheap. BA will be charging $10 per minute but as the service will be initially limited to first class passengers, pricing levels will not be crucial. BA are already planning to introduce a two-way service before long and extend transmissions to fax and data.

Meanwhile, regular TWA business class travellers will be receiving along with the hostess smile, a Motorola cellphone – though whether you can direct call the pilot to complain if the onboard movie has passed its useful shelf life, is not clear.

Amstrad Laps it up

For once news from Amstrad has been over shadowed by its rivals. The best the troubled company could manage was the release of the 286/386SX Laptop computer. The new machines from 'UK's leading British computer manufacturer' (one wonders just what ICL make of that claim) weighs in at 7·00kg. The rechargeable Ni-Cd battery pack gives a 2 hour life with normal usage. The models are priced at £1599 and £1999 plus VAT. Details: (0277) 228888.

East Looks West for Telecom Solutions

With Eastern European barriers coming down, the US telecom industry is expecting to see their trade expand enormously, says a recent Frost and Sullivan Report. The UK consultancy Applied Network Research, which has been acting as a telecoms advisor to Romania, agrees. "The Eastern European countries are many years behind their neighbours in the West and there is an urgent requirement for telecom networks – both local and international as business and commerce revive".

One of the first off the mark has been Hungary who have installed a cellular radio telephone system supplied by an American company. ANR believes that UK-based suppliers will have to fight hard to achieve sales in the face of the highly aggressive US companies. Details, Tel: ANR 01-892-9165.

Body Talk

Stamford University have produced an electronic musical instrument the Biomuse which will play body movements. Apparently by putting electrodes on the skin, movement feeds through to a computer linked to a synthesiser, and musical notes are created. As the report says, flexing the forearm creates a crescending note while eye blinks make a series of staccato beats or a slow drawl. Future Top of the Pops performers could really be wired for sound.

Star Wars

Last month saw the much delayed launch of British Satellite Broadcasting. As a result, the four Sky channels – Sky One: Sky Movies: Sky News: and Eurosport will be competing with BSB's Movie channel: Now – The Channel for Living: Galaxy: and The Power Station.

Although coming in some 15 months later and requiring a different receiver dish, BSB are confident that their programme line-up will run satellite rings round Sky. Sky however are less convinced and with over 1·15m homes already able to tune in, they would seem to be well placed to see off any challenge. Already the Sky pan-European channel Eurosport has a 18m home reach in 22 countries across Europe. That number looks likely to be boosted following the signing of the major Formula 3 motor car racing events this year.

Supporting the Lost IT Cause

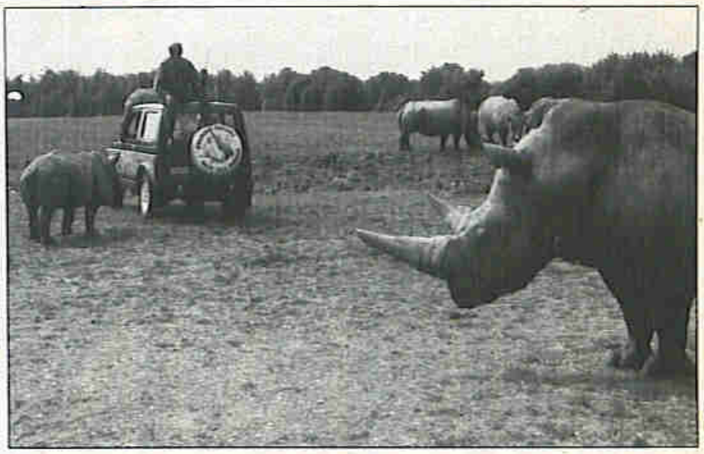
Talk about hitting your head against a brick wall in Selsdon. The Manual Business Systems Association aims to prove that small companies do not necessarily need a computer in order to be efficient. According to director Cheryl Hyland, many business computers are condemned to being used as an expensive typewriter, storing nothing more important than Christmas card lists. Demand for manual office systems, the Association believes, is on the up and up, acting as a stepping stone to greater efficiency. Founder members of the back-to-paper-movement are surprisingly the Midland Bank and accountants Grant Thornton but not the obvious body, the Data Protection Authority. Details, Tel: (0785) 850811.

Hold The Line

According to a recent ROCOM industry survey, the top selling novelty telephones include Mickey Mouse, SWALK Red Lips, A Pepsi can and a Ferrari. The Dr Who Tardis phone is also a best seller, though whether it de-materialises from time to time is not revealed.

The Hi-Tech Good Book

According to the computer industry authority, 'Computergram' a UK company has developed a special line in Ecclesiastical software databases, which suggests hymn lists for every season plus a communion stock control routine. This would seem just the right sort of package to run on the new Sony book-sized computer which has done away with a keyboard in favour of hand printed data entry. The system can recognise the Roman alphabet, just the job for the local priest.



Picture Caption Challenge

"IF HE CALLS ME HORNY JUST ONCE MORE..."

Is it...

★ An army patrol waiting for the AA man

★ An extract from the Japanese TV programme 'Endurance'

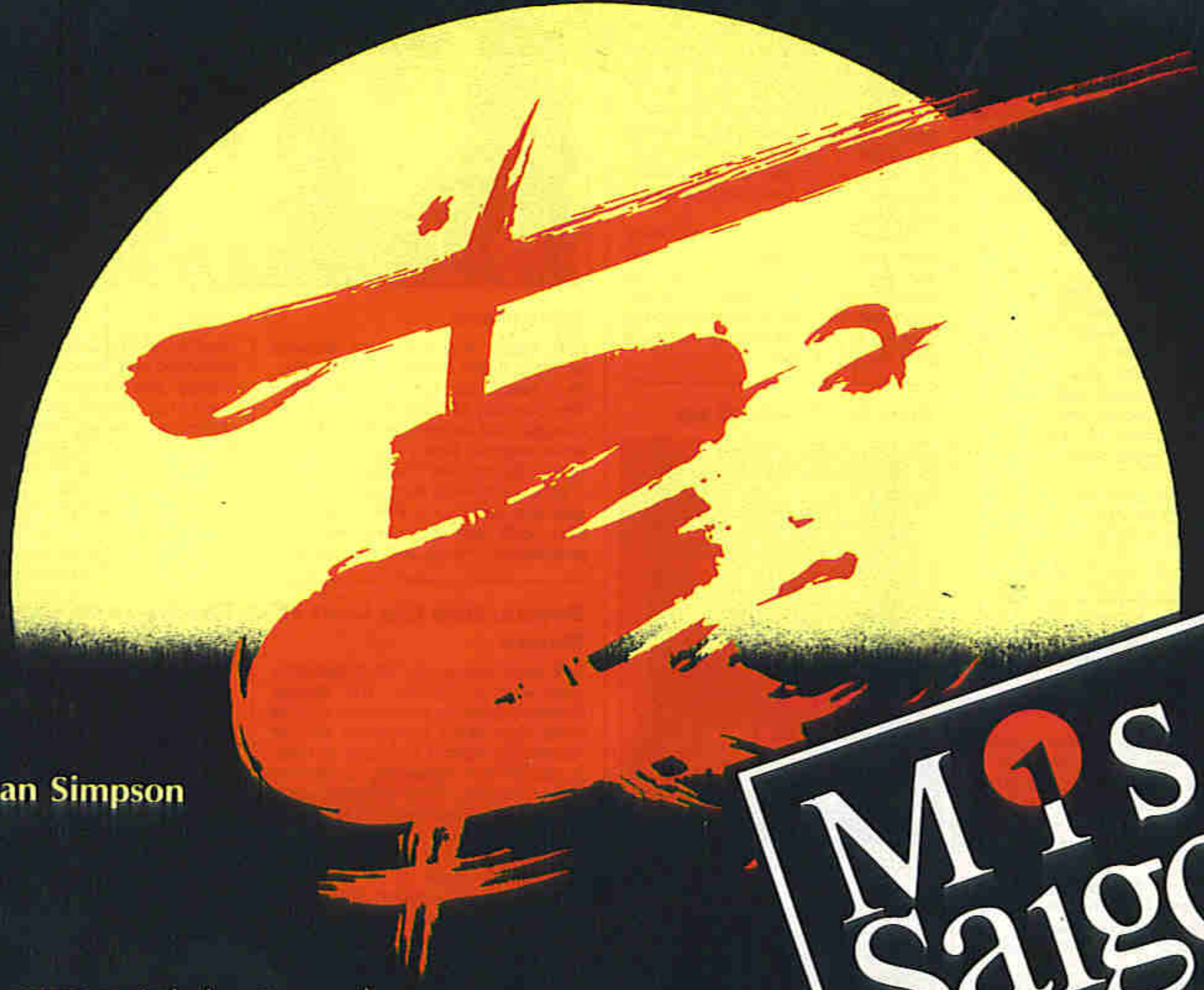
★ Testing a new shock proof car computer

★ Damn, I forgot to fill up the petrol tank and recharge the cell phone.

For once we are giving British Telecom a break. The picture comes courtesy of Car Link Communications of Southampton.

The company is helping the Zoological Society of London in a new effort to protect endangered black rhinos on a wildlife reserve in Kenya. Handportable radios are helping anti-poaching protection activities.

CURTAIN UP ON HI-TECH



by Alan Simpson

London stage musicals do not come any more spectacular than Miss Saigon, now settled in for a long run at The Theatre Royal, Drury Lane. Certainly no show packs such a high- tech punch. Scenery shifts around at a startling pace, a helicopter zapps around, and American cars roll on and off. The cast is pretty energetic too, particularly the dancing of the raunchy bar girls.

But away from the glamour and glitter of the performers, behind the scenes a sixty-strong team is busy making the high-tech happen. At the touch of a button, vast quantities of props come and go, sound is amplified and balanced and lights focused.

Supporting the back stage team are several specialist companies including Stage Drives & Controls, Advanced Systems Automation Products and Graham Bell Design – all high-tech suppliers to the world of theatre.

Cue One – GO

The Miss Saigon action is triggered by the stage manager, Sam Hunter who has her finger firmly placed on the 'Cue One - GO' button routine. The action follows the music with the standby red light flashing to green on countless terminal desks plus a verbal "GO" command. At this signal, the various operators will trigger their start program button. It is essential says Sam that everyone knows what is happening, both behind the scenes and on the stage.

A High-Tech Challenge

This is a huge and very challenging high-tech show, confirms Sam, presented in a grand way. Very probably it is the most complicated ever seen in London. Although the action revolves round the scenery, the props must never get in the way of the central theme of the show – a GI meets and falls for a Vietnamese bar girl.

Each scene flows from one place to another in a highly creative and integrated format.

The stage manager is connected by closed ring Clearcom system and cordless radio to some 15 departments. These include the sound desk, 8 lighting operators, flyman, hydraulic operator and of course, the musical director. However Sam is no stranger to high-tech shows. After leaving the stage management course at The Central School of Speech & Drama, Sam worked on Chess, Anything Goes and Cats. Despite admitting that there were very few moments during the performance when you can relax and take a breather, Sam's dream would be to take the show abroad.

Sound Off

Steve Cooksey meanwhile is responsible for Miss Saigon sound. His track record includes studio recording with 10CC followed by running a mobile recording studio for external live concerts. Steve's role includes handling twenty four radio mikes/transmitters permanently attached to members of the cast, plus sound from the 31-piece orchestra, plus two synthesisers. In addition those bar girls are equipped with transmitters about the size of a cigarette package (but considerably heavier) and a mini-mike fastened into their hair.

Miss Saigon is responsible for having perfected a new concept for the theatre, that of delayed sound. With one of the largest stages in the world – it measures some fifty feet from the front to the back of the stage, it was decided to make the sound appear to move with the on stage action. This has been achieved by introducing delayed sound which uses a cue to cue change in the delay time incorporated into a performers' mike channel to compensate for different positions on the stage. Computer-based software ensures that the sound from the speakers at the back of the auditorium is delayed so that the sound arrives with the audience at the same time as the sound from the front speakers.

Scenes from the show.

The mixing desk.

Even more of the mixing desk!

Mixing With The Best

Steve's mixing desk has to be seen to be believed. It handles some 90 input channels. The volume of each channel is controlled by a voltage controlled amplifier (VCA). This allows any channel or combination of channels to be assigned by the computer from any of nine master faders, thus giving centralised control of any channel on the desk. The PC uses standard computer language which controls the desk via a MIDI interface. No expense was spared it seems. So keen were they to get the sound of that helicopter right, that the synth was overdubbed with the original sound.

First night nerves it seems were not limited to the actors – and backers. John Bell who is responsible for the software which automates the heavy scenery movement, had his fingers firmly crossed that everything would be all right on the night. A major problem was that only a short time was available to produce the highly complex computer controlled movements and with cast rehearsals taking place almost continuously, the mechanical equipment testing often had to take place at night.

The software which drives the mechanics, uses assembly language code, running on a powerful micro which constantly monitors the position of the scenery ten times a second. Much of John's past work had involved professional engineering. The theatre has added a new creative dimension to his job as well as responsibility. If the computer system fails, it could well be curtains for the show.

As performer Chooi Kheng Beh comments, the thought that the six pylons, each weighing half a ton, were moving across the stage at a steady 1.2 metres a second, helps to concentrate the mind – and keep us on our toes. But as the applause dies down for the performers, give a thought to the back-stage high-tech team who play a large part in creating that theatrical magic.

MISS SAIGON CONTEST

No, we can't provide you with a chance to win tickets for London's top show, Miss Saigon. But we do have the very next best thing. Yes, the opportunity to win the Miss Saigon Original Cast Album.

We have 5 double cassette packs and 5 double albums to give away to the first ten correct answers drawn from the editor's hat.

★ Which of the following musicals is not an Andrew Lloyd Webber production:
Jesus Christ Superstar
Starlight Express
Les Miserables
Evita

★ Cameron Mackintosh is the producer of Miss Saigon. Which other current West End productions are his:
Cats
Phantom of the Opera
Les Miserables

★ Alain Boublil and Claude-Michel Schonberg wrote Miss Saigon. Which other musicals have they written:
Les Miserables
A Chorus Line
42nd Street
South Pacific

What is the name given to the well known ghost who inhabits The Theatre Royal, Drury Lane:
Kermit
The Man in Grey
Norman Tebbit
Cromwell

Andrew Lloyd Webber is married to:
Doris Day
Sinead O'Connor
Sarah Brightman
Julie Andrews

Zapp your entry, on a post card to:
'Electronics – The Maplin Magazine'
Miss Saigon Contest
P.O. Box 3,
Rayleigh,
Essex,
SS6 8LR.
The contest closes 30th September 1990. Don't forget to tell us whether you want the album or cassette version of the prize.

SATELLITE SOUND BROADCASTING – A WHITE ELEPHANT IN ORBIT?

by J.M. Woodgate
B.Sc. (Eng.), C.Eng., M.I.E.E.,
M.A.E.S., M.Inst. S.C.E.

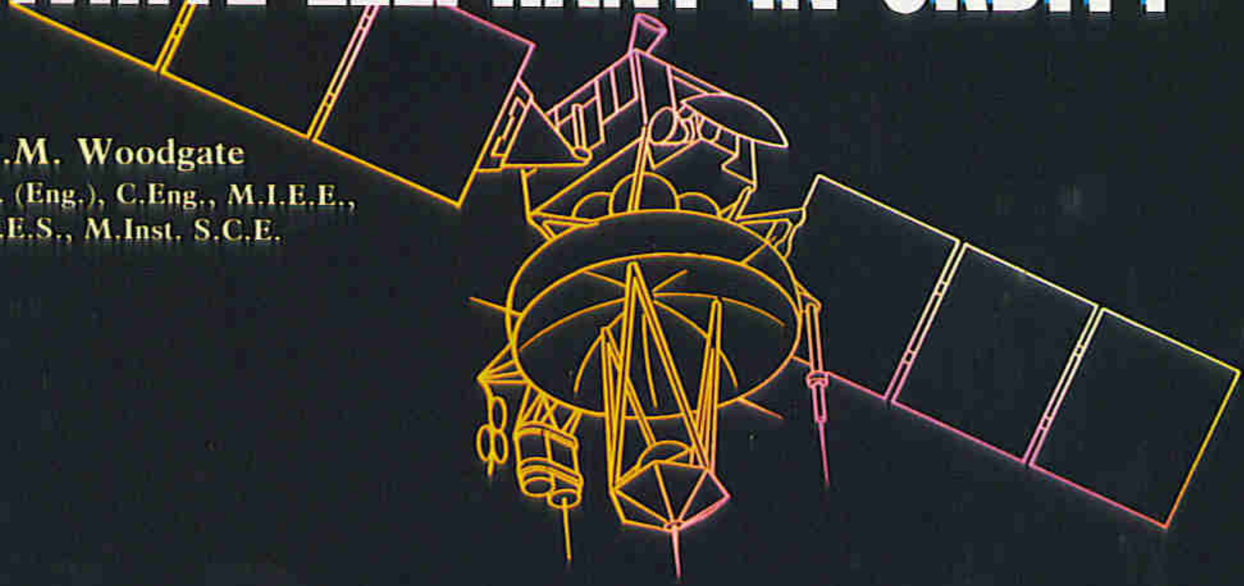
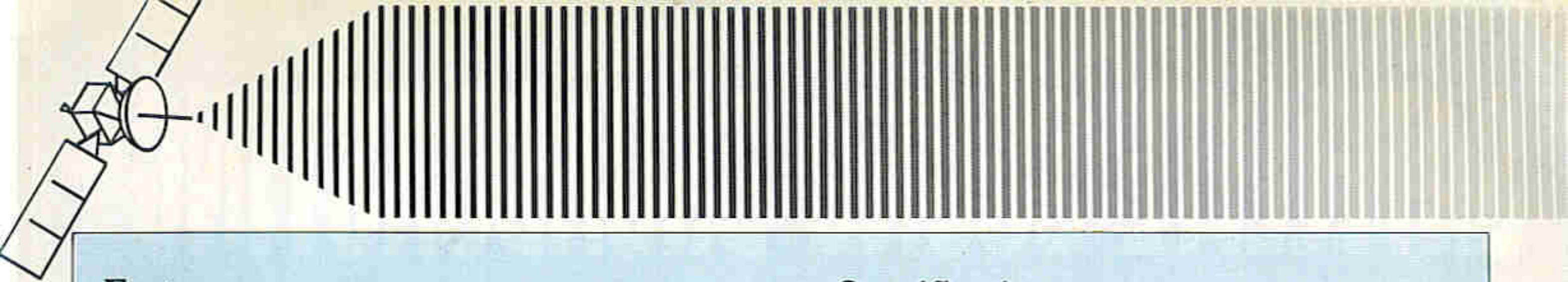


Photo 1. The first household receiver for the German DSR system is the Telefunken DT1000DSR, also available with the Thomson brand-name.



Features

- ★ Direct station selection with 16 pushbuttons
- ★ Reception of 16 stereo or 32 mono or bilingual programmes
- ★ Direct selection of programme type with 16 pushbuttons
- ★ Fluorescent display for programme name, programme type, station selector number and stereo/mono
- ★ Display switchable between German, English and French
- ★ Separate volume controls for speech and music, with automatic changeover
- ★ LED monitor indicators for input signal level, synchronization and data retrieval quality, and speech/music
- ★ Headphone output with adjustable volume
- ★ Infra-red remote control
- ★ VLSI decoder chip Valvo SAA 7500
- ★ Ceramic SAW filter for selection of the 118 MHz channels
- ★ Floating-point technique for 16-bit qualilty
- ★ Digital filter for band limitation
- ★ Digital error-correction system with automatic interpolation for interference-free reproduction
- ★ 3 pole analogue filter for high-frequency interference suppression
- ★ Microprocessor for decoding the programme-name and programme- type data
- ★ Metal cabinet with massive metal front panel
- ★ Dimensions (WxHxD) 44 x 9.5 x 29 cm

Specification

- ★ Input frequency: 118 MHz
- ★ Input bandwidth: ±7 MHz
- ★ Input impedance: 75Ω
- ★ Input voltage level, C/N > 14 dB: 59 dB (μV) to 94 dB (μV)
  C/N > 10 dB: 54 dB (μV) to 94 dB (μV)
- ★ Bit error rate: $\simeq 10^{-3}$ at C/N = 10 dB
- ★ Selectivity (±8 MHz): 40 dB
- ★ Digital Audio Interface: IEC 958
- ★ Output connectors, electrical : phono
  optical : Toshiba
- ★ Dynamic range: 94 dB
- ★ Noise level (A weighted): −110 dB
  (unweighted): −106 dB
- ★ Total harmonic distortion (1 kHz): 0.007%
- ★ Stereo separation (1kHz): 80 dB
- ★ Output voltage/impedance: 2V, 330Ω, adjustable to −20 dB for speech and music separately
- ★ Output connectors: 2 x phono
- ★ Rated load impedance: ≥ 47 kΩ
- ★ Sampling frequency: 32 kHz
- ★ D/A converter: 16-bit, 4 x oversampling
- ★ Error correction and concealment: ≤ 1 residual error per hour at BER = 10^{-3}

Table 1. Features and Specifications of the Telefunken DT1000DSR.

Broadcasters have been considering for a long time whether, and if so when, to introduce sound radio broadcasting by satellite direct to household receivers, including portable and car radios. Satellite broadcasting has a number of advantages (once the satellite is in orbit and the launch fees have been paid!):

1. Wider and more uniform coverage of the service area.
2. Instant coverage, as soon as the satellite is working, instead of a slow build-up as terrestrial transmitters are brought into service.
3. Greatly reduced civil engineering costs for transmitter buildings and antenna structures, and ancillaries such as access roads.
4. Reduced energy consumption (one ground station for the up-link replaces many terrestrial transmitters. The satellite's power comes from solar cells, at no on-going cost, of course).
5. If VHF or higher frequency bands are used, many programmes can be accommodated in one transmission channel (typically 8MHz to 27MHz wide).
6. VHF (or higher) band transmission also offers enough bandwidth for some form of digital modulation to be used, offering a very high quality of received audio signal.

Although the possibility of a.m. or n.b.f.m. transmissions in the 26 to 27MHz band was seriously considered by the European Broadcasting Union (EBU) before the World Administrative Radio Conference in 1979 (WARC79), most of the subsequent interest has been in systems using the 1GHz, 3GHz and 12GHz bands. Some programmes, transmitted by ordinary analogue techniques, are already available from the Astra and Eutelsat 1–F4 satellites. Research investigations are underway, concerning systems for the 26GHz and 40GHz bands, which should be ready to be exploited economically in the early part of the next century.

It may seem obvious that any sensible sound broadcasting system should allow not only home reception, but also the use of portable and car radio receivers. Nevertheless, this has not stopped the German government from pushing ahead with a project which does not fulfil this requirement, and has been beset with other problems as well. The basis of the German decision is that the only way, which at present is considered feasible, of transmitting by satellite to portable and mobile receivers, particularly in built-up areas, is to use frequencies in the band from 500MHz to 2GHz. But the lower part of this band is already used for terrestrial television services, and can't be shared with anything, while there is intense demand for spectrum space in the middle and upper parts of the band for other important services, such as cellular telephones and defence uses. It seems most unlikely, in spite of lobbying by the EBU, that any of this band can be released for satellite sound broadcasting in the foreseeable future. Meanwhile, the German authorities consider that there is a very strong consumer demand for the 16 channels of near CD-quality radio that their system can offer.

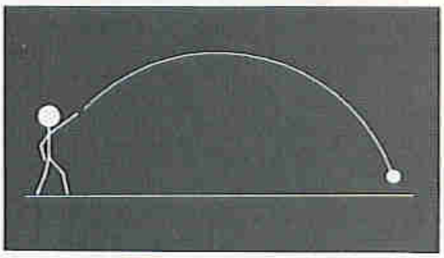


Figure 1. Throwing a ball on a flat Earth. The trajectory (path) of the ball is a *parabola,* but no matter how hard or high you throw it, the ball comes back down.

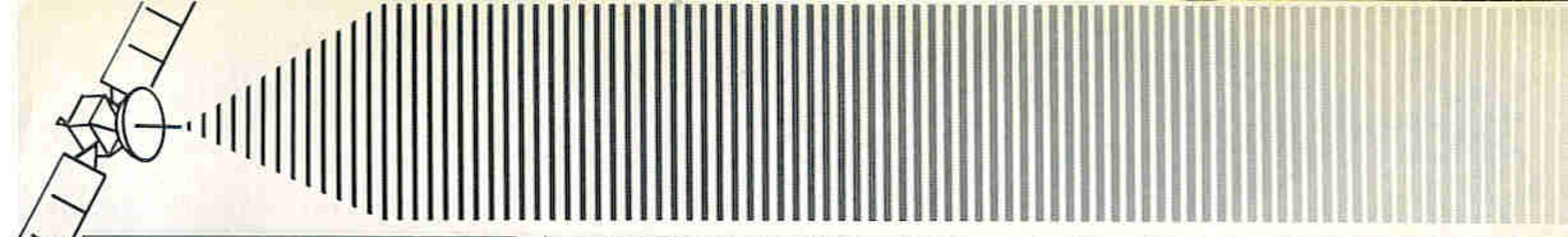
Sky Hooks

Since we still have a plague of radio and newspaper journalists who parade their ignorance of science and technology in the media, and thereby mislead people who seek the truth, we had better start at square one and consider that what keeps a satellite (not a 'space rocket') in orbit is *not* because it is 'beyond gravity', or some such nonsense. In simple terms, if you throw a ball in the air, in any direction except vertically upwards, it falls back to earth some distance away (Figure 1). If you could throw it fast enough, it would fall back so far away that it would continue to fall for ever around the curvature of the Earth's surface (Figure 2). In other words it would go into orbit around the Earth. Looking at Figure 3, the force required to prevent the ball flying off at a tangent (literally) into space is provided by the force of gravitational attraction between the ball and the Earth:

$$mv^2/r = GMm/r^2,$$

where 'm' is the mass of the ball, 'v' is the orbital velocity (speed round the Earth) of the ball, 'r' is its distance from the centre of the Earth, 'G' is the Newtonian gravitational constant and 'M' is the mass of the Earth.

The first thing to notice is that 'm' cancels, so that the mass of the ball is irrelevant in determining the orbital velocity at a given distance. Putting in some numbers,



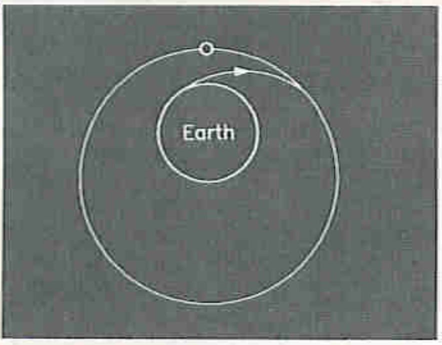


Figure 2. What goes up, stays up. Throw a ball on a spherical Earth and its trajectory is an *ellipse*, or part of one, with the centre of the Earth at one focus. Throw hard and high, and the ball stays in orbit.

$G = 6.672 \times 10^{-11}\ Nm^2.kg^{-2}$,
$M = 5.976 \times 10^{24}$ kg
and, for example,
$r = 10{,}000$ km,

gives $v = 6314\ ms^{-1}$. Not even a West Indies fast bowler can reach that sort of speed. The orbit of any object in 'free fall' around another is, in general, an ellipse, which is a smooth closed curve having a maximum diameter and a minimum diameter at right angles. A circle is a special sort of ellipse, having the same diameter in any direction. If our ball happens to be in a circular orbit, the circumference of the orbit is 2π times 10,000 km and the orbital velocity is $6314\ ms^{-1}$, so the orbital period 'T' is:

$T = 2\pi r/v$,

which comes to 9951 seconds, or about 2¾ hours. If we could make our satellite go round the Earth in the plane of the Equator once every 24 hours, it would stay vertically above one point on the Earth's surface and remain fixed in the sky when viewed from any other place where it is above the horizon. We can juggle our equations into a form which connects 'r' and 'T':

$r3 = GMT^2/4\pi^2$

This is a statement of Kepler's Third Law, discovered by Johannes Kepler (who else?) around 1700. Putting T = 864,000 s (24 hours), we get 'r' as 42,164 km, measured from the centre of the Earth, or about 36,000 km above the surface. Such a 24 hour orbit around the Equator is called a 'geostationary orbit', and it is where the television satellites, and most of the well-known communications satellites, live.

This is a good place to put a satellite for reception by fixed ground stations (such as household satellite radio or TV sets) which are not too near the North or South Pole, because you don't need a steerable antenna, but it is not too good for portable or mobile reception outside the Tropics, because not only does the antenna, if directional, have to point in one fixed direction, no matter how the receiver or the vehicle twists and turns (a device which is too expensive for anyone but the military), but, since in our latitudes the satellite appears rather low in the sky, the line-of-sight path is bound to be often obstructed by buildings, or even people. The Russians produced a successful answer to this, for their Molniya series of satellites.

These are positioned in highly elliptical 12-hour orbits, in sets of three satellites, spaced apart by 120° in orbital position. The orbit has its closest approach to Earth (perigee) at about 1,000 km above the surface, but the furthest point (apogee) is at about 40,000 km. The orbital plane is inclined at about 63° to the plane of the Equator. Consequently, the satellites rise high in the sky in our northern latitudes, and each remains well above the horizon for nearly 8 hours out of the 12 hour orbital period. Thus, at least one satellite is above the horizon, and easily receivable, at all times. As it happens, a set of satellites in Molniya orbits suitable for western Europe could also provide a useful service in Japan and south east Asia. A mobile or portable receiver could use a directional antenna with a beam-angle of about 45°, giving a gain of about 12dB, whereas mobile or portable reception of a geostationary satellite with a fixed antenna would require a nearly omnidirectional characteristic, with a gain of less than 3dB. From another point of view, it is just as well that an alternative to the geostationary orbit exists, because it is getting very crowded already!

Transmission Systems

Until recently, there was quite a bit of interest in using the same analogue stereo multiplex systems for satellite broadcasting as have been used for some 30 years in Band II. However, these systems (of which the pilot-tone system used in this country is by far the most popular) are not very suitable for SHF (above 3GHz) because they require both a high carrier-to-noise ratio at the receiver and considerable protection against adjacent-channel interference. This means that, although the transmission takes up about 200kHz of spectrum space, the channels either side of it cannot be used by the same service, so that the effective channel spacing has to be about 600kHz as a minimum.

Various forms of digital modulation can do better. About 20MHz of spectrum space can carry up to 16 stereo channels of near CD-quality sound, while suffering no perceptible adjacent channel problems, and requiring a carrier-to-noise ratio at the receiver input of no more than about 8dB. Three systems have so far been submitted to the CCIR (Comite Consultatif International de Radio, the United Nations organisation which seeks to co-ordinate broadcast systems, and other usage of the radio spectrum, internationally). These are the German system mentioned before, called 'Digital Satellite Radio' (DSR), the 'Full-field MAC-Packet system' from the European Broadcasting Union (EBU), and the Japanese MDSD system (Multichannel Digital Sound/Data System).

The German DSR system

This is the only system that is 'up and running', but it has had a chequered career so far, and is too recently introduced to be a commercial success yet (see the 'STOP PRESS' section at the end of this article). The system allows the transmission of 16 stereo or 32 mono channels of high-quality audio through one satellite channel of 20MHz bandwidth. Originally (1982) it was planned to use the German 'TV-Sat' satellite to carry this channel, but the German Prime Minister was in 1987 not sympathetic to the priority of the DSR system; for the satellite WARC had foreseen a time-sharing application for the TV-Sat channel 'one-plus' when not carrying TV programmes (between 1 a.m. and 6 p.m.), and experts were of the opinion that this was not appropriate for DSR. Negotiations were then opened to use a channel of the French satellite 'TDF 1', which is in nearly the same orbital position as TV-Sat, but the French government was, in the event, unwilling to allow this. Plans to use the 'Olympus' satellite also failed to materialize, and it was finally decided to use a channel on the DFS 1 'Kopernicus' satellite. The field strength from this satellite over much of western Germany proved higher than expected, and satisfactory reception with a 60cm, or smaller, parabolic dish is possible over most of the country. There is competition among the satellites for viewers'/listeners' antennae to be directed to them, because this improves their attractiveness to advertisers, and the addition of DSR to the 12 German-language TV channels carried by Kopernicus was seen as improving the competitive position of Kopernicus considerably. Unfortunately, however, the Astra satellite, which carries 'Sky TV' programmes amongst others, is proving to be the 'hot bird' (most attractive satellite) over most of Europe, and Kopernicus is not a good second. This may not be totally disastrous, however, because much of Germany is

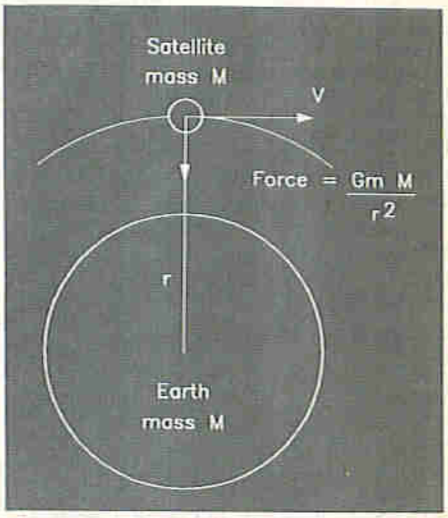
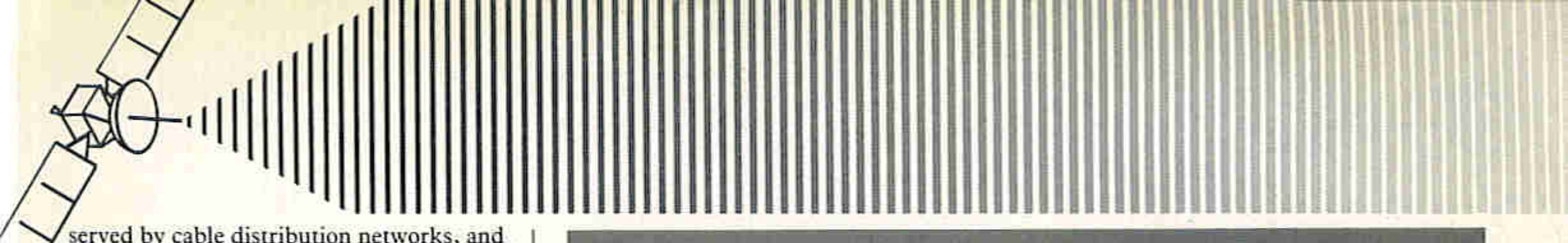


Figure 3. The dynamics of a satellite. Left to itself, the ball would travel along the tangent with speed V. Gravity pulls it into an elliptical (perhaps circular) path.



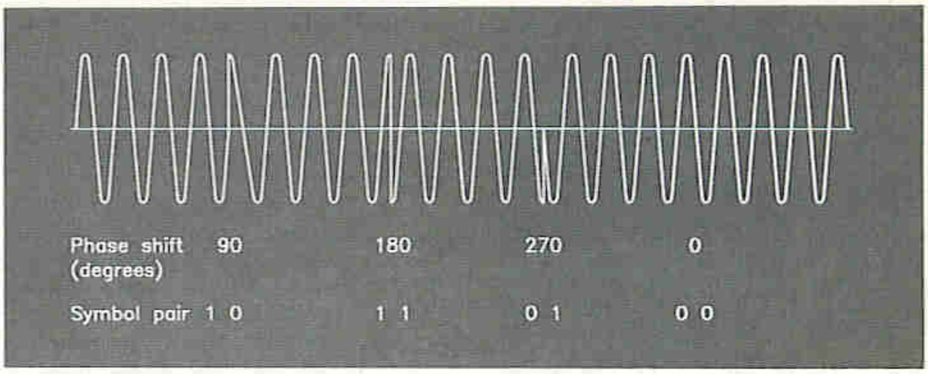


Figure 4a. Quadrature differential phase-shift keying (QPSK). This is what would happen if the data signal was not band-limited. Actually, there should be 600 cycles of carrier between the transitions. The modulation is carried out at a low radio frequency, which is changed eventually to the 12GHz band in the satellite. Demodulation in the receiver is carried out at 118MHz ±7MHz in current receiver designs.

served by cable distribution networks, and the DSR signals can be carried by these cables. So the loss of the TV-Sat channel may prove not to be very important. In any case, a channel on TV-Sat 2 may be free for use from mid-1990 until required for a TV channel for the western-most areas of Germany. (These plans are also not running smoothly, due to controversy over which transmission standard should be used.)

However, the question of who is going to provide these 16 new stereo radio programmes is not yet decided! Broadcasting in Germany is divided among the federal states (Laender), and, according to the WARC plans, each state could provide one programme and four states could provide a second. It is clear, however, that the recent political developments in Germany will profoundly influence matters such as these, and that no final decisions can be made yet. Meanwhile, 16 of the existing FM programmes are also being transmitted via the satellite. This is not quite so silly as the duplication of BBC programmes on AM and FM that has been happening in Britain for the last 30 years, and which ends in August this year, because there is no real 'nationwide' programme in Germany corresponding to Radio 2 or Radio 4. So, if your relatives live in Munich and you live in Hamburg, until now you couldn't hear the same programmes as them. But now, via the satellite, you can, and this possibility is proving very attractive.

In this system, the sampling frequency is 32kHz, the standard for non-studio use in broadcasting. This is determined by the capacity of the digital links from the studios to the ground station (the satellite up-link transmitters). The 32kHz sampling frequency requires the audio bandwidth to be limited to (in theory) 16kHz to avoid aliasing, but to achieve 16kHz bandwidth puts an impossible specification on the anti-alias filter, so the bandwidth used in practice is 15kHz. Even so, the filter has to be very carefully designed indeed to avoid audible effects.

There are some similarities between the German system and the NICAM 728 system developed for stereo sound with terrestrial television in Britain. DSR could be called 'NICAM without the NIC', because the main difference is in the way that the need to transmit 16 digital bits for each sample of the signal is avoided. (Transmitting all 16-bits would reduce the number of channels that can be squeezed into the 20MHz satellite channel bandwidth.) NICAM 728 starts with 14-bit coded signals and uses 'Near Instantaneous Compression' to reduce this to only 10 sample bits for transmission, without any perceptible effect on quality (except that the best possible signal-to-noise ratio is reduced from 96dB to 84dB), whereas the German system uses a floating-point technique to achieve the same acceptable quantisation noise level while transmitting 14-bits.

In fact what is common between the systems is the concept of transmitting fewer bits than 16, together with a relatively infrequent 'scaling' signal which locates the shortened signal bytes within 16-bit words. The German system uses a 'floating point' technique. Consider a 16-bit sample word representing a very small signal. The word must begin '00000000...' if positive or '11111111...' if negative. Instead of sending all those identical leading digits, we can send a binary number representing them. We would need 4-bits to send up to 15 leading digits, but with 3-bits we can signal up to 7 repetitions of a leading zero (or 1). For example, instead of '0000000011011010' we can send '0 11011010 111'. The gaps in this word aren't actually sent: they are there so that the structure can be explained. In practice, the structure is determined in the receiver by using sync. information. The leading zero (or 1) is always sent. The following group of bits is the useful part of the signal, and the '111' (binary 7) tells the receiver decoder to 'repeat the leading digit 7 times'. We have sent a word with 16-bit resolution using only 14-bits! It turns out, because of the way audio signals change with time, that we need send the binary 'scale factor' number only once every 64 samples, or 2ms, without degrading the subjective quality of the signal. This means that even more bit saving can be achieved: the 'scale factor overhead' is reduced from 3-bits in 14 to 3 in 64 x 14 = 896.

Strong error protection is provided for the 11 most significant bits of the sample words. The 11 MSB's of four samples are combined as 44-bits of a 63-bit word; the remaining 19-bits form a cyclic redundancy check (CRC) word which can correct 2 errors and detect up to 5 errors. (A full explanation of how cyclic redundancy checks work would be too long for this article.) The 3 least significant bits of each word are transmitted without error correction. The scale factor bits are very heavily protected indeed, because an error would be extremely audible.

Also common to both systems is the way the signal digitally modulates the carrier, and this is known as Differential Quadrature Phase-Shift Keying (DQPSK). In this system, pairs of bits decide what happens to the phase of the carrier signal:

00 = no change, 01 = change by 270°,

10 = change by 90°, 11 = change by 180°.

Figure 4a shows a carrier phase-modulated in this way, and if this was transmitted, the sudden shifts in phase would require a very large bandwidth. Luckily, it is possible to low-pass filter the signal so that the phase transitions are 'smeared-out' over many cycles of carrier, and the bandwidth requirements are very considerably decreased (Figure 4b), without making it impossible to detect the phase changes in the receiver.

Along with the actual signal sample bits, numerous bits are required for such

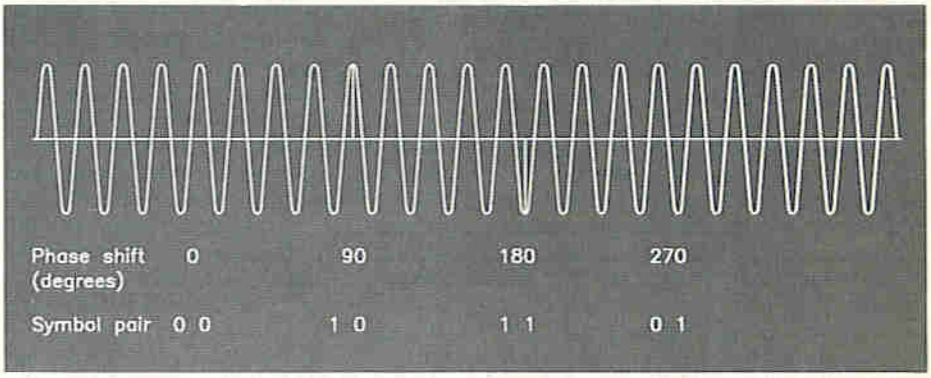
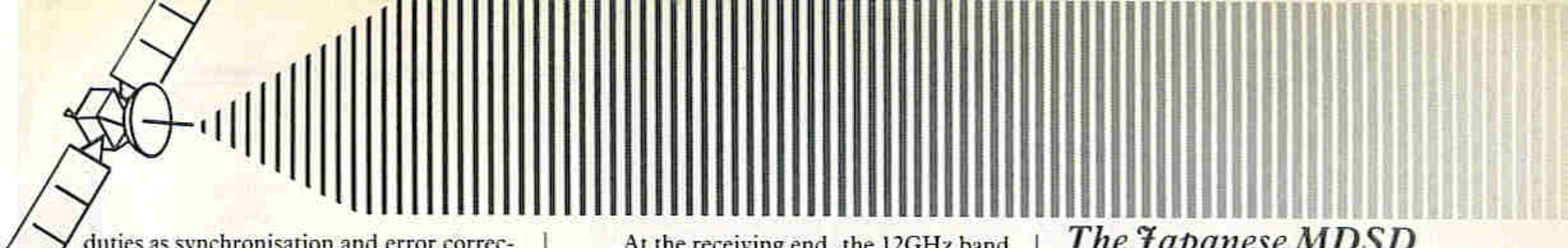


Figure 4b. Quadrature differential phase-shift keying (QPSK). Approximate representation of the effect of band-limiting the data signal. The phase change occurs progressively during the 600+ cycles of carrier (represented as 4 cycles in the Figure). The 'glitches' at 90 and 180 degrees are due to the plotter program, but help to mark the transitions.



duties as synchronisation and error correction. A low speed data channel is also provided alongside each sound signal. (The actual sound signal itself can be replaced by a high-speed data signal as and when required.) There is also room for some data on 'programme type', similar to that sent out with RDS signals. This allows receivers to be designed which can select the type of programme that you want, out of what is available. You could set the receiver to search for any one of the following:

All programmes
News
Current affairs
Information
Sport
Education
Drama
Culture
Science
Varied
Pop music
Rock music
M.O.R. music
Light classical music
Serious classical music
Other music

and it would find anything that was available on any of the 16 channels. It is also possible to solve the persistent problem of the mismatch in subjective loudness between music and speech (the preferred difference in loudness differs from listener to listener and with the mood of an individual listener and therefore cannot be set at the transmitter) by providing two volume controls on the receiver and arranging programmes flagged as 'speech' to switch to the 'speech volume control', while music programmes switch to the 'music volume control'. Furthermore, it is possible for the transmitted programmes to carry double identifications (e.g. Pop music/Information). This same data slot, which recurs every 2ms in the synchronising sequence, can also carry mono/stereo/bilingual flags. Bilingual transmissions are possible because the crosstalk between pairs of channels is well below -60dB, so that the unwanted language is inaudible.

The basic digital signals from the 16 stereo channels are combined together and synchronisation, auxiliary data and error-protection bits are added, before the whole is digitally modulated on to the carrier as described above. The error protection allows 2-bit errors to be corrected, and at least 3 more to be detected and concealed. Concealment can be achieved by repeating the last correct bit instead of the one in error or, better still, by averaging between the bit before the error and the one after. Synchronisation (for the data decoder in the receiver) is provided by an 11-bit word.

In order to prevent interference by the digital sound radio signal when there is no audio signal, or very little present, such as during the programme breaks, an energy dispersal signal is also added. This is a 308-bit section of a 511-bit pseudo-random binary sequence, added to all the bit stream except the sync. and certain data bits. This signal must be noise-like, but has to be 'subtracted' (actually exclusive-ORed) in the receiver, so that the nature of the sequence must be known, hence the use of a pseudo-random signal. The total bit rate comes out at 20·48Mbit.s^{-1} (Mbits per second).

At the receiving end, the 12GHz band signals are first frequency-changed to the band 950MHz to 1350MHz, just as for satellite TV. The second frequency change brings the selected programme channel into the band 118MHz ±7MHz. In Germany, and some other countries, TV tuners cover the whole range from 45MHz to 860MHz continuously, so that they can receive cable television and sound programmes on the so-called 'special channels' outside the normal broadcast bands. It so happens that there are two such channels at 113MHz and 123MHz, and these are intended to be used for DSR signal distribution in cable systems.

Prototype or pre-production receivers have been shown by various manufacturers, including Telefunken (who were chosen by the German government to develop the receiver end of the system) and Philips. The first receivers cost as much as a very good conventional high fidelity tuner, and it is only to be expected that sales are slow. It remains to be seen whether any other countries, including Britain, introduce such a system. It might be particularly attractive to the nations of eastern Europe, who may now want to expand their broadcasting networks quickly at the lowest possible cost.

The Full-Channel MAC-Packet System

The whole point about MAC-Packet is that it can be used for transmitting *anything*, so it is not surprising that digital sound radio is included. The variants of MAC mostly differ in the way they handle the sound/data part of the signal. C-MAC and D-MAC offer a data rate of 20·25Mbit.s^{-1}, while D2-MAC offers half this, being invented to shoe-horn MAC signals into Continental 8MHz cable channels. C-MAC uses 2− or 4−PSK modulation, whereas D and D2 use duo-binary FM. All these variants use NICAM coding as a first choice, with 14-bit linear coding as a second choice, and can have either 1 parity bit for error protection, or the much more effective Hamming code protection which takes up 5 extra bits. Thus all offer four different possibilities for sound coding and error correction. No doubt every country will make a different choice: in developing a system beyond criticism, the engineers have actually developed something with less rigidity, a philosophy, perhaps. The different choices vary in their channel capacity, from 14 to 53. Can you imagine fifty-three radio channels?

MAC packets contain 751 bits. The first 31 bits contain synchronising bits and words describing what the packet contains, and where it is being sent, just like a postal packet address. The remaining 720 bits are for the data, which can be digital sound signals or anything else. The receiver has the task of identifying the packets containing the wanted sound signals and reassembling them into a continuous data stream.

The Japanese MDSD System

This system has two main modes of operation, A and B. Mode A has a 32kHz sampling frequency and uses 14/10-bit NICAM or something very similar, while Mode B offers more than the full CD specification, with 48kHz sampling frequency, 20kHz audio bandwidth and 16-bit linear coding. The channels can also carry asynchronous data. Strong error protection is employed, similar to that used on DSR. Mode A allows 48 channels to be transmitted in one satellite channel, while Mode B allows 24. The modulation system is called Minimum Shift Keying (MSK), and is a form of phase-shift keying that offers much promise for bandwidth economy in the future, since receiver complexity can be allowed to increase while the prices of VLSI devices continue to fall. The maximum transmission bit-rate is 24·576Mbit.s^{-1}, but only experimental transmissions, using the BS-2 satellite have been made, yet. Even so, a prototype receiver designed for home use has been tested on these transmissions.

STOP PRESS

A business trip to Frankfurt coincided with the deadline for this article, so the Kindly Editor allowed me a few more days for an up-to-the-minute report.

The public DSR service actually began in January this year, and there has been quite a strong public interest. The only receiver at present available is the Telefunken DT1000 DSR, which retails at DM1999 (over £700!). All 16 channels are available, duplicating most of the important FM broadcasts, but making them available all over the country (and in neighbouring countries, of course). The DT1000 DSR requires a 118MHz input signal, which can be from cable or from a down-converter supplied by the antenna manufacturer. This receiver has some VLSI chips, but also many general purpose LSI and MSI. The next generation of receivers will have many more VLSI chips and will be substantially cheaper. They will also accept input at 1.3GHz, and will thus be able to tune to different satellite channels, receiving 16 sound channels from each one! Some sales are expected of steerable dishes, which cost about twice the price of a fixed dish, but will allow reception from satellites in different orbital positions.

It was particularly interesting, during my visit to the hi-fi shop of the major Frankfurt dealers 'Radio Diehl', to learn that about 30% of their hi-fi equipment sales are of British equipment, and I saw products from Celestion, Quad and Mission there, among others. It was very clear, in spite of the problems with finding a satellite channel and the present high cost and limited choice of receivers, that if the German manufacturers and retailers have anything to do with it, satellite sound radio will be anything but a white elephant in the future.

Maplin's Marketing Director Doug Simmons (left) handing over the car keys to Robert and Pat Vieira.

Happy Valentine's Day to the Winner of Maplin's Biggest Ever Prize Draw!

Included with the Maplin Winter Showcase brochure, and available to customers at our shops, were details of a special free to enter prize draw, in fact Maplin's Biggest Ever Prize Draw! All of the entries received before 1st February 1990 were registered and entered into the prize draw. Our computer selected at random 5,000 numbers from every possible customer number that could have been issued by the closing date (all entrants who did not have a customer number were issued a number automatically).

On Thursday 1st February 1990 the seal on the envelope containing the numbers was broken. The first registered customer at the top of the list won the 1st prize of a superb Vauxhall Astra GTE 16V. The second registered customer on the list won the 2nd prize of a luxurious trip for two to Paris on the Venice Simplon Orient-Express. The next 500 registered customers each won the runner-up prize of a beautifully bound and illustrated Road Atlas of Great Britain.

On February 14th – Valentine's Day, the lucky 1st prize winner, Robert Vieira and his wife Pat were presented with the Vauxhall Astra GTE 16V. Little did Robert, who lives in Chigwell in Essex, think that when he ordered a hand-held digital multimeter back in November, that it would lead to his winning the Maplin Winter Showcase First Prize! Pat said, "When Vic Sutton, Maplin's Marketing manager phoned and told us the news, I thought he was joking."

In fact winning the new car was highly opportune. Pat had just a few weeks earlier written-off her car. Although it was Robert whose entry won the car, it looks as if Pat will be the driver.

Robert, who markets high level IBM systems, is a keen electronics hobbyist and radio ham. He has been a Maplin customer for around six years, and likes the idea of not having to shop around. "The very wide range of components, coupled with keen pricing and excellent service, makes Maplin my first choice."

Pat is a science technician at Epping Forest College (a Maplin customer) and is responsible for helping to organise practical work in the labs. Pat also looks after the bees at their country cottage on the Norfolk border.

Both Robert and Pat agree that, *"Maplin made our Valentine's Day!"*

Celebrations are also in order for Mr. Hawley from Ayr in Scotland who won the 2nd Prize of an unforgettable trip for two to Paris on the Venice Simplon Orient-Express!

* * *

500 lucky runner-up winners will each receive a Road Atlas of Great Britain:

K. Hutchison, Castle Douglas;
D. Clark, Huntingdon;
W. Blackman, Newent;
J. Van Went, Reading;
G. Monk, Dunmow;
P. Whiting, Leicester;
J. Pierce, Bolton;
A. French, Bedford;
T. Foster, Peterborough;
E. Davison, Beverley;
R. Kenyon, Liverpool;
Mrs. Bloomfield, Harlow;
D. Beales, Bury St. Edmunds;
M. Goddard, Dover;
D. Walker, Bushmills;
S. Law, Littleborough;
R. Parkes, Skelmersdale;
R. Wilson, Maidenhead;
F. Wootten, Totnes;
M. Woolley, Rushden;
A. Sutherland, Hull;
W. Webster, Flint;
J. Doull, Thurso;
T. Cardy, Newtownards;
M. Patel, Stalybridge;
N. Carr, Kendal;
A. Stuttard, Liss;
R. Perkins, London;
J. Roberts, Bristol;
C. Allum, Brighton;
T. Buckley, Woolwich;
I. Russell, Bristol;
J. Galsworthy, Dudley;
J. Mearns, Brechin;
C. Roberts, Telford;
C. Paynter, Rugeley;
R. Pink, King's Lynn;
R. Prichard, Ilford;
I. Busby, York;
A. Wright, Faversham;
F. Weston, Tynygongl;
R. Osborne, Hereford;
M. Warner, Walton-on-Thames;
C. Hills, Worcester;
J. Hosier, Pwllheli;
A. Eales-White, Sturminster;
B. Campbell, Norwich;
I. Hatton, Gloucester;
P. Sendonaris, London;
D. Bishop, Preston;
J. Bowes, Ormskirk;
K. Lake, Barnet;
C. Newcombe, Nottingham;
J. Bamford, Wells;
R. Gurowich, Wells;
E. Abbott, Orpington;
R. Cato, Horsham;
G. White, Manchester;
R. Davis, Haslemere;
Ms. Chand, Birmingham;
A. MacNaughtan, Poole;
M. Newbold, Leamington Spa;
S. Marshall, Pickering;
A. Daws, Derby;
M. Holmes, Leicester;
M. Hill, Southampton;
G. Wall, Slough;
J. McKay, Choppington;
N. Thomas, St. Albans;
M. Brondhurst, Gainsborough;
E. Palin, Nantwich;
M. Moss, Poole;
W. Mallett, Slough;
W. Holden, Dartford;
D. John, Glasgow;
J. Wright, Broadstairs;
D. Goudie, Pickering;
C. Jenkins, Gloucester;
A. Osborn, Burgess Hill;
A. Lochmuller, Northampton;
T. Yasin, Winsford;
P. Tasker, Brighton;
C. Austin, Coventry;
A. Tipper, Liverpool;
R. Gilham, Ramsgate;
W. Simpson, Lydney;
J. Ferguson, Camberley;
C. Cartwright, Liss;
W. Speakman, Grantham;
S. Hopkins, Treharris;
R. Clark, Wallasey;
F. Jackson, Burnley;
A. Thomson, Glenrothes;
K. Jewell, Bootle;
P. Hynam, Bristol;
M. Dibben, Welwyn;
A. Latty, Cramlington;
D. Whitelaw, Tillicoultry;
E. Golding, Cardiff;
G. McIntosh, Grantown-on-Spey;
C. Rolinson, Walsall;
P. Simpkins, Woodford Green;
A. Warburton, Spalding;
C. Abrey, Bury St. Edmunds;
H. Bond, Bradford;
N. Thomas, Glasgow;
A. Jones, Neath;
L. Buist, Ferryhill;
K. Ballard, Newnham;
G. Aldous, Buxton;
A. Kimberley, Hove;
D. Barker, Ipswich;
D. Thomas, Oxford;
R. Barnell, Northampton;
C. Cox, Newbury;
A. Seator, Stromness;
J. Beare, Dartford;
J. Rose, Gillingham;
V. Ferneyhough, Stafford;
P. Rose, Royston;
N. Skelton, Hitchin;
S. Nash, Enfield;
I. Cardy, Enfield;
S. Ottaway, Reading;
M. Hyman, Deal;
S. Ludkin, Bexhill-on-Sea;
J. Nestola, South Woodford;
Mr. Summit, Birmingham;
E. Watson, Barrow-in-Furness;
D. Ellis, Rotherham;
N. Gray, Amersham;
K. Shenton, Stoke-on-Trent;
J. Jackson, Rotherham;
P. Smith, Leicester;
S. Neil, Buntingford;
E. Bloxham, Felixstowe;
R. Tugwell, Northampton;
G. Griffiths, Stockport;
P. Johnstone, Thame;
F. Lewis, High Wycombe;
T. Cartwright, Leicester;
L. Harvey, Hythe;
D. Geary, Berkhamsted;
G. Hayden, Oxford;
A. Kelly, Basingstoke;
J. Phillipson, Basingstoke;
N. Fairless, Stockton-on-Tees;
R. Rose, London;
D. Bisp, Middlesbrough;
A. Dudley, Portland;
D. Chivers, Brixham;
S. Greenaway, Swindon;
A. Keith, Arbroath;
J. Houseman, Brackley;
L. Stratford, Cambridge;
J. Crowden, Thurso;
D. Wood, Hemel Hempstead;
B. Gardener, Southport;
L. Boden, Stroud;
A. Jones, Newcastle;
K. Ware, Whitstable;
E. Field, Northampton;
S. Baker, Selby;
M. Case, Solihull;
J. Peppiatt, Northampton;
J. Alexander, Ipswich;
R. Gage, Winchester;
J. Mitchell, Whitstable;
M. Chesher, Bedford;
D. Tugby, Birmingham;
J. Cummings, Grimsby;
J. Rooke, Kingsbridge;
S. Spencer, Sheffield;
J. Malt, Great Yarmouth;
M. Worrall, Mexborough;
K. Rogers, Bristol;
W. Beedle, Wolverhampton;
S. Fenton, Manchester;
W. Surgenor, Wrexham;
C. Brewis, Tadworth;
N. Fitzgerald, Oxford;
A. Brassington, Stone;
K. Forward, Bognor Regis;
A. McAlpine, Bristol;
M. Kelly, Wigan;
A. Baird, Wallsend;
T. Smith, Milton Keynes;
M. Ikram, Birmingham;
G. Daly, Peterborough;
D. Matheson, Loanhead;
A. Callard, London;
F. Unsworth, Bedford;
R. Porter, Coleraine;
R. Yarham, Norwich;
G. Bowen, Abergavenny;
M. Fryer, Colchester;
G. Berry, Cupar;
H. Pattison, Swindon;
A. Brierley, Norwich;
R. Cauldwell, Bury St. Edmunds;
S. Markham, Cheltenham;
R. Yarham, Norwich;
O. Fairgrieve, Isle of Lewis;
I. Hipkins, Oxford;
A. Graves, Brigg;
A. Middleton, Brighton;
C. Panter, Kettering;
P. Whiteside, Ilford;
B. Francis, Enfield;
D. Fyfe, Cardiff;
M. Hosford, Newtownards;
S. Gibbons, Crawley;
B. Wilcox, Swansea;
A. Tough, Newton Abbot;
N. Wright, Manchester;

J. Gamble, Ely;
R. Armstrong, Newtownards;
C. Skett, Weston-Super-Mare;
K. Lewis, London;
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R. Makin, East Linton;
J. Egleton, Stonehaven;
F. Tow, Scunthorpe;
I. Roberts, Wirral;
D. Tomkins, Exeter;
A. West, Burgess Hill;
P. Haydon, Reading;
C. Davies, Mold;
Mr. Browne, Burton-on-Trent;
F. Grimwood, Ipswich;
J. Poole, Middlesbrough;
L. Delamare, Billericay;
F. Dowdy, Oxford;
D. Hickson, Whitehaven;
J. Williams, Bromley;
M. Martin, Calne;
L. Wadeson, Epsom;
Miss Stephens, Warrington;
D. Liddle, Maidenhead;
J. Hughes, Pontypridd;
S. Plumridge, Dartford;
M. Baxter, Bristol;
Dr. Fisher, Wembley;
J. M'Cormick, Sheffield;
A. Cornish, Eastbourne;
D. Moffat, Witney;
J. Davies, Thornton Heath;
Q. Garlick, Saxmundham;
J. Black, Aberdeen;
P. Kempley, Aldershot;
J. Hulme, Woking;
A. Peel, Leicester;
T. Webber, Northwich;
P. McAtamney, Woking;
A. Lyons, Barnet;
D. Ogara, Derby;
G. Wild, Wimborne;
P. Gant, Slough;
V. Hobby, Reading;
M. Aldridge, Bedford;
R. Smith, Shipston-on-Stour;
A. Patterson, Aberdeen;
A. Nicolaou, Gravesend;
J. Humphreys, Blackburn;
F. Lupton, London;
M. Goodrick, Henlow;
P. Rogers, Jersey;
H. Collins, Didcot;
D. Willcocks, Plymouth;
R. Derkacz, Oxford;
J. Francis, Tredegar;
C. Hodgson, East Ham;
E. Smith, Birmingham;
P. Clark, Dunstable;
R. Thomas, Camberley;
H. Mitchell, Peterborough;
R. Skidmore, Exeter;
D. Johnson, Chichester;
B. Whitehead, Oxford;
D. Coleman, Hemel Hempstead;
C. Sparrow, Beith;
I. Horne, Paisley;
A. Lennon, Liverpool;
R. Potter, Dorking;
A. Walter, Alton;
W. Brittain, Grantham;
P. Pendlebury, Bridgend;
J. Marsh, Bognor Regis;
L. Colwell, Helston;
T. Wood, Hartlepool;
L. Hayes, Coulsdon;
G. Shelton, Polegate;
R. Carter, York;
B. Hubbard, Halifax;
M. Gardener, Aylesbury;
W. Cook, Swansea;
J. Hudson, Chessington;
F. Holland, Southampton;
R. Bevan, Ross-on-Wye;
P. Allen, Chelmsford;
B. Hay, Horley;
P. Brown, Colchester;
P. Holbrook, Thetford;
P. Cox, Welwyn Garden City;
G. Ballantyne, Sleaford;
G. Poole, Durham;
A. Attwood, Widnes;
R. Campbell, Newtownabbey;
P. Nicholas, Oswestry;
S. Hodge, Wolverhampton;
R. Newman, Colchester;
R. Leeming, Preston;
I. Slack, Scunthorpe;
J. Cairns, West Calder;
P. Willmer, Solihull;
W. McCulloch, Irvine;
P. Jeffcote, Nuneaton;
C. Cullimore, Paignton;
M. Bartlett, St. Austell;
T. Humphries, Egham;
S. Bradshaw, Canterbury;
B. Jenkinson, Stockport;
I. Owen, Tycroes;
G. Smeeton, Barnstaple;
P. Mountain, Grays;
F. Boulton, Glasgow;
R. Bowles, Lowestoft;
E. Spall, Basildon;
D. Tabberer, Worcester;
M. Coventry, Burntisland;
A. Beal, Sheffield;
T. Morley, Bolton;
G. Walker, Camberley;
E. Reinlo, St. Albans;
M. Bell, Carlisle;
D. Collings, Huntingdon;
L. Corke, Southall;
D. Meek, Strathaven;
A. Blake, Bournemouth;
T. White, St. Ives;
E. Rogers, Sudbury;
A. Rees, Epping;
V. Djan, London ;
G. Paraskeva, London;
T. Brice, Cobham;
M. Smythe, Bracknell;
R. Scott, Tewkesbury;
J. Calladine, Reading;
D. Murdoch, Ayr;
S. Rolph, Dunmow;
J. Hawkins, Christchurch;
S. Williams, Stroud;
R. Ridgewell, Norwich;
P. Rendall, Weymouth;
D. Maina, RAF Wildenrath;
T. Harvey, Chelmsford;
M. Roberts, Lincoln;
D. Parry, Swansea;
J. Brown, Glasgow;
T. Mummery, London;
Dr. Collins, Southampton;
M. Parsons, Tunbridge Wells;
K. Wells, Aylesbury;
T. Swinburne, Daventry;
A. Thomson, Whitley Bay;
S. Holmes, Hemel Hempstead;
D. Reeves, Swindon;
W. Lowe, Connel;
M. Nash, Gloucester;
I. Sleat, Welwyn;
L. Hird, Aberlour;
C. Mitchell, Dumfries;
I. Stone, Gillingham;
R. Hill, Camberley;
K. Black, Wallingford;
H. Courtenay, Stockport;
S. Lewcock, Kirkcaldy;
H. Nash, Lancaster;
J. Fernie, Cowdenbeath;
J. Dermott, Camberley;
D. Cassidy, Redcar;
P. Neill, Portrush;
J. Padhar, Leicester;
P. Dunn, Plymouth;
J. Bowen, Carnoustie;
G. Ireson, Bridgend;
R. Distill, Uxbridge;
R. Regan, Belfast;
R. Yorston, Reading;
J. Gouck, Ramsey;
R. Warn, Walton-on-the-Naze;
R. Perkins, Haverfordwest;
L. Sarson, Ilford;
S. Slee, Thetford;
R. Pettitt, Colchester;
A. Mitcham, Coventry;
G. England, Carmarthen;
C. Forsey, Beaminster;
P. Paterson, Basingstoke;
A. Sharp, Cardiff;
M. Wopshott, Cheltenham;
L. Hepworth, Derby;
B. Munt, South Norwood;
P. Elliott, Newport;
R. Moore, Richmond;
G. Coy, Grantham;
A. Brooks, Henfield;
S. Gawlowski, Boston;
A. Sinclair, Wick;
J. Rowe, Lincoln;
D. McDonald, Hamilton;
A. King, Pickering;
B. Hughes, Abergele;
A. Hill, Halesowen;
R. Dalton, Sheffield;
E. Gosling, Ilfracombe;
P. Evans, Llanelli;
S. Moyler, Faversham;
A. Burley, Peterborough;
G. Blair, Glasgow;
S. Whiteley, Goole;
S. Markwell, Aldershot;
S. Hargreaves, Ashton-under-Lyne;
R. Bunney, Romsey;
J. MacFarlane, Feltham;
J. Lancaster, Dorking;
R. Munday, Hailsham;
J. Saunders, Chepstow;
P. Nicholson, Dunvegan;
A. Rose, Derby;
N. Cooray, Lewes;
M. Walker, Didcot;
Dr. Joiner, Lybster;
C. Varnham, St. Albans;
T. Maule, Ipswich;
N. Redhead, Torquay;
A. Abbott, Kirkcaldy;
N. Virgo, Crawley;
P. Edwards, Bath;
J. Bateman, Weybridge;
J. Stamp, Redcar;
G. Anderson, Chatham;
S. Gray, Didcot;
N. Titmus, Sandy;
P. Andersen, London;
M. Buttle, Sutton;
L. Baker, RN Commcen;
P. Stephens, Luton;
M. McQuillan, Barnsley;
B. Grady, Birmingham;
H. Trinh, Halifax;
I. Paton, Whitney;
J. Spencer, Leicester;
P. Field, Stafford;
W. Harris, Glasgow;
J. Bowie, Stowmarket;
E. Delves, Ipswich;
J. Smellie, Glasgow;
K. Dean, Crawley;
R. Arnott, Leeds;
D. Brough, Hartlepool;
A. Hewlett, Fraserburgh;
A. Kennelly, Huddersfield;
M. Johnson, Grantham;
R. Ridelle, Southampton;
J. Rutherford, Glasgow;
K. Norman, Stroud;
N. Clarke, Liverpool;
S. Baxter, Liverpool;
V. Crewe, Blackburn;
A. Jones, Croydon;
B. Hill, Selkirk;
D. Roads, Milton Keynes;
G. Farrow, Essex;
R. Stevenson, Newbury;
S. Maw, Scunthorpe;
G. Wilyman, Harleston;
S. Greenway, Coventry;
E. Balsara, King's Lynn;
D. Horsfield, Tyne & Wear;
C. Martin; King's Lynn;
B. Coleman, Grantham;
K. Ball, Basingstoke;
T. Andreou, Reading;
Dr. Forbes, Leeds;
T. Jacob, London;
V. Varsani, London;
R. Hey, Surrey;
T. Vickers, Dyfed;
L. Milton, Hastings;
J. Lee, Bexhill-on-Sea;
R. Wiltshire, Hoddesdon;
S. Jones, Dyfed;
S. Morris, Newbury;
D. Pickup, Darwen;
N. Hodgson, Scarborough;
A. Morris, Derby;

MAPLIN'S TOP TWENTY KITS

THIS MONTH	LAST MONTH		DESCRIPTION OF KIT	ORDER CODE	KIT PRICE	DETAILS IN PROJECT BOOK
1.	(2)	▲	Digital Watch	FS18U	£1.98	Catalogue
2.	(1)	▼	Live Wire Detector	LK63T	£3.95	14 (XA14Q)
3.	(3)	▲▼	150W MOSFET Amplifier	LW51F	£19.95	Best of E&MM
4.	(4)	▲▼	Car Battery Monitor	LK42V	£8.95	Best of E&MM
5.	(8)	▲	Mini Metal Detector	LM35Q	£5.25	25 (XA25C)
6.	(10)	▲	Watt Watcher	LM57M	£3.95	27 (XA27E)
7.	(5)	▼	Partylite	LW93B	£9.95	Best of E&MM
8.	(6)	▼	I/R Prox. Detector	LM13P	£9.95	20 (XA20W)
9.	(7)	▼	Siren Sound Generator	LM42V	£3.95	26 (XA26D)
10.	(18)	▲	TDA2822 Stereo Power Amp	LP03D	£6.45	34 (XA34M)
11.	(14)	▲	LM386 Kit	LM76H	£3.75	29 (XA29G)
12.	(16)	▲	15W Amplifier	YQ43W	£6.45	Catalogue
13.	(9)	▼	PWM Motor Driver	LK54J	£9.45	12 (XA12N)
14.	(12)	▼	8W Amplifier	LW36P	£5.95	Catalogue
15.	(–)	▲	Digital Playback	LM85G	£14.95	31 (XA31J)
16.	(11)	▼	U/Sonic Car Alarm	LK75S	£19.95	15 (XA15R)
17.	(13)	▼	Car Burglar Alarm	LW78K	£9.95	Comp 2 (XC02C)
18.	(–)	▲	Car Digital Tacho	LK79L	£17.95	37 (XA37S)
19.	(–)	▲	Noise Gate	LK43W	£9.95	Best of E&MM
20.	(–)	▲	Record/Playback	LM80B	£36.95	30 (XA30H)

Over 150 other kits also available. All kits supplied with instructions.

The descriptions above are necessarily short. Please ensure you know exactly what the kit is and what it comprises before ordering, by checking the appropriate Project Book mentioned in the list above.

2ND Time Around

Syntom DRUM Synthesiser

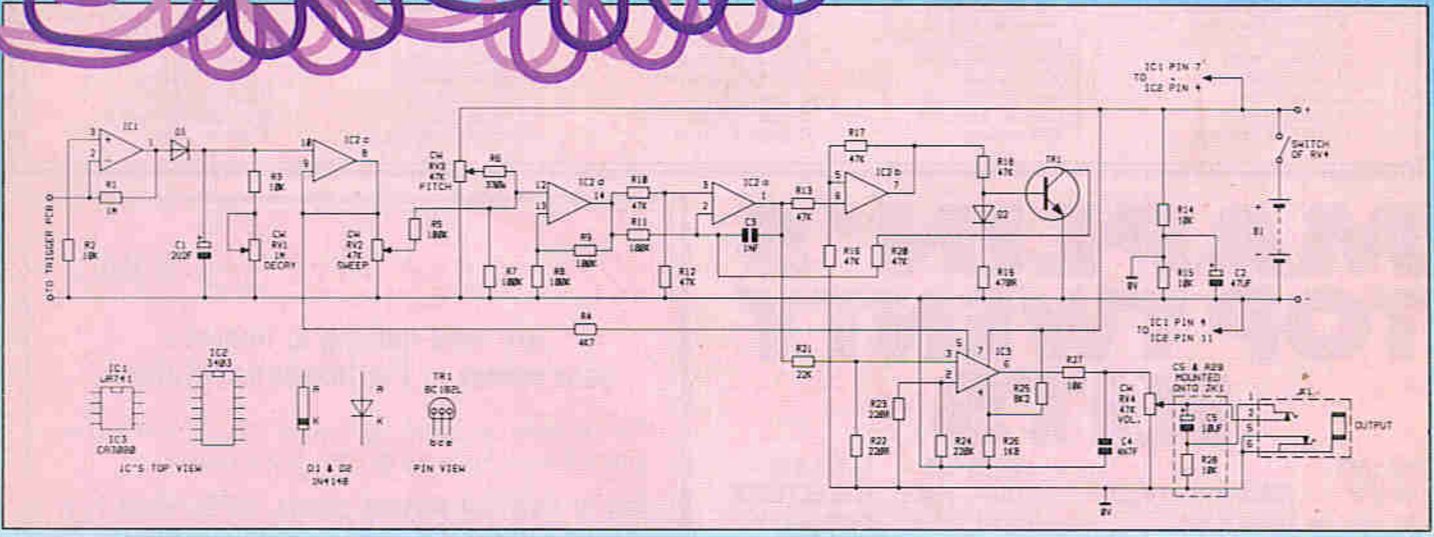


Figure 1. Circuit diagram, syntom

by Alan Williamson

based on an original project by Clive Button

Particular projects from the Maplin range have proved to be very popular over the years. Unfortunately modern technology and electronic components have a habit of changing, with the result that some of these projects are in danger of becoming obsolete as the originally specified components become unavailable or standards change. In order for some of the more popular projects to remain available updates and improvements are necessary, and to this end these projects are being reviewed in the series "2nd Time Around". This time it is the turn of the Syntom Drum Synthesiser.

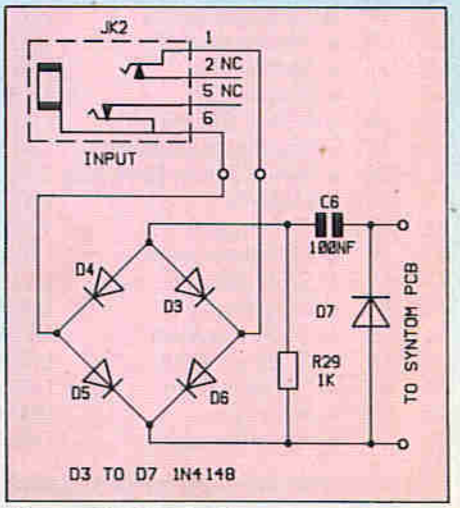
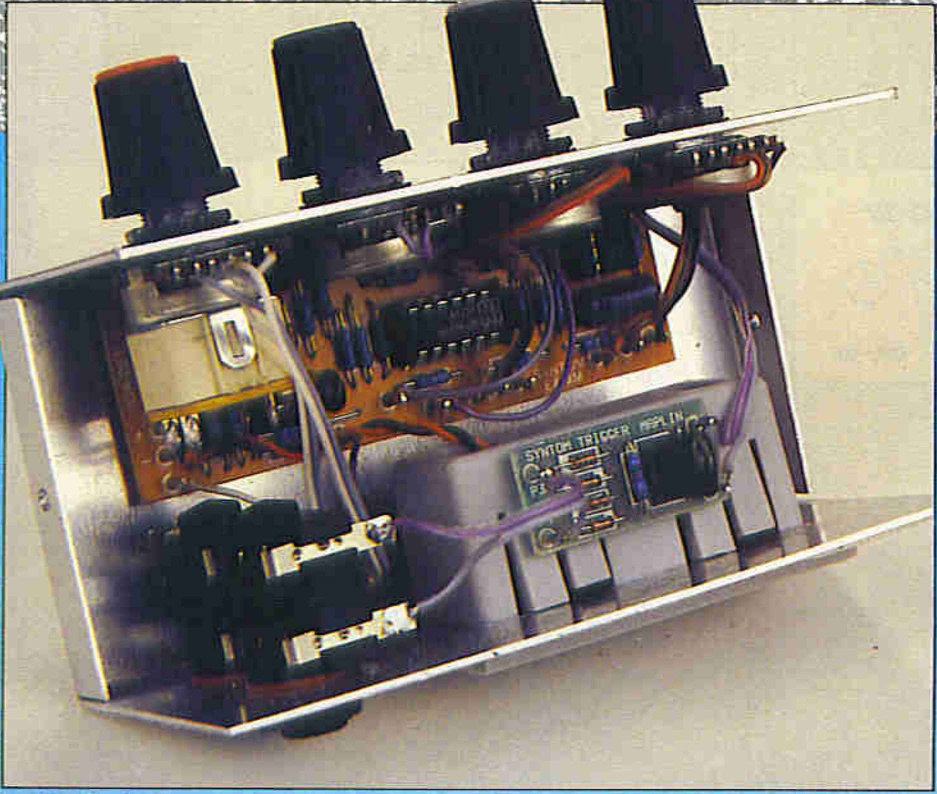


Figure 2. Circuit diagram, input trigger.



Inside the box

Syntom

The Syntom is a very effective drum synthesizer that can produce a variety of fixed and falling tonal effects, either by tapping a crystal transducer directly, by striking an existing drum to which the transducer is attached, or by applying a voltage signal in the range of 1.5 to 9V. Different voltage levels produce different sounds. This voltage could be a trigger output from a keyboard instrument, for example. Four potentiometers control different characteristics of the sound. As well as determining the level of the output signal sent to the externally connected amplifier, the 'Volume' control is also the power 'on-off' switch for the internal battery supply. The 'Decay' control governs the time taken for the sound to die away after each strike, from less than 1/10 sec. to several seconds, giving a wide range of envelopes. The frequency of the note produced can be varied over the entire audio range by means of the 'Pitch' control, and 'Sweep' is used to introduce a control voltage which causes the pitch to fall as the amplitude decreases. These controls, when used in combination with each other, enable the most popular synthesiser effects, as heard on commercial recordings, to be obtained.

Circuit

The circuit is in four main parts: the Input Trigger Circuit (using the small PCB), the Envelope Generator, the Voltage Controlled Oscillator (VCO), and the Voltage Controlled Amplifier (VCA). Figures 1 and 2 show the circuit diagrams for the main PCB and the Input Trigger PCB. The Envelope Generator requires a negative edge trigger pulse. This is derived from D3 to 6, arranged to form a bridge rectifier, producing a negative output voltage which is AC coupled to the inverting input of IC1 via C6. R29 is used to remove any DC charge from C6 afterwards, and D7 clamps the inverting input of IC1 to 0V to prevent it becoming more negative than the 0V rail, with the risk of damaging the op-amp.

IC1 forms the first stage of the envelope generator, detecting the signal produced by the crystal earpiece, or the drum to which it is fitted, when struck. The trigger signal charges C1 via D1, and the capacitor is then discharged slowly by RV1 and R3. This envelope voltage is buffered by IC2c and sent to the VCA via R4. It is also sent via RV2, the 'Sweep' potentiometer, to IC2d. Here it is mixed with a voltage from the 'Pitch' control RV3, to drive the VCO section. The VCO consists of an integrator formed around IC2a, and a schmitt trigger (IC2b) driving

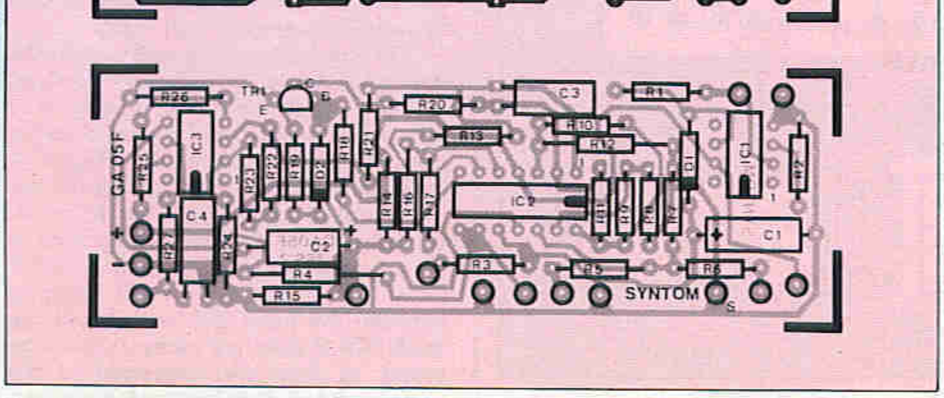


Figure 3. Syntom PCB track and legend.

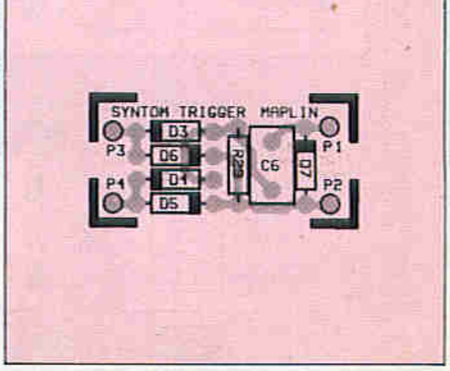
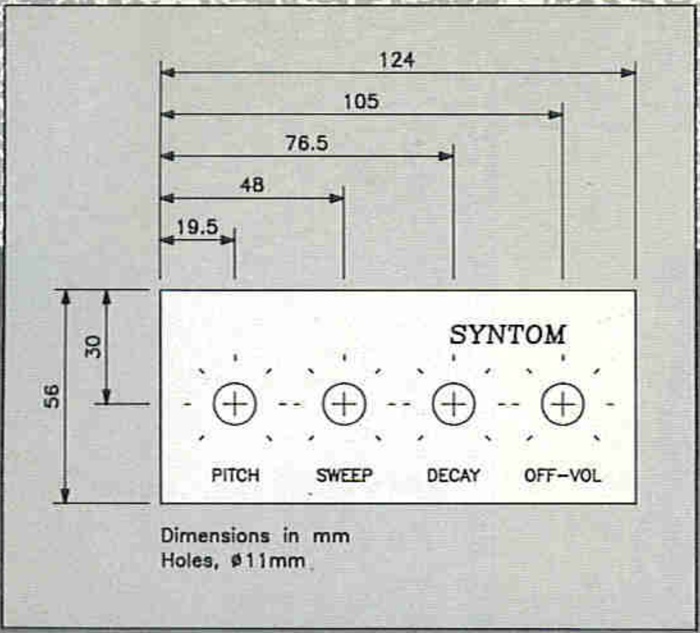
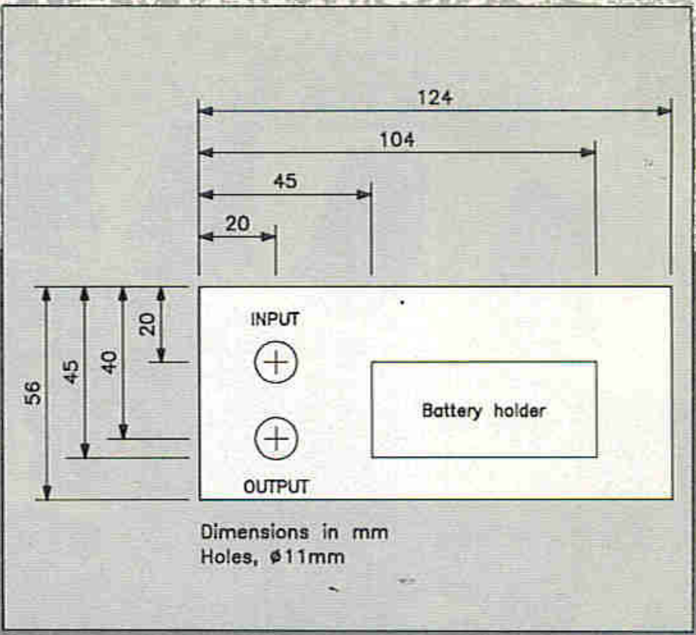


Figure 4. Input trigger circuit PCB track and legend.



Dimensions in mm
Holes, ø11mm

Figure 5. Front panel drilling.



Dimensions in mm
Holes, ø11mm

Figure 6. Rear panel drilling.

TR1. When the integrator voltage reaches the lower threshold of IC2b, TR1 is turned on, effectively 'shorting' the inverting input of the integrator to ground (−VE) via R20, forcing it to act in the non-inverting mode. Hence the output voltage rises until the upper threshold is reached, IC2b then changes state, turning off TR1, and the output voltage from IC2a starts to drop, as it is now back in the inverting mode.

The resultant signal, which is a triangular waveform, is then delivered to the VCA section. This comprises a CA3080 transconductance amplifier, IC3. The gain of this amplifier is controlled by the output of the envelope generator, in such a way that as the envelope voltage at C1 decays, the triangular waveform signal is increasingly attenuated until it is reduced to a very low, inaudible level. The output of the CA3080 is to RV4, the 'Volume' control, and from there to the output jack socket via C5. R28 is the terminating resistor which sets the output impedance to 10kΩ.

A dual supply for the syntom circuitry is derived from the single 9V battery by a potential divider formed by R14 and R15, providing a central 0V rail which is stabilised by C2.

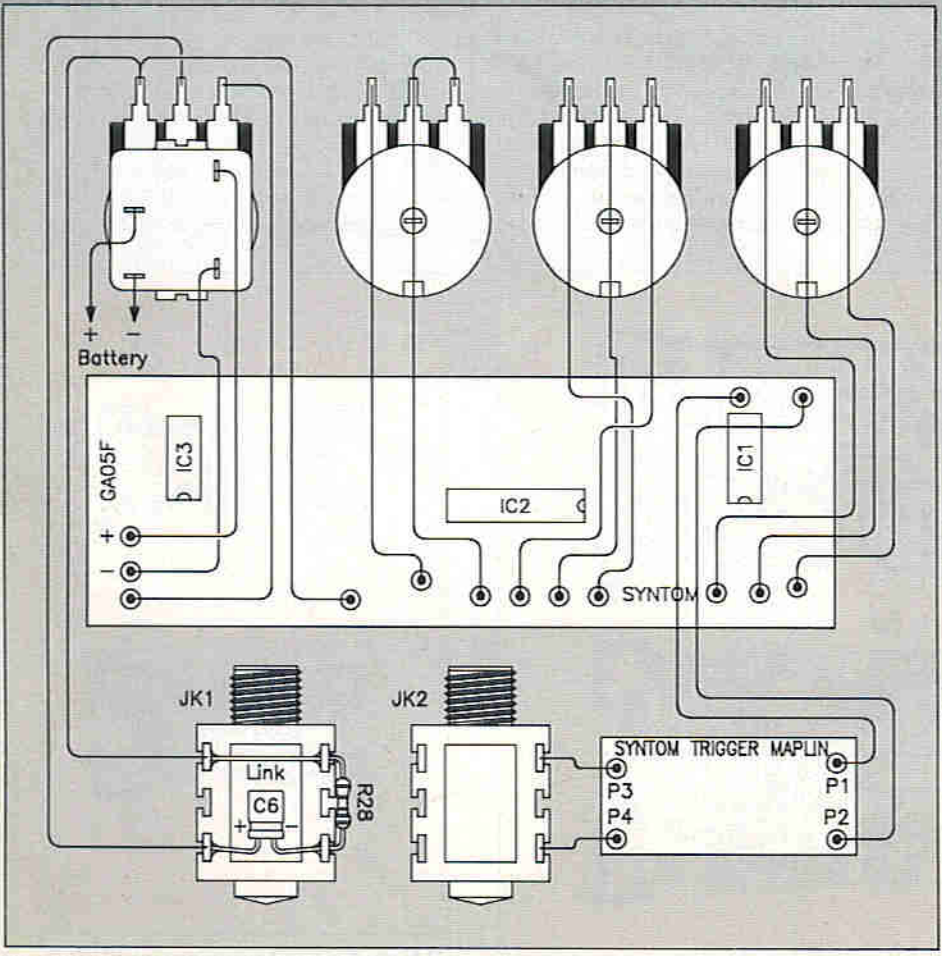


Figure 7. Potentiometer and wiring layout.

Constructional Details

If you are fairly inexperienced at project building then please refer to the Constructors' Guide for hints and tips on soldering and constructional techniques.

Note that there are two PCB's in the kit, the main PCB and the Input Trigger Circuit PCB (the smaller one). Figure 3 shows the main PCB and Figure 4 shows the Input Trigger Circuit PCB. All resistors, capacitors, (except R28 and C5), semiconductors and pins are mounted onto the printed circuit boards – the pins are inserted from the track side. Insert, solder and crop each component one at a time, working from the smallest to the largest, taking care as always with the orientation of electrolytic capacitors, IC's, diodes, and the transistor. Then after completing the PCB's, wires can be soldered to the pins for connection to the input PCB, potentiometers and jack sockets.

Some holes are required to be cut in the box, see Figures 5 and 6. Having drilled or cut all of the holes required, the main PCB can now be fitted into the box, close to the front panel, with equal spacing at the sides of the box. The PCB is then fixed using quick stick pads of *double* thickness (two together) to avoid shorting the track side of the PCB against the metalwork of the box. The shafts of the potentiometers need to be trimmed down in length to 10mm with a junior hacksaw or similar. Once this has been done, the potentiometers can be fitted into the box and wired up exactly as in Figure 7.

Fit the battery box and solder the battery clip to the 'on/off' switch terminals of the 'Volume' control and main PCB. Solder C5 and R28, and a wire link to the output jack socket as shown in Figure 8. Next make the connections from the 'Volume' control to the jack socket 'break' contacts. The small PCB can then fixed to the top of the battery box using quickstick pads. Leads should now be soldered between the input jack socket and the small PCB (it does not matter which way round, as they are connected to the bridge rectifier). Both jack sockets are then

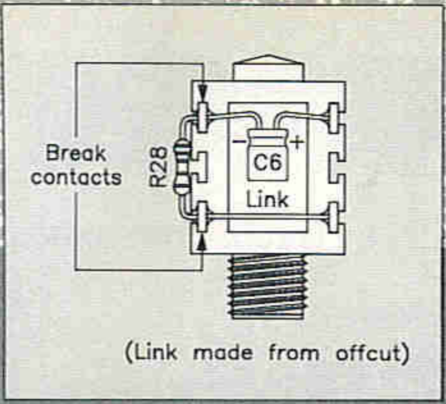


Figure 8. Jack socket, capacitor and resistor.

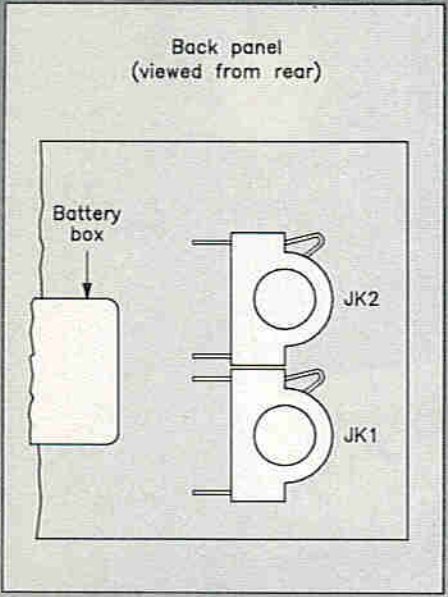
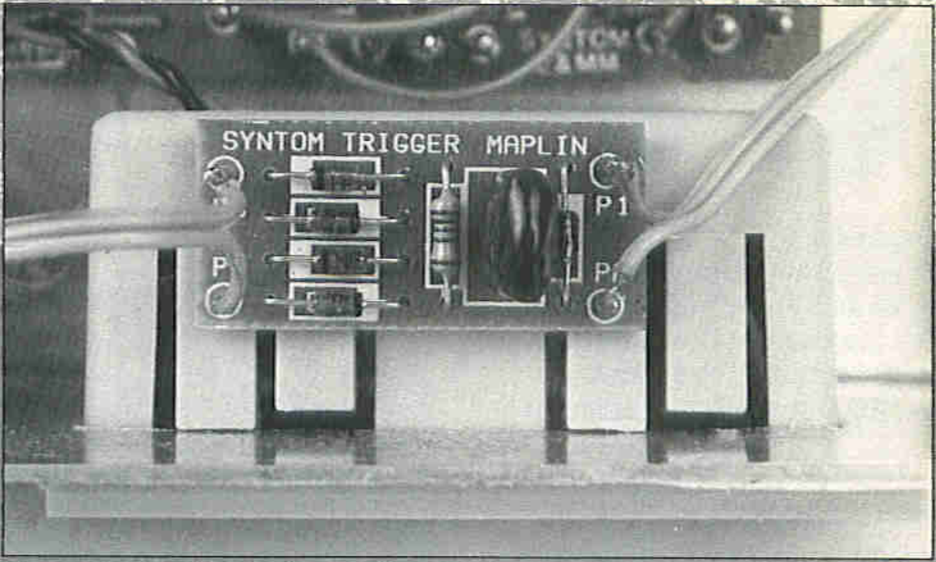


Figure 9. Jack positions in box.



Close up view of input trigger pcb

fitted into the box, see Figure 9. The unit is completed by fitting the knobs to the potentiometers and sticking rubber feet to the bottom of the box. The unit is now ready for testing.

Testing and Use

Connect the drum synthesiser to an external amplifier, and with all the Syntom controls at midway position, firmly tap the crystal earpiece. A medium duration, falling pitch effect should be heard, experimentation with the controls will soon reveal the whole range of sounds available. The sensitivity of the unit has been fixed to respond to a direct hit, but not to external sounds and vibrations, including those from other drums in the kit. When the crystal earpiece is fixed to a drum, the Syntom can be set off just by hitting the drum rim with the stick, or caused to sound along with the drum if the skin is hit. Since the sound varies with stick impact, particularly interesting effects can be produced by, for example, using a sharply falling pitch with an envelope of similar length to the natural drum sound, and playing single hits and rolls of differing impact force on the drum skin. Since the drum synthesiser is battery powered, it should be turned off when not in use to conserve power, though a single PP3 battery will still provide up to 60 hours of continuous playing as the current consumption is only 6mA maximum.

SYNTOM DRUM SYNTHESISER PARTS LIST

Resistors: All 0.6W 1% Metal Film			
R1	1M	1	(M1M)
R2,3,14,15,27,28	10k	6	(M10K)
R4	4k7	1	(M4K7)
R5,7,8,9,11	100k	5	(M100K)
R6	330k	1	(M330K)
R10,12,13,16,17,18,20	47k	7	(M47K)
R19	470Ω	1	(M470R)
R21	22k	1	(M22K)
R22,23	220Ω	2	(M220R)
R24	220k	1	(M220K)
R25	8k2	1	(M8K2)
R26	1k8	1	(M1K8)
R29	1k	1	(M1K)
RV1	1M Log Pot	1	(FW28F)
RV2,3	47k Log Pot	2	(FW24B)
RV4	47k SW Log Pot	1	(FW65V)
Capacitors			
C1	2µ2F 100V Axial	1	(FB15R)
C2	47µF 16V Axial	1	(FB38R)
C3	1nF Mylar	1	(WW15R)
C4	4n7F Mylar	1	(WW17T)
C5	10µF 16V Minelect	1	(YY34M)
C6	100nF Mylar	1	(WW21X)
Semiconductors			
IC1	µA741	1	(QL22Y)
IC2	3403	1	(QH51F)
IC3	CA3080	1	(YH58N)
TR1	BC182L	1	(QB55K)
D1,2,3,4,5,6,7	1N4148	7	(QL80B)
Miscellaneous			
JK1,2	Mono-jack Socket	2	(HF90X)
	Mono-jack Plug Adaptor	1	(RW00A)
	Main PCB	1	(GA05F)
	Input PCB	1	(GE44X)
	Ribbon Cable 10 way	1 Mtr	(XR06G)
	Pins	1 Pkt	(FL24B)
	Constructors Guide	1	(XH79L)
	Crystal Earpiece	1	(LB25C)
	PP3 Battery Clip	1	(HF28F)
Optional			
B1	PP3 Battery (Alkaline K9V)	1	(FK67X)
	Case WB1	1	(LF02C)
	Battery Box	1	(XX33L)
	Knob	4	(YG40T)
	Blue Knob Cap	1	(QY01B)
	Green Knob Cap	1	(QY02C)
	Grey Knob Cap	1	(QY03D)
	Red Knob Cap	1	(QY04E)
	Rubber Feet	1 Pkt	(FW38R)
	Quickstick Pads	1 Strp	(HB22Y)

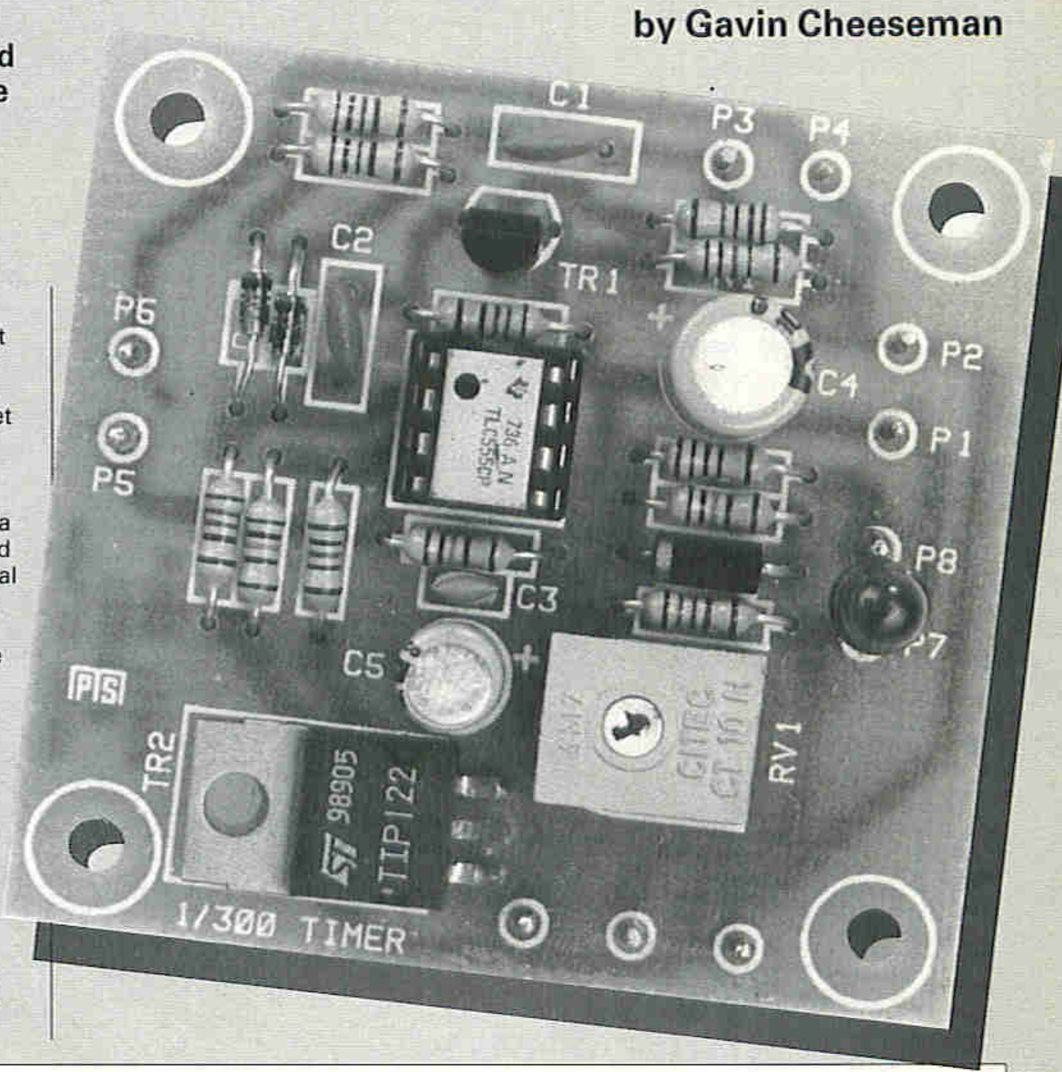
A complete kit of all parts, excluding Optional items, is available:
Order As LP34M (Syntom Kit) Price £11.95
The following item is also available separately:
Input Trigger PCB **GE44X Price £1.65**

1/300 Timer

by Gavin Cheeseman

Features

- ★ Adjustable Operating Period
- ★ Wide Supply Voltage Range
- ★ Low Current Consumption
- ★ Switches up to 500mA
- ★ LED Output State Indicator



Introduction

Many applications call for a short duration timer to provide a 'time out' (auto switch off) function for devices such as lights and sounders after a set period. The 1/300 timer provides a switched output with an adjustable period of between approximately 1 second and 5 minutes. Current up to a maximum of 500mA may be switched using the timer module making it ideal for driving relays, sirens, etc. A light emitting diode is included in the design to provide an indication of the output state.

Circuit Description

Referring to Figure 1, it may be seen that the circuit is based around the TLC555 timer IC; this device is a low power CMOS version of the NE555 timer and has the additional advantage that it typically draws around 1/50 of the current of the standard device. Additional features have been implemented to make the 1/300 Timer more versatile than a

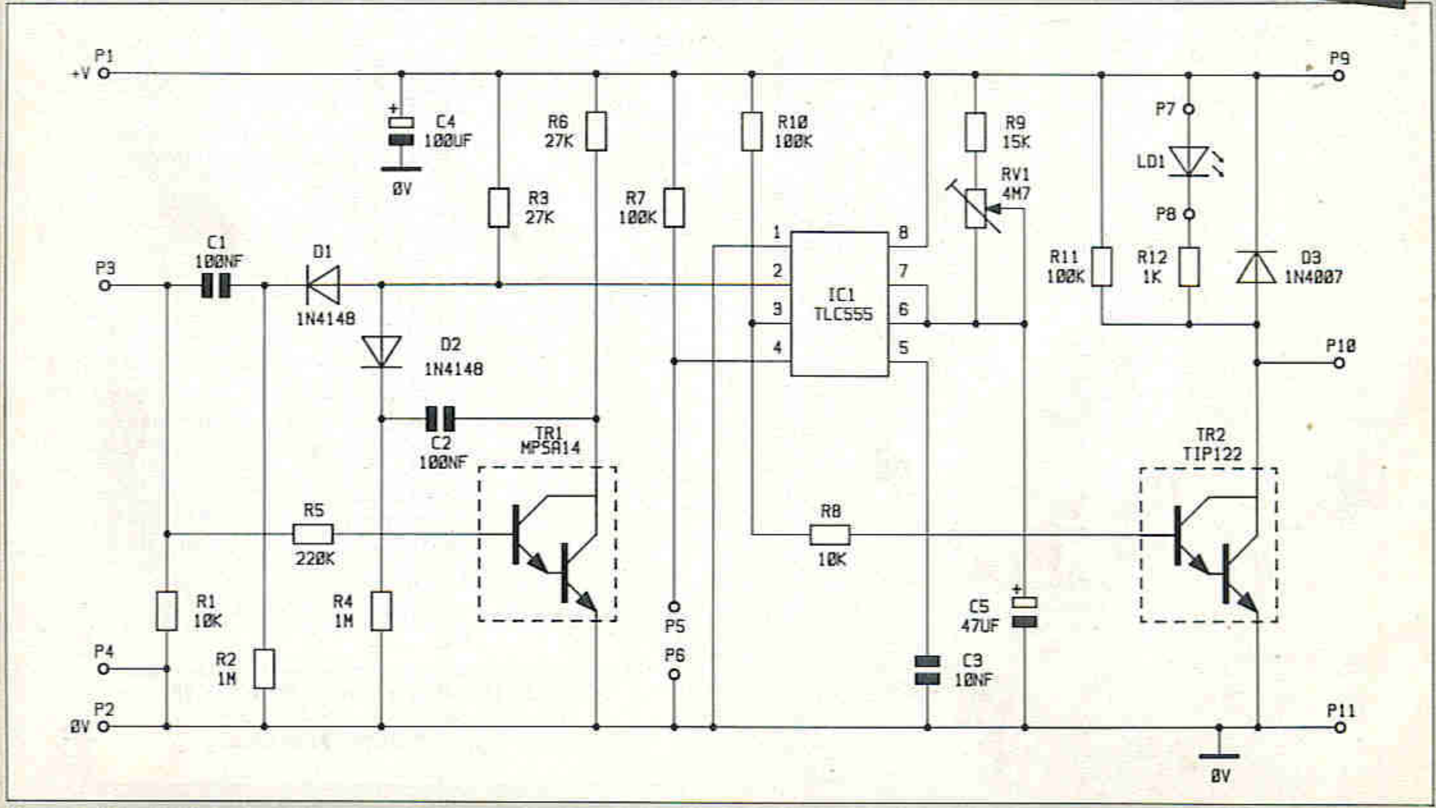


Figure 1. Circuit Diagram

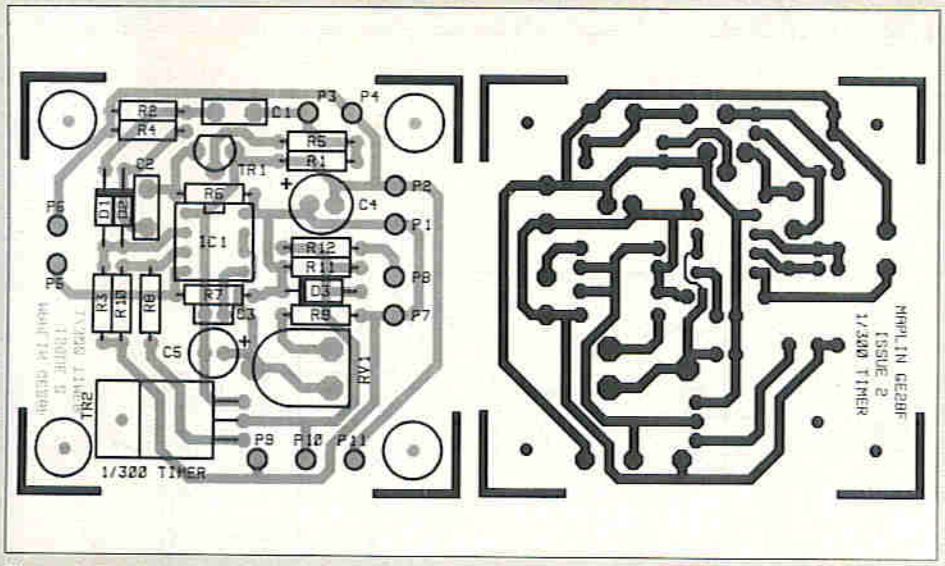


Figure 2. Track and Legend

circuit based around the IC alone.

As standard, the TLC555 is triggered by a negative going pulse on the trigger pin; although this is usually quite acceptable, there are applications in which it is necessary to trigger the device on both negative and positive going pulses. To allow for this possibility, an inverter circuit is included in the design to invert positive pulses to negative pulses suitable to trigger the timer. Capacitors, C1 and C2 isolate the input from DC whilst allowing a pulse to pass unhindered. If DC is applied between P3 and P4, the capacitor charges rapidly, producing a suitable pulse to trigger the IC. Diodes D1 and D2 allow only negative going pulses to reach the trigger input of IC1. Resistors R1 and R2 provide a discharge path for C1 so that the circuit may be quickly re-triggered and R3 pulls up the trigger input of IC1 allowing it to be pulsed low.

The operating period of the timer is determined by the value of R9, RV1 and C5. Preset resistor RV1 is included in the circuit to allow period adjustment providing a minimum/maximum ratio of approximately 1/300. With the values included in the kit, on-times of between around 1 second and 5 minutes are possible.

Resistor R10 acts as a load for IC1 and the output from the device is fed to the base of transistor TR2 via current limiting resistor R8. A darlington transistor is used for TR2 as this exhibits a higher input impedance and a superior switching characteristic to most single bipolar transistors. Diode D3 protects TR2 from damage due to any high voltage spikes that may develop when driving inductive loads such as relay coils. An indication of the output state is provided by light emitting diode LD1, which lights when TR2 is switched on; the current through the LED is limited by R12. So that the module may be used to drive additional high impedance circuitry, R11 is included to provide a load for the transistor when no other load is connected. The value of R11 can be changed to suit different drive requirements.

Construction

Insert and solder the components onto the PCB referring to the legend (Figure 2). It is a good idea to start with the resistors as these are relatively small and may be more awkward to fit once the other components are in place. Take care when soldering RV1 as it can be easily damaged if overheated. Next fit the IC socket, ensuring that the notch at one end corresponds with the polarity marking on the PCB legend. Do not insert the IC until all of the other components have been soldered in place. When fitting the capacitors make sure that the lead marked by a negative (−) symbol on the polarised (electrolytic) capacitors is positioned away from the positive (+) symbol marked on the printed circuit board. Diodes D1 - D3, as with all semiconductors require some caution during installation; in particular, make sure that you do not overheat these during soldering and that you observe the polarity markings on the legend. The end of the diode marked by a band should line up with that on the PCB outline. Similar considerations apply to transistor TR1, where the case of the transistor should be positioned so that it corresponds with the outline on the legend. Transistor TR2 has a different package style and is fitted so that its heatsink mounting tab is in contact with the surface of the PCB as shown in Figure 3. Finally, insert PCB pins P1 - P11 into the PCB and press them into position using a hot soldering iron. When the pins are heated in this way, very little pressure should be required to push them into place. Once correctly positioned the pins can then be soldered. Finally, insert IC1 into the socket so that the polarity notch is at the same end as that on the PCB outline. LED indicator LD1 may either be wired to the PCB pins directly or via a short length of cable; the cathode of the LED is indicated by the short lead and the flat side of the case. For further information on soldering and construction techniques please refer to the constructors' guide included in the kit.

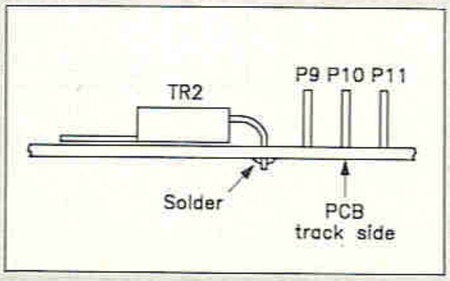


Figure 3. Mounting TR2

Testing

Before applying power to the completed 1/300 timer module, it is a good idea to double check your work to make sure that all of the components are fitted correctly and also to ensure that there are no dry joints or short circuits caused by 'blobs' of solder across adjacent tracks. If a multimeter is available it is a good idea to measure the resistance between the power supply pins (P1 and P2) to make sure that there are no short circuits. The resistance may start off at a relatively low value but this should increase rapidly as the capacitors in the circuit start to charge; the final value after a few seconds of connecting the meter should be in excess of 1000 ohms.

The module requires a 3V – 15V supply that is capable of delivering at least 20mA. If the same power supply is also used to drive the output load (as is usually the case), then the load current must also be added to the current drain of the module. As can be seen from Figure 4, the power supply is connected to P1(+V) and P2(0V). For reliable operation, it is recommended that power supply ripple is kept to a minimum and if possible a regulated supply should be used.

Apply power to the unit and set preset resistor RV1 to the fully clockwise position. If P3 is connected to the positive supply rail (+V), this will trigger the timer and LD1 should then light for a short time (typically around 1 second but the time may vary slightly depending on the operating conditions). If P3 is connected to +V until LD1 is extinguished and then disconnected the timer will then be triggered by the negative going pulse produced as the potential on P3 returns from the supply voltage to 0V; LD1 should then light for a further period and then return to the off state. If RV1 is then turned to the fully anti-clockwise position and the above test is repeated, the operation of the module will remain the same but the switch on period should then be in the region of 5 minutes.

If a multimeter is available you can measure the voltage between P9 and P10 when the output is both in the on and the off states to check that TR2 is switching properly. In the off state there should be very little potential between the two pins but in the on state the voltage should be only a fraction of a volt less than the supply voltage.

Using the 1/300 Timer

The 1/300 timer can be used in many varied applications requiring a short duration timer. For example, the module could be used to switch off a light automatically if it was left on unnecessarily for an extended period or to switch off an alarm siren after a set period. The maximum operating period is achieved by setting RV1 to the fully anti-clockwise position. It should be remembered that the 1/300 timer is not intended for use in precision applications and the operating times stated may vary considerably due to component tolerances.

In some applications it may be necessary to switch higher voltages or currents than are possible directly. In this case the module can be used to switch a relay which is suitable for higher power switching. The open collector output makes the circuit ideal for operating relays. It is important to make sure that the relay coil is suitable for use at the power supply voltage you have chosen for the 1/300 Timer and also that the contact rating is correct for the voltage and current level that you are switching. Typical examples of suitable relays for general purpose use are stock codes JM18U for 12V operation and JM17T for 6V operation. Relay coil connections are made to P9 and P10.

PCB pins P5 (reset) and P6 (0V) provide access to the reset line of IC1 to allow the user to inhibit the output of the module independently of the input state. When P5 is not connected the reset line is automatically pulled high, allowing the timer to function normally. Access to the reset input can be useful when it is necessary to return the output to the off state before the timing cycle is complete (to switch off a light manually for example). The timer remains reset as long as P5 is in the low state. If P5 is held low when power is applied to the module, the output will remain in the off condition even if trigger pulses are applied to the input; the timer will only respond to input signals when P5 is allowed to return to the high state.

The 1/300 Timer is ideal for use with the Audio Controlled Switch kit (Stock code LP29G) as it is triggered by both positive and negative going pulses. Figure 5 shows how the two circuits can be interfaced together.

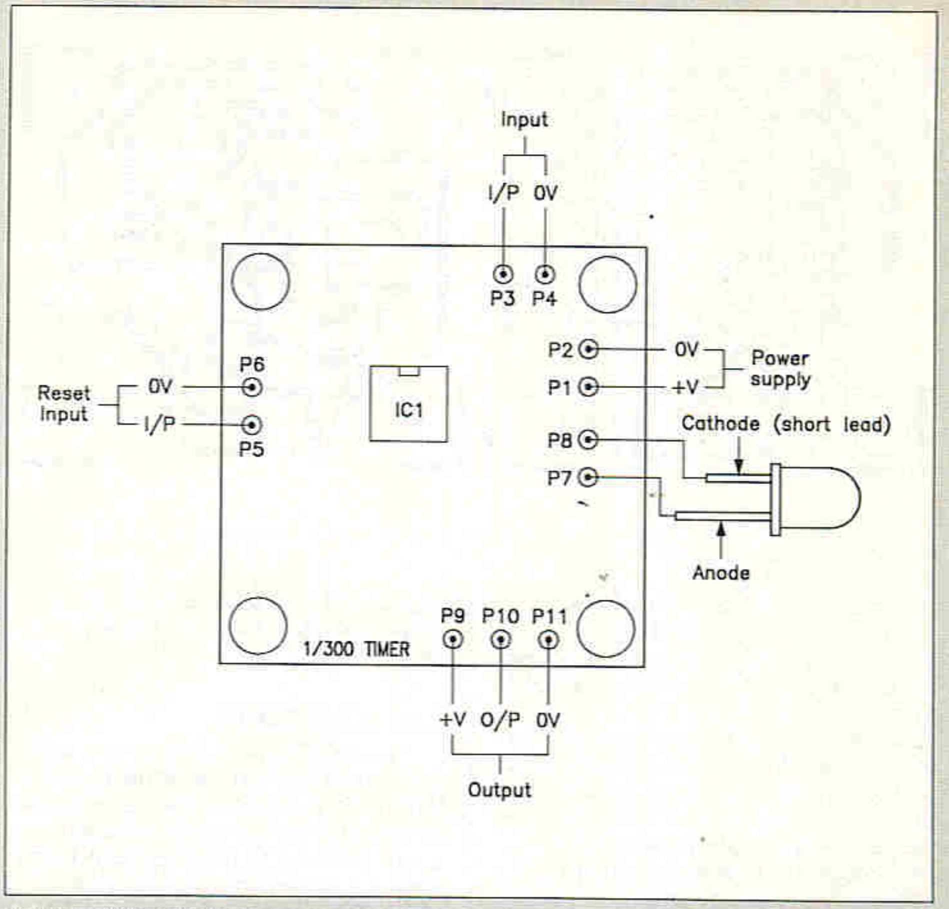


Figure 4. Wiring Diagram

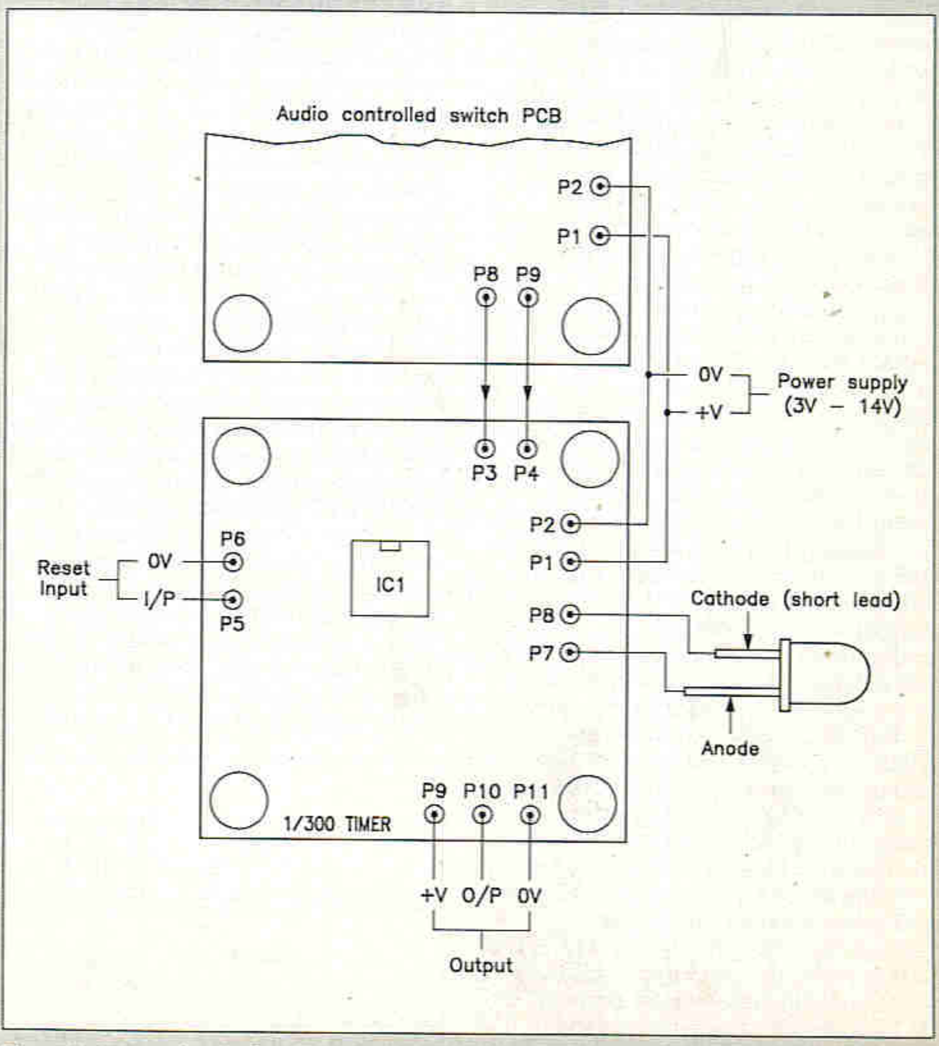


Figure 5. Connection to the Audio Controlled Switch

Specification of prototype

Power Supply Voltage		3V – 15V
Power Supply Current	With no external load	12mA Maximum at 12V
Maximum Load current		500mA
Switch-on Period	Adjustable	1s – 310s Approx.
Input Trigger	Positive & Negative Edge	± Supply Voltage
PCB Dimensions	57mm x 54mm	

Table 1. Specification of Prototype

When used in this way the timer provides an automatic shut-off facility, switching off the current supply to the load after a preset period. If the two projects are used together it is not necessary to fit R13 or LD1 on the audio control switch module as the timer module has a separate LED indicator.

Finally, Table 1 shows the specification of the prototype 1/300 timer module.

1/300 TIMER PARTS LIST

Resistors: All 1% 0.6W metal film.

R1,8	10k	2	(M10K)
R2,4	1M	2	(M1M)
R3,6	27k	2	(M27K)
R5	220k	1	(M220K)
R7,10,11	100k	3	(M100K)
R9	15k	1	(M15K)
R12	1k	1	(M1K)
RV1	4M7 Hor. Encl. Preset	1	(UH11M)

Capacitors

C1,2	100nF Minidisc	2	(YR75S)
C3	10nF Ceramic	1	(WX77J)
C4	100μF 16V Minelect	1	(RA55K)
C5	47μF 16V Minelect	1	(YY37S)

Semiconductors

TR1	MPSA14	1	(QH60Q)
TR2	TIP122	1	(WQ73Q)
IC1	TLC555CP	1	(RA76H)
LD1	LED Red	1	(WL27E)
D1,2	1N4148	2	(QL80B)
D3	1N4007	1	(QL79L)

Miscellaneous

P1-11	Pins 2145	1 Pkt	(FL24B)
	DIL Socket 8-Pin	1	(BL17T)
	PC Board	1	(GE28F)
	Constructors Guide	1	(XH79L)

A complete kit of parts is available:
Order As LP30H (1/300 Timer) Price £4.75
The following item in the kit is also available separately, but is not shown in the 1990 catalogue:
Adj Time Sw PCB **Order As GE28F Price £2.25**

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WANTED. Powertran kits especially Powertran Vocoder and Powertran digital delay. Any condition from untouched to part built to finished kit. Contact Paul Stokes on (0428) 77666 (office hours) and (0428) 712098 otherwise.

WANTED. Old type Spectrum interface one with micro ports, not just joystick ports type. Tel: George 01-300-1649.

WANTED. Denco green D.P. coils ranges 3, 4 and 5. Tel: Robin on (02977) 225 (after 5pm).

WANTED. To complete a project, I.C. TDA1050. Price to: L Myers, 70A Lawford Road, London N1 5BL.

WANTED. TDA1022 Bucket brigade delay integrated circuit. Tel: home (0642) 564109 or work (0325) 300004 and ask for Nigel Harris.

WANTED. Digital miles-per-gallon meter or speed sensor for the above. Tel: Abid 01-346-3859.

WANTED. Maplin organ leaflets MES51, 52, 53 and 54. To buy, beg or borrow for copying. Dave Marsden, 56 Collin Avenue, Marfleet Lane, Hull HU9 4RR.

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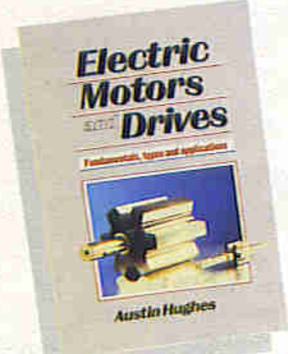
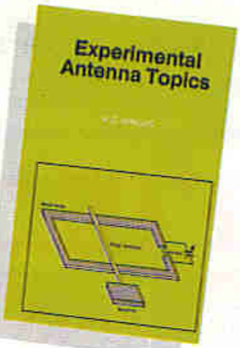


Electric Motors and Drives

by Austin Hughes

Radical changes have taken place over the last twenty years in the design and construction of electric motors and the means of driving them. For a hundred years or so, different kinds of motors have had to be designed for as many different purposes. The reason for this was that there was no easy way of achieving motor control; supply voltage or frequency could not be modulated with accuracy, and so speed regulation under load has had to be done within the motor itself.
Power controlling electronics has changed all that. The first breakthrough came with the thyristor (SCR), which for the first time allowed a relatively cheap, compact, and easily controlled variable voltage supply for the main armature circuit of a DC motor. The second major breakthrough resulted from the development of variable frequency inverters, with which single or three phase brushless induction motors can be controlled for speed. These developments resulted in the demise of many specialised motors, leaving the majority of applications to be catered for by a comparatively few types. What has happened is that the emphasis has shifted from complexity within the actual motor to sophisticated control circuitry external to the motor.
This book explores most of the currently widely used modern types of motor and electronic driving methods, including conventional and brushless DC, mains and inverter fed induction motors, both with or without closed loop speed control; stepping motors, mains and converter fed synchronous motors, and reluctance motors.
Applications are deliberately spread throughout the text in order to emphasise the fact that there is no longer any automatic correlation between motor type and application.
If you need to do anything with an electric motor you must read this super book first.
1990. 320 pages. 135 x 203mm, illustrated.

Order As WS84F (Electric Mtr & Drivs) *Price £14.95 NV*

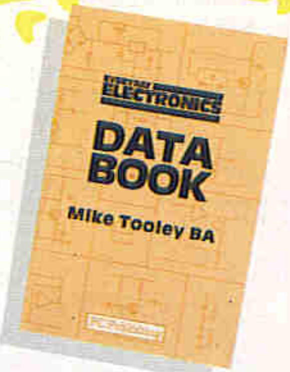


Experimental Antenna Topics

by H.C. Wright

Although nearly a century has passed since Marconi's first demonstrations of radio communication, there is still research and experiment to be carried out in the field of antenna design and behaviour. The aim of the experimenter will be to make a measurement or confirm a principle, and this can be done with relatively fragile, short-lived apparatus. Because of this, devices described in this book make liberal use of cardboard, cooking foil, plastic bottles, cat food tins, etc. These materials are, in general, cheap to obtain and easily worked with simple tools, encouraging the trial-and-error philosophy which leads to innovation and discovery.
Although primarily a practical book with text closely supported by diagrams, some formulæ which can be used by straightforward substitution and some simple graphs have also been included.
1990. 80 pages. 110 x 178mm, illustrated.

Order As WS86T (Exp Antenna Topics) *Price £3.50 NV*

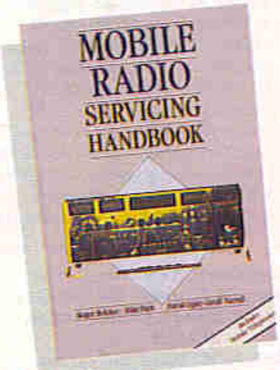


Everyday Electronics Data Book

by Mike Tooley BA

This book is an invaluable source of information of everyday reference in the world of electronics. It contains not only sections which deal with the essential theory of electronic circuits, but it also deals with a wide range of practical electronic applications.
It is ideal for the hobbyist, student, technician and engineer. The information is presented in the form of a basic electronic 'recipe' book with numerous examples showing how theory can be put into practice using a range of commonly available 'industry standard' components and devices.
A must for everyone involved with electronics.
1990. 256 pages. 139 x 215mm, illustrated.

Order As WS87U (Everyday Elec Data) *Price £8.95 NV*



Mobile Radio Servicing Handbook

by Roger Belcher, Mike Fitch, David Ogley and Geoff Varrall

An authorative and practical information source-book on the servicing and repair of VHF and UHF mobile radios and base stations, together with the maintenance and support requirements of the overall radio system, including antenna and mast installations. The fast changing component and system technology of mobile radio communications is having a major impact on the way in which equipment is installed, commissioned, serviced and maintained. The four highly experienced authors have combined to supply the technician or engineer with sufficient information to be able to undertake or plan, repair and maintenance work on modern mobile radio systems, with handheld or vehicle mounted mobiles. In addition, the book covers the impact of data over radio, cellular radio, and trunking technologies on servicing, diagnosis and repair procedures.
Essential background topics covered include radio theory, amplitude (AM) and frequency (FM) modulation, radio wave propagation, reception and demodulation, fundamentals of receiver and transmitter systems, principles of transmitter and receiver design, synthesiser techniques, selective tone signalling and the digital signalling control and access protocols of cellular and trunked radio, but the handbook is intended primarily as a source of readily accessible information on how to fault-find and repair mobile radio equipment – mobiles, base stations and antennae – to circuit module and component level.
1989. 298 pages. 160 x 240mm hard-cover, illustated.

Order As WS92A (Mobile Radio Svcing) *Price £25.00 NV*

How to Set Up a Home Recording Studio

by David Mellor

For musicians, recording enthusiasts and students, this book explains how to set up a home recording studio with practical details on equipment, wiring, acoustics and sound-proofing, with a useful glossary of terms and lists of useful addresses.
The book describes the setting up of an eight to sixteen track studio with an outline of the musical and recording equipment needed, but concentrates on the techniques of putting that equipment together into an efficient and productive recording studio in the home. Includes invaluable but hard to come by advice on patchbay wiring schemes, and describes how to custom build a rack to suit your own particular requirements. If you already have a studio at home or are thinking

about setting one up, there's something in this book for you. 1990. 124 pages. 136 x 215mm, illustrated.

Order As WS88V (SetUp Hme Rec Studio) ***Price £6.95 NV***

Electronic Power Supply Handbook

by Ian R. Sinclair

This book covers the often neglected topic of electronic power supplies. All types of supplies that are used for electronic purposes are covered in detail, starting with cells and batteries and extending by way of rectified supplies and linear stabilisers to modern switch-mode systems, IC switch-mode regulators, DC-DC converters and inverters.

The devices, their operating principles and typical circuits are all dealt with in detail. The action of rectifiers and the reservoir capacitor is emphasised, and the subject of stabilisation is covered. The book includes some useful formulæ for assessing the likely hum level of a conventional rectifier and reservoir supply. An invaluable book on an often neglected subject. 1990. 144 pages. 135 x 215mm, illustrated.

Order As WS89W (Elec Pwr Supplies) ***Price £7.95 NV***

Power Electronics

by Kjeld Thorborg

Provides a functional engineering approach to the subject of power control electronics, emphasising selection of components, basic analysis of circuits and problem solving techniques based on simple approximations. Written primarily as an undergraduate textbook, it is also a useful reference book containing many examples of power control techniques for anyone interested in this subject. Features include coverage of semiconductor devices, passive components including capacitors, coils, transformers, fuses and resistors; power circuits and filters. Some of the essential maths is mentioned together with asynchronous motors, reliability and electrical noise. Another chapter details the systems design (in 'building-block' form) for control electronics. A description of now classical thyristor (SCR) circuits as well as some new methods not yet in common use, together with an evaluation of the advantages and disadvantages of differing types of circuit.

The book includes numerous worked examples and problems with solutions, together with appendices which include maths adapted for power control usage.

1988. 518 pages. 173 x 234mm, illustrated. Hardback.

Order As WS90X (Power Electronics) ***Price £18.95 NV***

Microcomputer Interfacing

by Mike Cavenor & John Arnold

Adopts a highly practical approach in presenting the topic of microcomputer interfacing. The material is based upon the Z80 MPU, an industry standard, and its support peripheral chips. While it is not the most modern microprocessor, the Z80 nevertheless is ideal for learning the fundamentals of this important subject. Once basic interfacing techniques employed with the Z80 have been learned, little difficulty is experienced in moving on to more complex microprocessors and peripheral devices.

The subject is most effectively learned when ample opportunity is provided to reinforce theoretical concepts with relevant real exercises. Full notes are provided for up to forty actual experiments. This approach will encourage the reader to carry his design work through to a final operating system stage. The examples use a small number of peripheral circuits and cover topics which include data acquisition, signal processing and the design of elementary microprocessor controlled instrumentation. In the process, you will have to write much of the assembly language programs yourself, however, the book shows how to set about carrying out the construction of real hardware which includes a monophonic organ and pulse and waveform generators, seven segment displays, keyboard interface, digital storage oscilloscope, intruder alarm controller, serial communications and serial links, and much more.

1989. 382 pages. 170 x 234mm, illustrated. Australian book.

Order As WS85G (MPU Interfacing) ***Price £17.95 NV***

The ROCK circus

Competition Winners

In the December '89 to January '90 issue of 'Electronics – The Maplin Magazine' our roving reporter, Alan Simpson, visited Madame Tussauds Rock Circus in London. There was the chance to win five tickets to visit this superb animated wax works in a free to enter 'Match the Tune' draw. Entrants had to correctly match up ten tunes with their corresponding artistes, the first five answers drawn from the hat were the winners.

The answers to the Rock Circus Competition questions are as follows:

Title	Artiste
That'll be the Day	**Buddy Holly**
Rock around the Clock	**Bill Haley**
She Loves You	**The Beatles**
Purple Haze	**Jimi Hendrix**
Suspicious Minds	**Elvis Presley**
Respect	**Aretha Franklin**
Maggie May	**Rod Stewart**
Benny and the Jets	**Elton John**
Layla	**Eric Clapton**
What's love got to do with it	**Tina Turner**

The five lucky winners are:

Mr G. Stevens, North Walsham, Norfolk; Mr A. Shepherd, Swindon, Wiltshire; Mr R. Bridgett, Blythe Bridge, Staffordshire; Mr T. Cole, Southport, Merseyside; Mr J. Yates, Didcot, Oxon.

Each winner will receive a double ticket to the Rock Circus in London.

COMPUTERS IN THE REAL WORLD

Part 6 By Graham Dixey C.Eng., M.I.E.E.

The Computer Keyboard

There are a variety of devices that allow the user to input data directly into the computer. Of these the keyboard is certainly the most familiar and commonly used. Other devices, such as the mouse, trackerball, graphics tablet, etc., act merely as some-time alternatives to the keyboard and not as complete replacements.

The complexity of a keyboard may vary between the spartan simplicity of a hexadecimal keypad (providing nothing more than the hexadecimal digits 0-9, A-F, plus a few control functions are needed) and the luxury of a full typewriter-style keyboard. The latter may well have been expanded even further by the addition of a set of function keys and special control keys, according to the exact nature of the computer with which it is associated.

Keyboard Problems – Rollover and Lockout

It is virtually impossible to type without, at some time, pressing two or more keys in such rapid succession that they are almost instantaneous. Without some effective method of guarding against the consequences, this could result in the wrong codes being generated. There are three available techniques to prevent such errors. They are known as, 'n-key lockout', '2-key rollover' and 'n-key rollover'.

The simplest and cheapest is n-key lockout. In this method, the first key down generates a pulse known as a 'keyboard strobe'. This causes the code for that key to be fetched. During this period any other keys down are totally ignored. The obvious disadvantage is that there are likely to be a number of missed keys, since one key must be fully released before the next is depressed. In 2-key rollover, any key down will generate a keyboard strobe; a delay is then introduced for any further keyboard strobe until the first key has been released. The second key down will then be accepted. This is a method that works well as long as no more than two keys are down at a time.

The n-key rollover method is generally considered to be a luxury without much merit because of the considerable degree of complexity of hardware that it requires. Its operational feature is that any number of keys down will immediately generate the required codes for those keys, in the sequence of the keys pressed.

The Keyboard Matrix

The electrical pattern beneath a keyboard is usually in the form of a matrix of conductors, consisting of 'm columns' by 'n rows'; this matrix is not necessarily physically similar to the keyboard layout. The keyswitches are each wired across a column-row intersection. Thus, an 8-column by 8-row matrix will accommodate up to 64 keyswitches. The use of such a matrix offers the possibility of a system in which the columns (say) are the input lines and the rows are the output lines. If no key is held down, then there is no conducting path between any of the columns and any of the rows. Naturally, a key down will then provide such a path. Every path is unique and is, therefore, potentially capable of identifying which key is down at any time. An obvious problem in this respect is that an input on any of the 'n rows' could have originated from any one of the 'm columns'. Some means must be found of making each column identify itself when a keypress occurs. One method of doing this, called 'scanning the keyboard', will be described shortly.

Non-Encoded and Encoded Keyboards

All keyboards will fall into one of the two above categories, though most will occupy the latter one. In a non-encoded keyboard, the process of scanning, and subsequent key identification, is largely software orientated. In the encoded type of keyboard, the accent is on the hardware.

Taking the example of a simple 16-key keypad, this would be organised as a 4 x 4 matrix, as shown in Figure 1. To scan it, a 4-bit binary pattern, in which a single logic 1 is constantly circulated through the pattern, is applied to the four column wires.

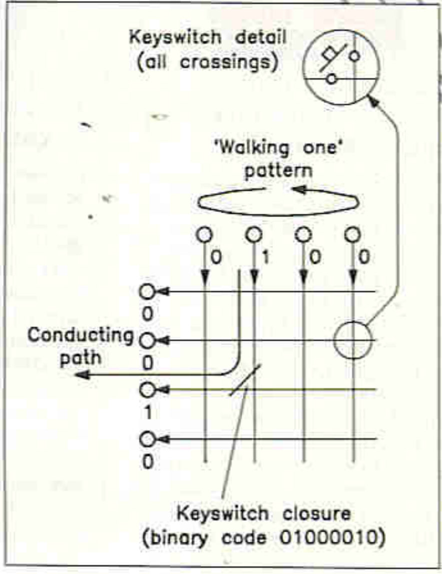


Figure 1. A 16-key keypad with the columns scanned by a 'walking one' pattern.

Thus, each of these wires is energised in turn by the logic 1, all others at this instant being at logic 0. Such a binary pattern is easily generated by software and sent to the column wires via four lines of the computer's input/output port, dedicated for this purpose. The successive states of the four column lines will be, starting with 1000, next 0100, 0010, 0001, then 1000, and so on, the sequence repeating indefinitely. The result of scanning the columns in this way is that, when a key is down in the column which is at logic 1, this logic level will be passed out through the appropriate row line. Since the scanning rate greatly exceeds the speed at which even the fastest typist can press successive keys, there is no chance of the keypress being missed.

A moment's thought should show that the 'key down' has now been effectively identified. Each of the four column patterns listed above can form a possible combination with each of the four rows in which a keypress can occur. This gives the sixteen unique combinations or codes required for the sixteen keys of the keypad. For example, the code 01000010 (reading columns top to bottom; rows left to right) identifies the key that is in the second column in, third row down, as the one that has been pressed. The software must be written so as to include the following features:

(i) to identify when there is a 1 in the second half of the number (the row bits), since a 1 only exists here when a key is down.

(ii) to read the complete number so as to check it against a table of such numbers, held in memory, and thus identify the key pressed.

The program must continually be checking for the 1 on the row lines, as described, and this will correspond to the action of the 'keyboard strobe pulse' (see later). On finding the logic 1, the program will then jump to a routine that checks the whole number as described in (ii) above.

This idea, in which a logic 1 is used to scan the keyboard lines, is known by the rather picturesque title of 'a walking one's decode'.

In the alternative approach the 'walking one' pattern is generated by a piece of hardware, of which the ring counter (with one stage only set) is a prime example. The ring counter is a type of shift register that consists of a string of clocked D-type flip-flops in which the Q output of the final flip-flop is fed back to the D input of the first. Thus, the data is circulated continuously at the clock rate. Since only one flip-flop was set, the data will consist of a single 1 and n – 1 zeros (where n is the number of stages of the register).

In the case of a 64-key keyboard, the matrix would be organised as an 8 x 8 layout – eight columns and eight rows. A scan pattern on the columns and rows could be generated by an 8-stage ring counter for the columns and a '1 of 8 selector' for the rows. However, there is an important point here; either the columns ring counter must be clocked at eight times the rate at which the 1 of 8 selector is clocked, or vice-versa. For example, if the rows are clocked at a frequency 'f', then the columns could be clocked at a frequency '8f'. In this way, a row is held selected during the time that the 'walking one' energises each column in turn. Then the next row is selected while all the columns are energised again. In this way all keys are scanned in a logical pattern, row by row. A scheme along these lines is shown in Figure 2.

The codes for each of the keys in the matrix are contained in a ROM, which is also organised on an 8 x 8 basis. It is virtually a 'carbon copy' of the key matrix in this example; the spatial arrangement of memory locations where the key codes are stored mimicking the layout of the matrix. The coincidence of row and column obtained by a keypress generates a logic 1 on similar lines addressing the ROM locations. As a result, an 8-bit code is output from the ROM, from where it will be passed to the CPU.

	Control	Numeric	Uppercase	Lowercase	Special
00	Null	30 0	41 A	61 a	20 Space
01	Start of Heading	31 1	42 B	62 b	21 !
02	Start of Text	32 2	43 C	63 c	22 "
03	End of Text	33 3	44 D	64 d	23 #
04	End of Transmission	34 4	45 E	65 e	24 $
05	Enquiry	35 5	46 F	66 f	25 %
06	Acknowledge	36 6	47 G	67 g	26 &
07	Bell	37 7	48 H	68 h	27 '
08	Backspace	38 8	49 I	69 i	28 (
09	Horizontal Tabulation	39 9	4A J	6A j	29)
0A	Line Feed		4B K	6B k	2A *
0B	Vertical Tabulation		4C L	6C l	2B +
0C	Form Feed		4D M	6D m	2C ,
0D	Carriage Return		4E N	6E n	2D –
0E	Shift Out		4F O	6F o	2E .
0F	Shift In		50 P	70 p	2F /
10	Data Link Escape		51 Q	71 q	3A :
11	X-on		52 R	72 r	3B ;
12	Tape		53 S	73 s	3C <
13	X-off		54 T	74 t	3D =
14	Device Control 4		55 U	75 u	3E >
15	Negative Acknowledge		56 V	76 v	3F ?
16	Synchronous Idle		57 W	77 w	40 @
17	End of Transmission Block		58 X	78 x	5B [
18	Cancel		59 Y	79 y	5C \
19	End of Medium		5A Z	7A z	5D]
1A	Substitute				5E ^ or ↑
1B	Escape				5F _ or ←
1C	File Separator				60
1D	Group Separator				7B {
1E	Record Separator				7C ¦
1F	Unit Separator				7D }
7F	Rub Out or Delete				7E ~

Table 1. The standard ASCII keyboard codes and their hexadecimal values.

ASCII Code

In theory a variety of coding systems could be devised to encode the keys of the keyboard. In practice there is one code in general use and a few others that may be encountered in certain circumstances. The code most often used is termed ASCII, which is an acronym for 'American Standard Code for Information Interchange'. This is generally regarded as a 7-bit binary code, though an 8-bit version also exists. This code is shown in Table 1, and it will be seen that all alpha-numeric characters, punctuation marks, other special characters and also a variety of control characters are to be found in this code. Each is represented by a two-digit hexadecimal number.

A scanning encoder is shown in Figure 3 in which the ASCII codes are generated directly by the keyboard matrix plus some extra logic. There is no ROM to store the codes in this case. Also included are two keys, of much value on computer keyboards in particular, namely SHIFT and CONTROL. Each of these used in conjunction with other keys allows many more functions to be generated. The SHIFT key, of course, produces the capital letters plus those punctuation marks in superior positions on the key caps; it also has some special uses in application programs such as word-processors, as does the CONTROL key.

In this design an 8 x 8 keyboard matrix is addressed by the outputs of a 1-of-8 decoder (column scan) and a 1-of-8 data selector (row scan). The two logic circuits have 3-bit binary inputs provided from the 6-bit output of a 'scale of 64' binary counter. The decoder takes the most significant three bits of this counter and uses them to generate a 'walking one' pattern on the columns. The data selector takes the least significant three bits and scans the rows for the appearance of a logic 1 (representing a keypress) at 'one-eighth' of the frequency that the columns are being scanned. This essential frequency relationship between the two scanning rates arises naturally because of the binary division between successive stages of the binary counter. That is, the overall division ratio of the counter is 64, this being achieved because the circuit is, in effect,

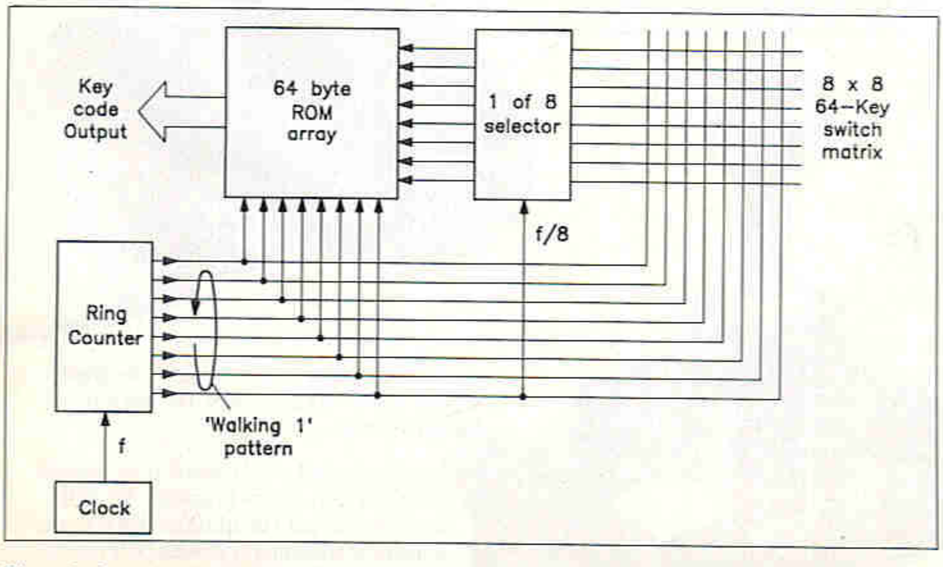


Figure 2. A 64-key keyboard, with the columns 'hardware scanned' by a ring counter; the key codes are held in a special ROM, which is addressed by the coincidence of row/column key colsure.

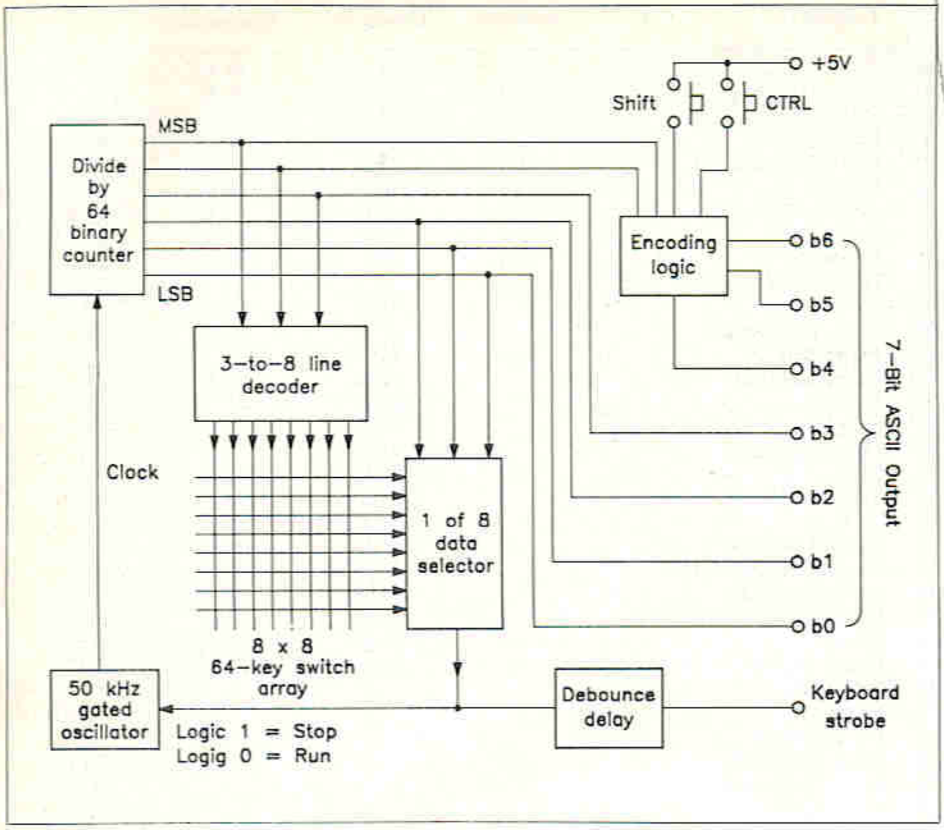


Figure 3. A keyboard in which the ASCII codes are generated directly by the hardware. Two-key rollover is inherent in such a design.

one 'divide-by-8' counter (that is for the columns) followed by a second identical counter (that is used for the rows).

The logic 1 output from the data selector, obtained when a keypress occurs, performs two functions. After a 'debounce delay', it is used as the 'keyboard strobe' to inform the CPU that a keypress has been detected and that data is available. It is also used to inhibit the 50kHz gated clock oscillator, thus preventing further keypresses from having effect while the current keyboard data is being accepted by the CPU, so providing inherent two-key rollover. This inhibit, of course, lasts only for as long as the key is down since, on the key being allowed to return to the normal position, the logic level on the inhibit line will return to logic 0 and the oscillator will restart. Relative to the speed that a human operator will depress and raise a key, the response of the CPU in detecting the keypress and accepting the data is extremely fast. There is, therefore, little chance of the keypress going undetected.

A Standard Keyboard Encoder

The General Instrument AY-5-2376 Keyboard Encoder is an IC that has achieved some degree of acceptance as a standard basis for the design of computer keyboards. This LSI device is a 2376-bit Read Only Memory that has the capability to encode single-pole, single-throw keyboard closures into a 9-bit code. The data and strobe outputs are directly compatible with TTL or MOS logic, thus obviating the need for any special interfacing. Among the features found on it are:

(i) Provision of external control for output polarity selection.
(ii) Provision of external control for selection of odd or even parity.
(iii) Two-key rollover operation.
(iv) N-key lockout.
(v) Externally controlled key 'debounce' network.
(vi) Internal oscillator circuit.

As stated already, the 2376 contains a ROM, which is organised as a 264 x 9-bit memory arranged into three 88-word by 9-bit groups. The SHIFT and CONTROL keys permit switching between the three 88-word groups. The 88 words themselves are addressed by the ring counters so that the actual address in the ROM that is accessed for data is formed from the 11 x 8 ring counter matrix with or without either the SHIFT or CONTROL keys. This, in theory, provides for a total of 264 keyboard characters, but this is rarely taken up.

The maximum of 88 keys that can be used with this IC should be wired on an 11 x 8 key matrix with a single-pole, single-throw switch at each crossing. In the 'standby' state, with no keys pressed, the ring counters sequentially address the ROM locations but the absence of a keyboard strobe pulse indicates that there is no valid data available.

An application circuit for the 2376 keyboard encoder is shown in Figure 4. When a key is depressed, a path is completed between one of the outputs of the 8-stage ring counter (X0-X7) and one of the inputs of the 11-bit comparator (Y0-Y10). Shortly after, the comparator sends a signal to the clock control and Strobe Output (via the delay network). The clock control stops the clocks to the ring counters and the data on the Data Outputs is now valid, as indicated by the Strobe Output. This data remains stable until the key is released.

Other forms of Input Device

Although the keyboard is the most commonly employed device for direct communication with the computer, there are others that have, under certain circumstances, particular advantages. It is worth considering the limitations of the keyboard in order to better understand why there might be a need for alternatives at all, and what is actually being considered as alternative means for a human operator to input data, in ways that may be more ergonomically sound.

For inputting text the keyboard is obviously ideal; all that is needed is the ability to type with reasonable ease. Probably most computer keyboard users have never had any formal typing training, but this rarely seems to matter. What the keyboard doesn't do quite so well is to allow control of what might loosely be termed, 'non-textual' matter, such as graphics. The implications here are broad. Graphical

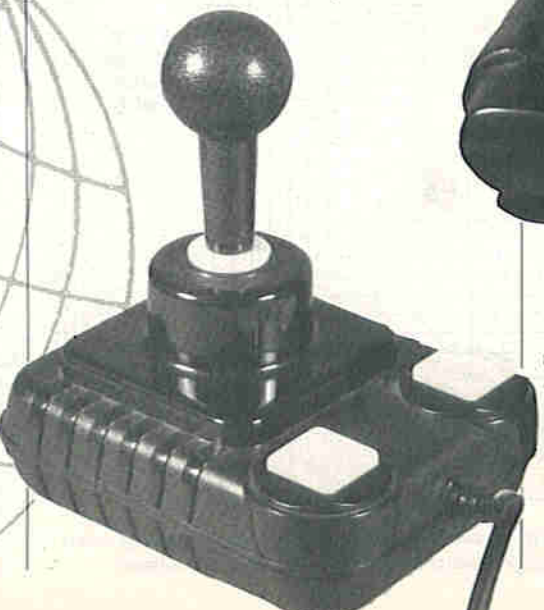


Photo 1. Two examples of joysticks in current use; useful both for serious and less serious applications.

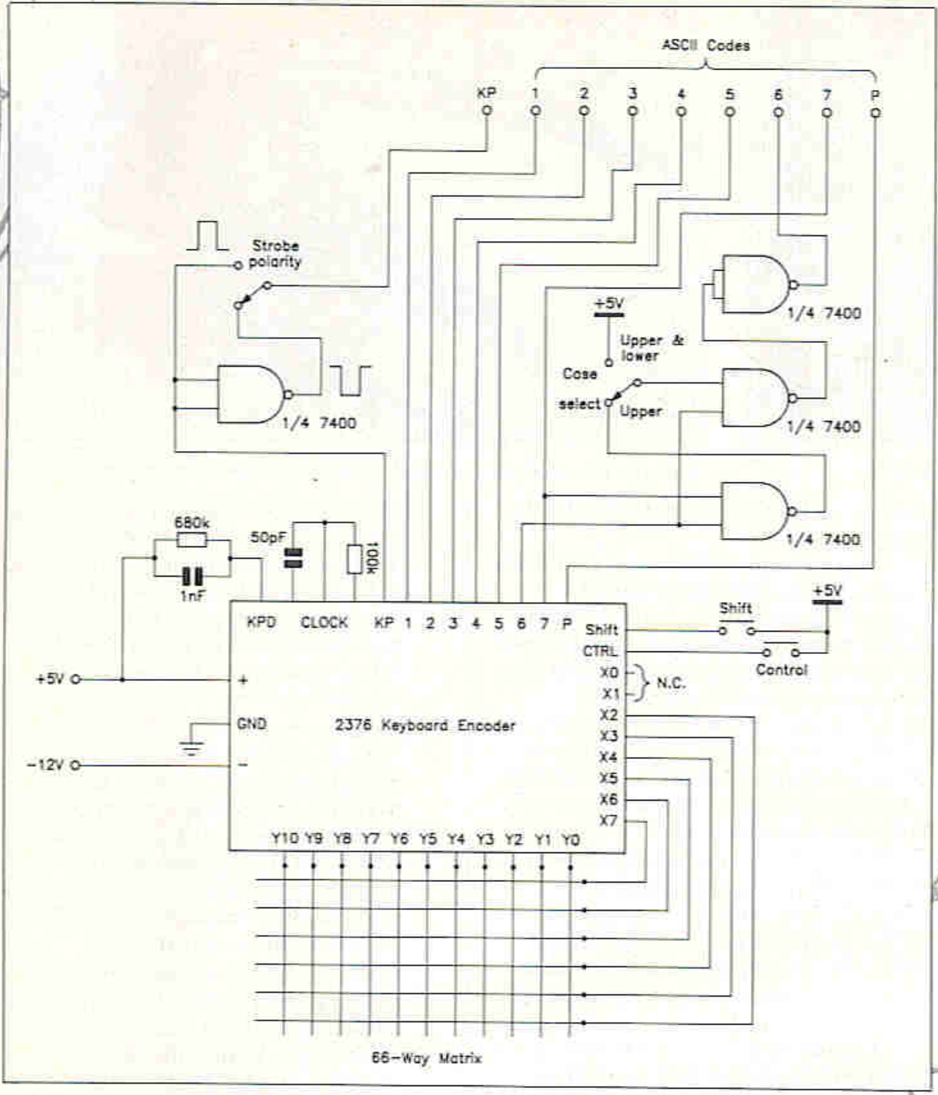


Figure 4. An application circuit for the 2376 keyboard encoder IC. Facilities include choice of polarity for the keyboard strobe, and choice of case: 'upper plus lower' or 'upper only'.

on-screen data can be found in the most serious of software as well as in the most trivial. For positional control using the keyboard, the 'cursor keys' are frequently used. These give fairly obvious up/down, left/right control but the feel obtained is not totally natural. For movements intermediate between the four directions stated, and for sudden reversals of direction, they are positively clumsy. An excellent direct replacement is the 'joystick' – hardly an unfamiliar object to many computer users. Connected to the computer through a standard 9-pin 'D' connector, the switch closures caused by the side-to-side, to-and-fro, movements are read by software. A key closure is a true binary event; either it is closed or it isn't. The two possibilities represent the binary values, 1 and 0. There is no middle choice. Not only can the software identify the four basic joystick movements; it can also tell four intermediate states, when two switches are closed at the same time: NE; SE; SW and NW. A 'fire button' is also a usual feature of a joystick and gives the software another switch closure to detect. Naturally, if the coincidence of this event together with the other switch closures is detected, this gives quite a few possibilities. The joystick, simple as it is, starts to look quite sophisticated. Ergonomically it is excellent. The handle sits comfortably in the hand with either a finger or thumb over a fire button. The natural feel is able to provide rapid, co-ordinated screen control, as needed in arcade and simulator games, but it can also be used in more serious applications. While there are some graphics software packages of the art/drawing variety that use the joystick, most serious software looks elsewhere for a suitable input device. Enter the mouse!

The Mouse

This colourfully named data entry device is an increasingly popular method of screen manipulation. It is not confined solely to 'arty' applications, but is also widely used as a means of communication in what is usually referred to as a 'WIMP' environment ('W' = Windows; 'I' = Icons; 'M' = Mouse and 'P' = Pointers). In this type of situation, of which the well known GEM (Graphics Environment Manager) is an example, the keyboard is largely ignored. Instead of typing in textual commands to obtain the required response, the mouse is used to move a pointer around the screen, which may contain text in Windows and/or pictorial symbols (the Icons). By positioning the pointer over appropriate text or icon and 'clicking on' the mouse, the required commands are ordered and executed.

A mouse is a highly developed form of joystick, in essence, though not necessarily a very close relation. The switches have been replaced by a pair of orthogonally mounted (that is, mutually at right angles) potentiometers. The arrangement is similar to the joystick control used in a radio control transmitter. However, instead of using a 'stick' to move the 'pots', a ball on the underside of the mouse body is rolled on a suitable surface and this motion is transmitted to them. The mouse is small and compact and sits comfortably in one's hand, the two or three switches, also found as a feature of the mouse, being positioned where the fingers fall on them naturally when required. A mouse often operates on a special non-slip 'mouse mat' and may even be kept in a 'mouse house' when not in use – though perhaps mouse 'garage' would be more appropriate! The mouse's 'tail' is, of course, merely the cable that connects the mouse to its special interface!

The latter may be external to the computer (where the mouse is not an integral feature of that particular machine) or be housed within the computer, where the mouse is supplied as part of the ensemble. Because the signals developed by the potentiometers are analogue ones, the interface must provide analogue-to-digital

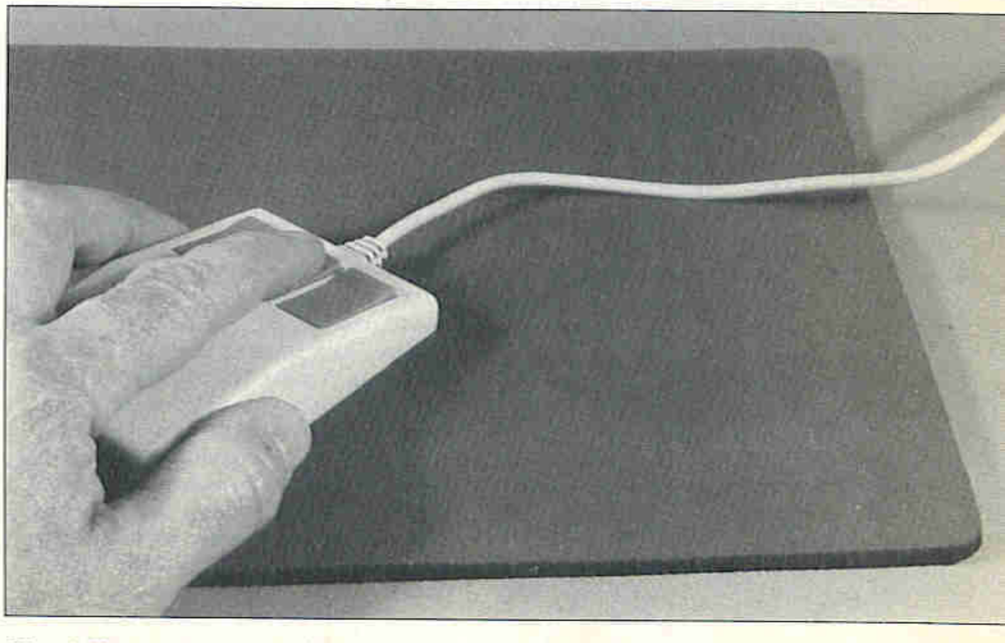


Photo 2. The mouse and its mouse mat – smooth, easy control for many drawing applications and other uses.

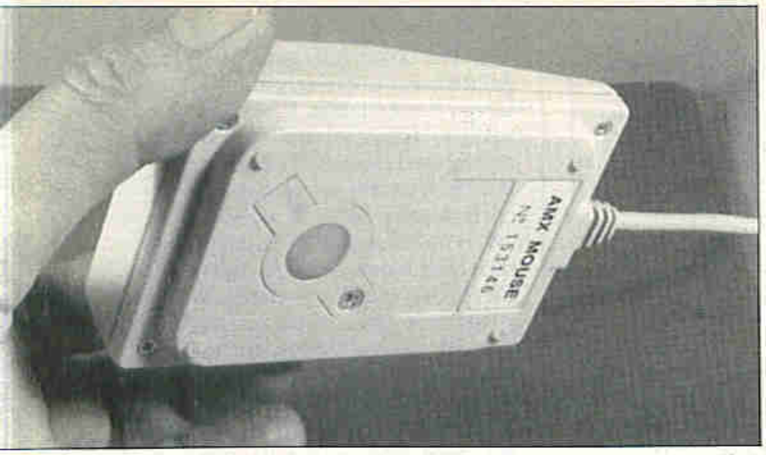


Photo 3. *Underside of the mouse showing its actuating ball.*

Photo 4. *A trackerball, not as nice as the mouse to use, but some people like it.*

conversion. The extra complications of the mouse are worth it. Positional control is smooth and positive, and the mouse can also detect, not merely position in terms of its X-Y co-ordinates, but also 'rate of change' of position.

The Trackerball

This device is, in effect, a mouse 'upside-down'! It has the principal characteristics of the mouse without, unfortunately, the latter's natural feel. The mouse allows positional control – the user's hand cupped downwards over the mouse body can lightly move it however required – while leaving the user's fingers free to 'click on' at any moment. The only way to perform the same combined operations with a trackerball is by using both hands. One hand spins the ball, while the other hovers over the buttons ready to depress one. The figure for the total number of trackerball users is probably quite low.

The Light Pen

This device, made in the shape of a pen, is used to point at some object of interest on the VDU screen. Because of the way in which the display is produced (the basic electron beam scanning process), there is a known time relation between the commencement of the scan and the position of the point at which the light pen is aimed. This makes it possible to identify what exactly the light pen is looking at. Provision for the light pen facility may be included in a special Cathode Ray Tube Controller IC, such as the 6845.

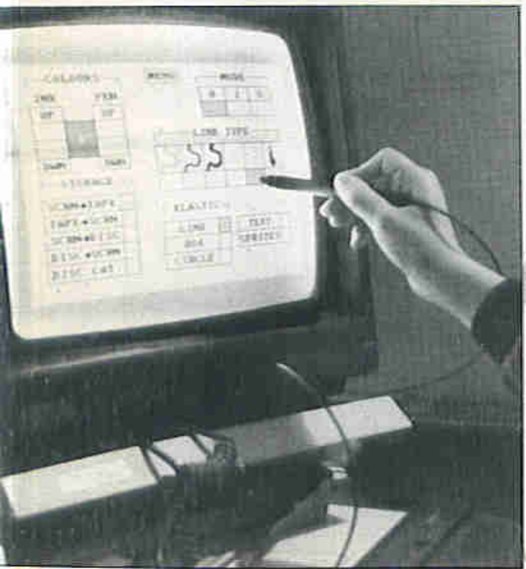


Photo 5. The light pen in use, to select from a menu in a drawing program in this instance.

As an example of its use, suppose that a number of options in a program are represented on screen by boxes that each contain a different symbol. If now the tip of the light pen is placed over a particular box, each time this area is scanned by the electron beam, there will be an output from the pen's optical sensor. Usually a key on the keyboard is pressed at this time and the coincidence of pen position and keypress initiates the required event.

The optical sensor, which may be a photo-cell, photo-diode or photo-transistor, may either be within the tip of the pen itself or in the pen body. In the latter case, an optical fibre link is used to transmit the light picked up from pen tip to sensor.

Another application of the light pen, apart from the above which could just as easily be performed by a mouse and pointer, is in the actual process of on-screen drawing. Naturally, the light pen is still working in the same way as previously described, but now the 'event' that it is initiating is producing a line, shape or pattern on the screen in real time. Drawing in this way may be 'fun' for a while but it is much more natural to draw on a horizontal surface that on a vertical one. The novelty wears off, even with young children.

The Writing Tablet

This is a square or rectangular tablet over which a stylus is moved to give continuous X-Y co-ordinate information. In any position on the tablet the press of a button loads the co-ordinates for that position into the computer. The movements on the 'digitiser tablet', as it may also be called, are reproduced on screen. Apart from originating new artwork in this way, the tablet and stylus can also be used to trace an existing drawing. The latter is placed in position on the tablet and the stylus run over the details of the drawing. The copy is 'echoed' to the screen. It can later be printed out. In case it might be thought that photocopying would be easier, it should be pointed out that such copying can be as selective as one wishes, allowing detail changes to be made. All of the data can be stored on disk, to be called up for further changes at a later date.

There are several types of writing tablet:

(i) The 'wire mesh' type consists of a mesh of fine X-wires separated from a similar mesh of Y-wires by a thin Mylar film. These are buried just below the surface. Gray-coded patterns of pulses are applied to the wires. At any given X-Y position there is a unique Gray-coded value, which the stylus can pick up by capacitive linking.

(ii) There is a type that works on the 'voltage gradient' across the tablet from one side to another, whether across from side-to-side or top-to-bottom. A resistive material, such as 'Teledeltos paper', may be used and the stylus picks up the voltages at any point on the surface. These uniquely identify the X-Y co-ordinates of that point.

(iii) In the 'pressure sensitive' tablet, the stylus pressure causes a direct electrical connection between closely spaced X and Y wires. All such intersections are, of course, unique and so identify the position of the stylus.

There are other types of tablet that use either acoustic waves or modulated high frequency signals. A major use of writing tablets is as part of a Computer Aided Design (CAD) system.

Up to now, all of the devices described in this article have been designed for the express purpose of putting data *into* the computer. They, therefore, represent only one link in the chain of interactive communication between the human operator and the computer. The output from the computer can be in several forms, either temporary or permanent. The latter is usually termed 'hard copy' and is what is obtained from printers, plotters, etc. The temporary output, as it is termed here, is the direct, real time feedback to the user, presented on the screen of a VDU. The latter device is what this final part of the article is about. Printers and similar output devices will be the subject of a later feature in this series.

The VDU (Visual Display Unit)

Sometimes referred to as a 'monitor', the VDU is the standard display device for the majority of computer users. Not only does it 'echo back' the user input from the keyboard thus completing an interactive feedback loop, but may be used to provide information, act as a graphics working area, design screen etc.

There are several divergent paths to follow in the search for a suitable monitor.

It is possible to either buy a purpose built design (the more usual choice for most users nowadays), or a TV receiver can be used if the video output from the computer (plus synchronising information) is made to modulate a compatible UHF signal. The latter choice will not be considered further. The price of a computer monitor varies greatly, being influenced by choice of colour or monochrome and degree of resolution chiefly. What is actually available and the likely cost can easily be learned by scanning the advertisement pages of the computing press. What is of more interest here are the basic principles employed for putting the 'dot matrix' pattern for text or graphics on the screen where required.

First it is necessary to dispel any doubts as to what the term 'dot matrix' means. See Figure 5, which shows the form of several dot matrix characters. A look through any Epson printer manual will reveal similarly constructed characters. But whereas a dot matrix printer produces a character by electro-magnetically firing fine pins at an inked ribbon, the VDU screen achieves a similar objective by turning on or off a minute dot of light formed by the bombardment of the screen phosphor by an electron beam (the so-called 'cathode ray'). In a character matrix consisting of 8 rows by 8 columns, there are clearly 64 dots that can be energised, or not, in a great variety of combinations to give an equal number of possible characters. Often the actual character only occupies a matrix of 7 rows by 5 columns, but the larger 8 x 8 matrix is needed to allow space between characters.

This basic idea is quite straightforward and probably familiar to most readers. What is somewhat more erudite is the way in which the dot matrix characters are actually sent to the screen in the required positions, and then moved about at will.

A Memory-Mapped VDU

To understand what the above term means, it is necessary to consider in more detail the layout of a VDU screen. The smallest element that can be displayed is the dot mentioned previously, which has the special name, PIXEL, meaning Picture Element. The resolution of a screen may be expressed in pixels, e.g. 640 (horizontal) by 200 (vertical). Another way is to talk about so many columns by so many lines of text, e.g. 80 columns by 25 lines. A moment's thought shows that these are just two alternative ways of expressing exactly the same thing.

Remembering that a single character occupies 8 pixels by 8 pixels, a screen that is 640 x 200 can hold 640/8 = 80 (columns) by 200/8 = 25 (lines) of text, as before.

The best resolution is obtained by making use of the basic pixel size as the finest detail of the picture (talking about graphics rather than text). This resolution can be 'degraded' by combining pixels, in a block of four for example, so giving rise to what are called 'chunky graphics'.

Returning to the 640 x 200 screen, the total number of pixels will be equal to 640 x 200 = 128,000. Since a pixel is a binary value (it is either ON or OFF) it can be thought of as a BIT of data in the usual way. Eight pixels will, therefore, occupy one byte and a whole 8 x 8 character will occupy eight bytes. The total number of bytes for a full screen of 128,000 pixels will be 128,000/8 = 16,000 bytes. This is almost 16K of data; 16K actually equals 16,384 bytes in computer terms. Ignoring the odd 384 bytes, one could allow 16K of memory to store a screenful of data. This is just what is done with a memory-mapped VDU. Everything that appears on the screen is held in a special area of RAM known as the 'screen memory'. This area of RAM is so organised that each column of every character's allotted space on the screen has its own unique memory location.

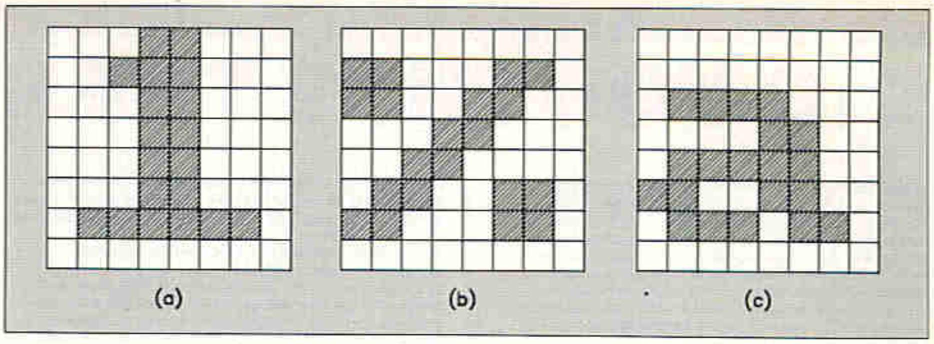


Figure 5. Examples of VDU 8 × 8 dot matrix characters: (a) number '1'; (b) 'percent' symbol and (c) lower case 'a'.

For example, the 16K block of memory reserved for screen use may be located at the top of the memory map (Z80 based machine). This would occupy the addresses C000H – FFFFH inclusive. The first address, C000H is at top-left and the last address, FFFFH, is at bottom-right. The first byte of memory at C000H represents the first 8 horizontal pixels across the screen, the second byte represents the next 8 pixels, and so on for the remaining bytes that make up the total of 80 bytes for the first line. It can be seen from this, that to make up a single character, eight rows of eight pixels (8 bytes) will be required. Each of the eight bytes will have locations within memory 80 bytes apart, i.e. they are on successive lines, one byte 'under' another.

Figure 6 illustrates the point by showing the data loaded into memory locations C000H, C050H, C0A0H, C0F0H, C140H, C190H, C1E0H, C230H, in order to place a capital A at the top left hand corner of the screen. Easy isn't it? Regarding the screen in this way, as just another area of memory, makes it easier to appreciate how any shape can be placed where wanted (by loading the relevent data into the required screen locations) and how this shape can be moved about (by moving the data for it about in screen memory).

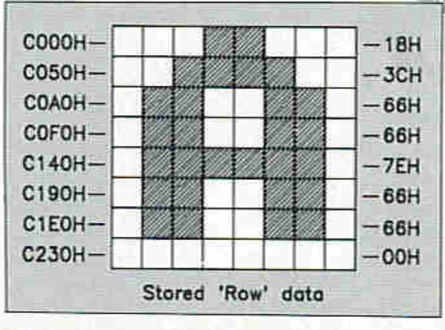


Figure 6. Capital A: it's dot matrix form, and the HEX column data stored in the screen RAM (addresses C000H-C007H inc.), as an example of memory-mapped VDU principles.

There is still the matter of producing a steady display on the screen. To do this means that the screen memory must be 'scanned' regularly in some way, the rate at which this scanning takes place being synchronised with the rate at which the electron beam scans the screen. If data is changed between one scan and the next then the screen display will change accordingly. As the user types in text from the keyboard, the data for this text is entered into the screen memory. As the latter is scanned, the new characters appear on the screen. Naturally, all of this process happens so quickly that it appears continuous.

The complexities of VDU scanning would occupy more space than is available here. The foregoing applies to specific 'dot graphics' displays. If only the standard ASCII characters need to be shown, along with some spare graphics shape characters perhaps, then it is not necessary to use up so much memory to literally draw each character in such fine detail. Instead, screen RAM can merely comprise a number of locations which contain the ASCII values of the characters in the required places, and for an 80 x 25 character screen say, only 2000 actual bytes of screen RAM are needed for this, a great saving on memory usage. The shape of each actual character is stored in a separate 'character ROM', which is addressed by a combination of the ASCII value plus a value of 0 to 7. The character ROM then has eight bytes for each character, each byte representing 8 dots (bits) which makes up one eighth of the character – the eight bytes are organised from top to bottom (eight dot rows). The VDU display circuit scans each text line in screen RAM eight times, to produce eight equivalent TV scan lines, using the ASCII value of each character in turn to find the right letter shape – and the scan line number (one of eight) to find the right row – in the character ROM. The relevant byte (row of dots) is loaded into a shift register and transmitted in serial form to the VDU by a high frequency counter commonly known as a 'dot clock'.

It can be seen that a lot of the work is carried out by a dedicated CRTC (Cathode Ray Tube Controller) IC, such as the 6845. This IC has 18 registers whose contents are controlled by the ROM operating system. But such a display controller is invariably 'self running' so all that the user (and the computer come to that) has to worry about is what to put in the screen RAM in the first place!

In the next issue, the disk drive unit, both floppy and hard variety, will come in for some detailed examination.

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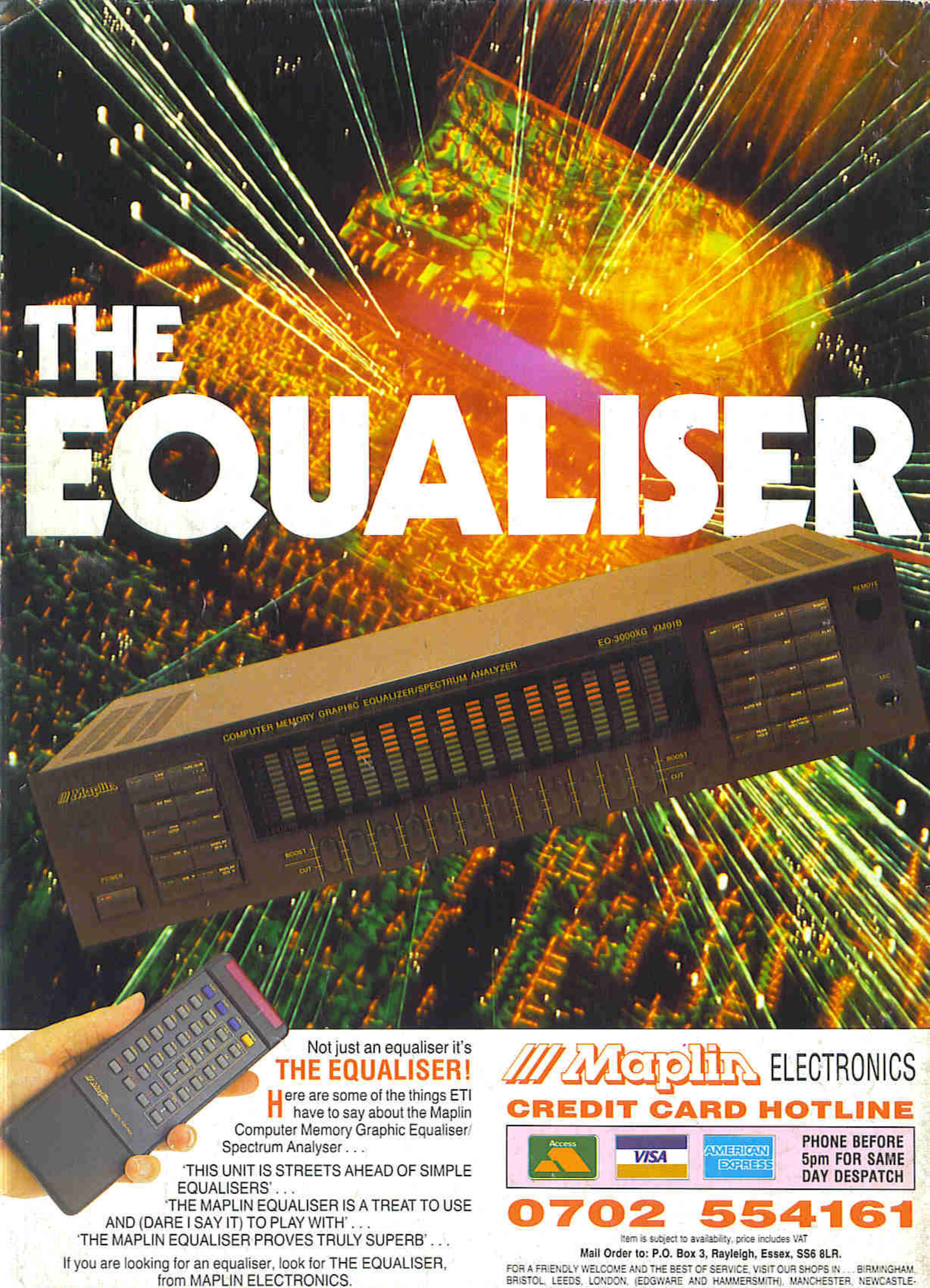
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