PROJECTS BOOK 30

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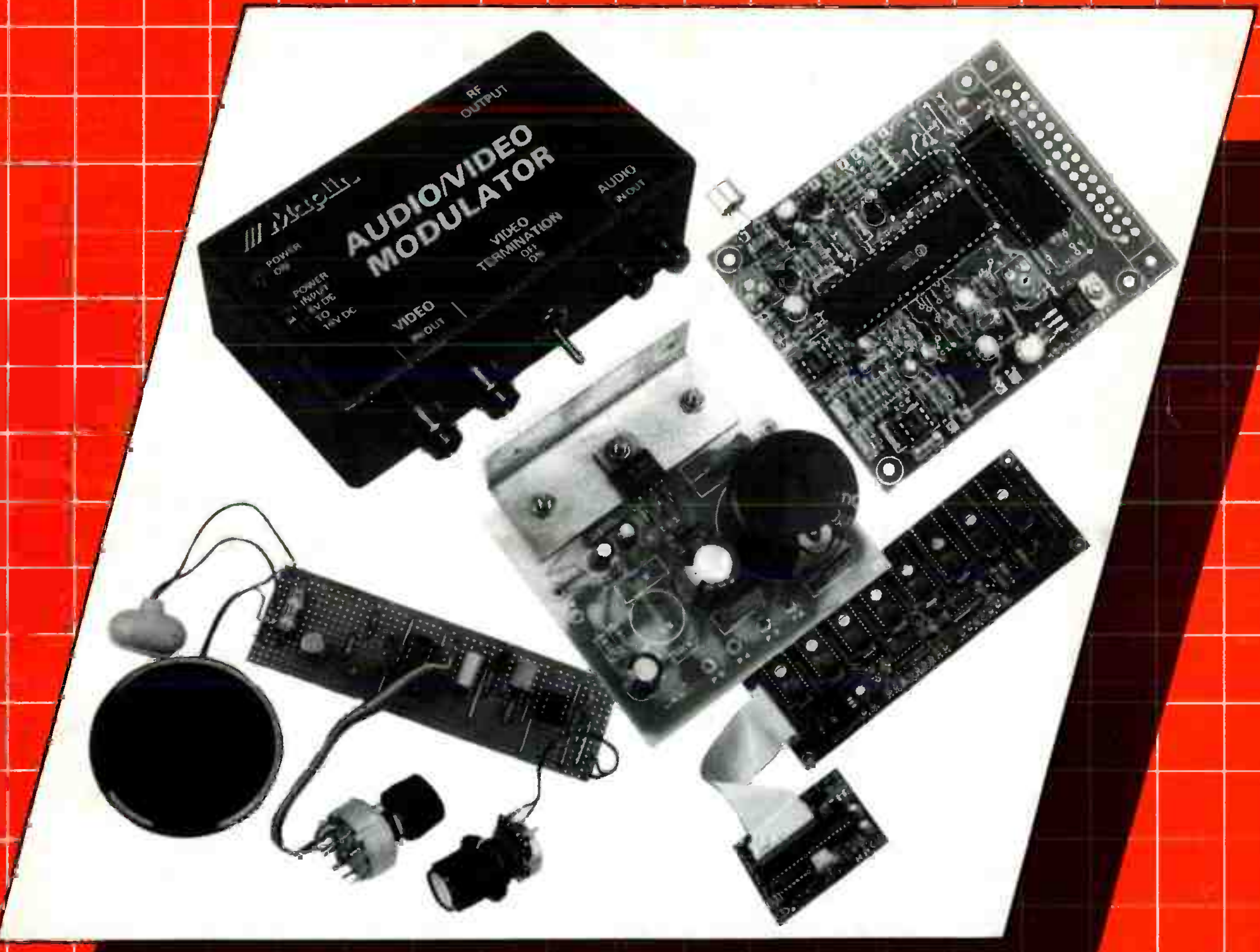

DIGITAL RECORD & PLAYBACK MODULE

DIGITAL SPEECH ROM EXPANSION MODULE

DATA FILE: LM1875

AUDIO & VIDEO MODULATOR

BOB'S MINI CIRCUITS

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MAPLIN PROJECTS BOOK THIRTY

EDITORIAL

▮This Project Book replaces Issue 30 of 'Electronics' which is now out of print. In addition one project from Issue 35 has been included in order to complete a series. Other issues of 'Electronics' will also be replaced by Project Books once they are out of print.
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R Ball

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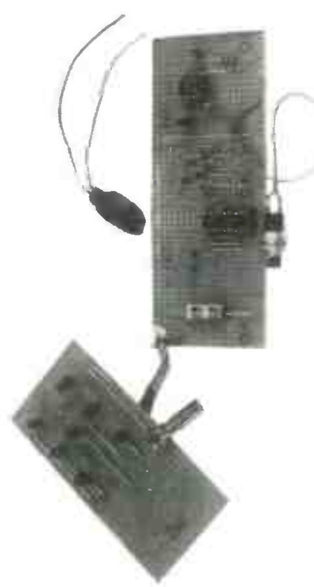
PROJECTS



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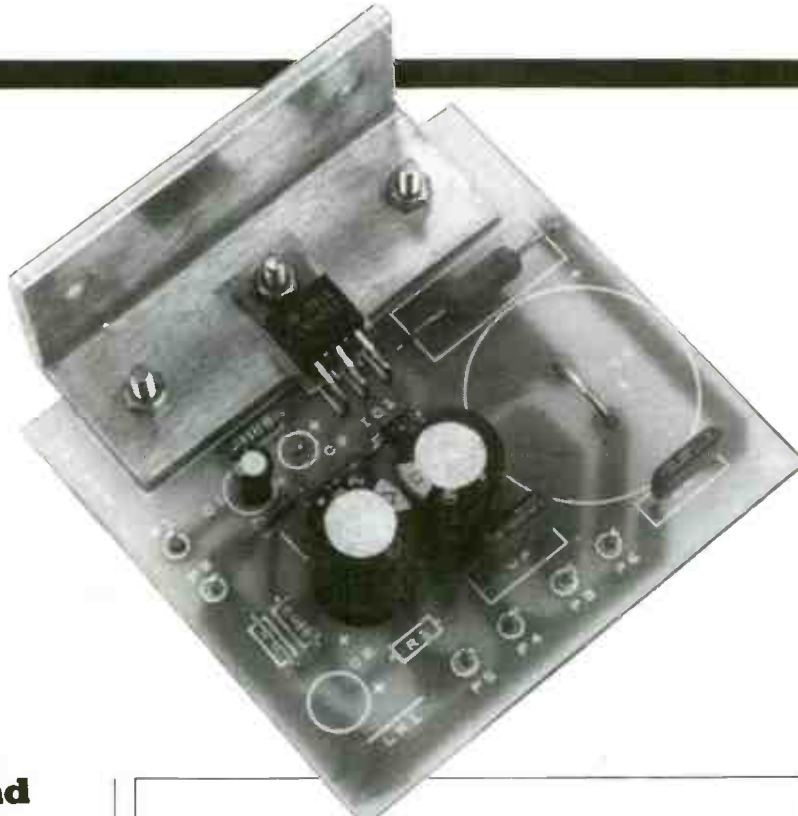
DATA FILE

LM1875 20 WATT AUDIO POWER AMP



Features

★ Output Power up to 30W (rms)
★ Wide Range of Supply Voltages
★ Split or Single Supply
★ Short Circuit Protection
★ Thermal Protection
★ Low Distortion
★ 5 pin TO220 package
★ PCB Available

Applications

★ High Quality Audio Amplifiers
★ Servo Amplifiers
★ Bridge Amplifiers

General Description

The LM1875 is a general purpose audio power amplifier that offers very high quality output using a minimum of external components. The IC pin-out is shown in Figure 1. The device operates over a wide range of power supply voltages from 20V to 60V DC and will deliver 20 watts rms into a 4Ω or 8Ω load when operated from a 50V supply. If a 60V supply is used, output powers up to 30W rms may be produced (if an increase in distortion is acceptable). By using advanced circuit techniques the amplifier IC offers minimal distortion even at high power levels. Other features include wide bandwidth, high gain, large output voltage swing and overload protection.
Table 1 gives the electrical characteristics of the LM1875 and Figure 2 shows some typical performance characteristics of the IC.

Stability and Distortion

The LM1875 is designed to be stable when operated with a closed loop gain greater than ten; however, as with any other high current amplifier, it may oscillate under certain conditions. Oscillation is often caused by poor circuit board layout or associated with input/output connections. When designing a layout it is important to return the load earth and the signal earth to the main earth point via separate paths. Preferably the load earth should be connected directly to the 0V terminal of the power supply. If the input and load earths are connected to 0V via the same rail, high currents on the rail can generate voltages which effectively act as input signals, leading to high frequency oscillation or distortion. It is recommended that the earth (0V) rails are kept as short as possible and that decoupling capacitors and output compensation

Parameter	Conditions	Typical	Tested Limits
Supply Voltage:			60V (±30V) Max
Supply Current:	P_{out} = 0W	70mA	100mA
Output Power (P_{out}):	THD = 1%	25W	
Load Impedance:			4Ω to 8Ω
THD:	P_{out} = 20W, 4Ω load, F_o = 1kHz	0·022%	
	P_{out} = 20W, 4Ω load, F_o = 20kHz	0·07%	
Full Power Bandwidth:			DC to 250kHz (−3dB)
Open Loop Gain:	DC	90dB	
Max Slew Rate:		8V/μs	

Table 1. Electrical characteristics of the LM1875.

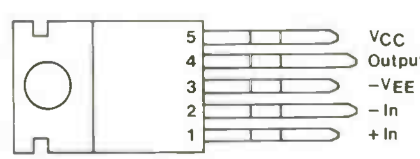


Figure 1. Pin-out of the LM1875.

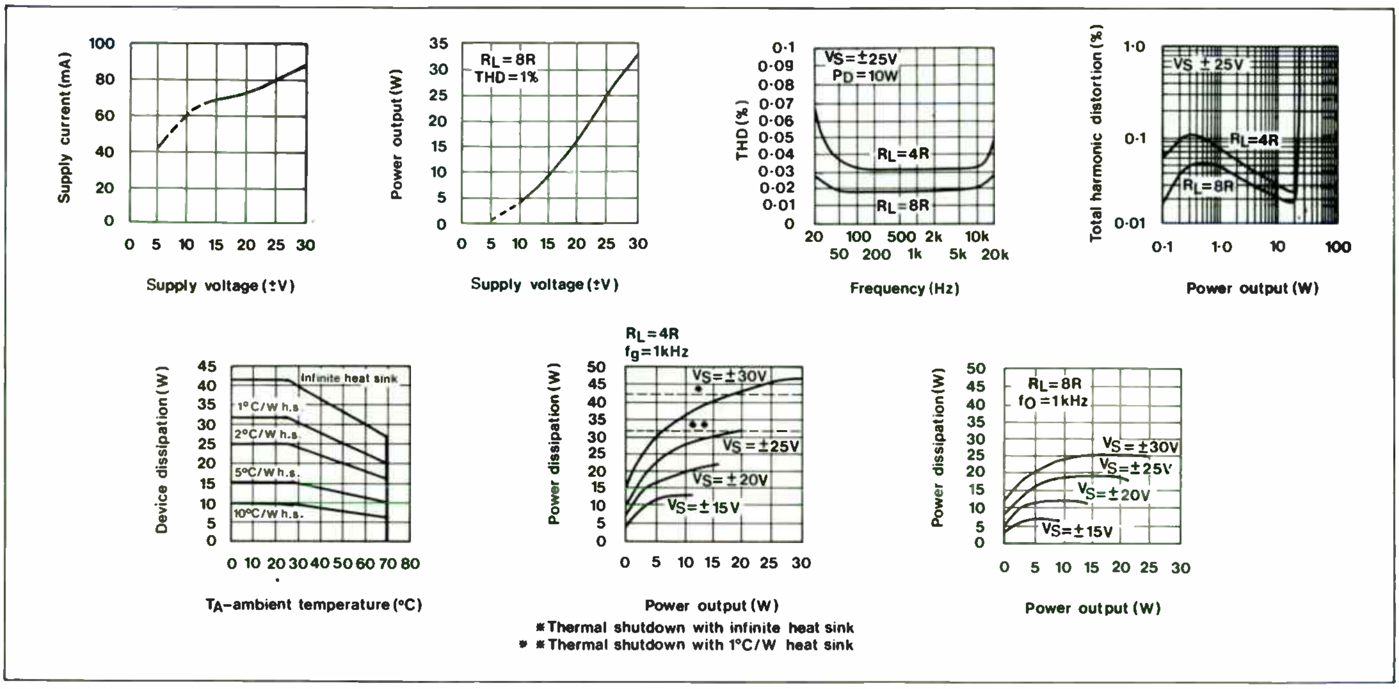


Figure 2. (a) Supply current vs supply voltage (quiescent). (b) Power output vs supply current. (c) THD vs frequency. (d) THD vs power output. (e) Device dissipation vs ambient temperature. (f) Power dissipation vs power output (4 ohm load). (g) Power dissipation vs power output (8 ohm load).

components are kept close to the IC to minimise the effects of track resistance and inductance. Sometimes oscillation can be caused by stray coupling between the output and input leads, especially if the leads are long and the source impedance is high; in order to avoid this, these leads should be kept as far apart and as short as possible. It is often possible to prevent oscillation due to stray input/output coupling by fitting a 50pF to 500pF capacitor across the circuit input terminals.

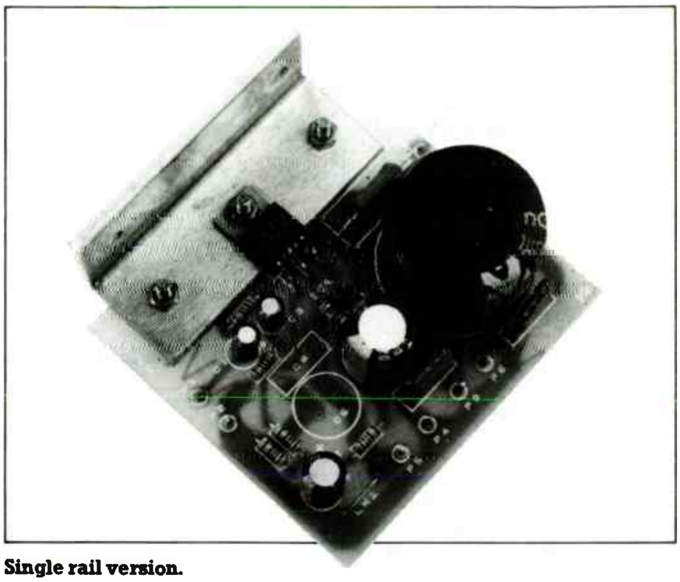
In addition to preventing problems with spurious oscillation, layout can also be an important factor in achieving minimum distortion. For low distortion the power supply wiring is also important; this should be kept as far away as possible from the input wiring to help prevent non-linear power supply currents being induced into the IC inputs. If possible the power supply wires should be kept perpendicular to the circuit board for a few centimetres.

Thermal Protection and Heatsinking

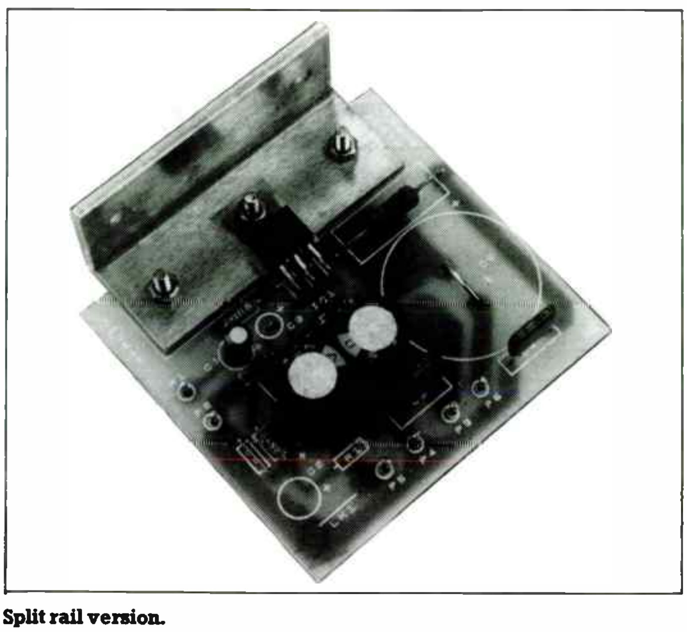
The LM1875 incorporates a sophisticated thermal protection system to help prevent any long term thermal stress to the device. If the IC (die) temperature reaches 170°C the amplifier shuts down until the temperature drops to around 145°C; if, however, the temperature starts to rise again the device will then shut down at around 150°C. The effect of the above characteristic is to allow the device to rise to a relatively high temperature under short duration fault conditions but limit the temperature of the device if the fault condition is sustained; this helps to improve the long term reliability of the IC.

It is important that the amplifier is always operated with a heatsink because even when off load, the device may dissipate up to 6W and when on load the dissipation may be as high as 30W. A heatsink should be chosen that is sufficient to keep the temperature of the device well below shutdown temperature. For reliability the heatsink should be the best possible for the space available.

If the amplifier is powered from a single rail supply, the IC mounting tab may be bolted directly to the chassis (0V). When the device is powered from a split rail supply, to avoid damage, it is important that the tab is completely isolated from 0V; an insulating bush and a mica washer is usually used for this purpose. If the amplifier is powered from a split supply, a larger heatsink may be necessary because the thermal connection to the heatsink through a mica washer is less efficient than a direct connection.



Single rail version.



Split rail version.

Current Limit

In addition to thermal protection, the LM1875 also provides current limiting. A power amplifier can be easily damaged by excessive applied voltage or current flow. Reactive loads are often a problem due to the fact that they can draw large currents at the same time as high voltages appear on the amplifier's output transistors. To prevent any damage that may occur, the LM1875 limits the current to around 4A and also lowers the value of this current limit when high voltage appears across the output of the device. Protection is also provided against the excessively high voltages that may appear on the output of the device when driving non-linear inductive loads.

Power Supply

The amplifier may be powered from either a single or split rail supply and will operate over a wide range of voltages between 20V and 60V (between ±10V and ±30V when powered from a split rail supply). Current requirements depend very much on output power and may range from a few mA to over 1A. It is important that the power supply is adequately decoupled to prevent the introduction of mains derived noise into the amplifier.

Printed Circuit Board

A high quality fibre-glass PCB with printed legend is available for the basic LM1875 audio amplifier application. Two different versions of the amplifier may be constructed using the same PCB; one version is for use with a single rail supply (see Figure 3) and the other is for use with a split rail supply (see Figure 4). A combined circuit diagram of both versions of the amplifier is shown in Figure 5 for reference purposes; this is the circuit used to produce the PCB which is shown in Figure 6. Provision is made for a PCB mounted heatsink bracket; power should not be applied to the amplifier until the bracket has been bolted securely to a suitable heatsink (for example, Maplin stock code FJ77J or a heatsink with at least 1500cm^2 surface area). Please note that if the amplifier is powered from a split rail supply, the IC tag must NOT be electrically connected to the chassis (0V); an insulating bush and a mica washer should be used to isolate the tag from the heatsink (see Figure 7). It is recommended that heat transfer compound is smeared between the IC and the

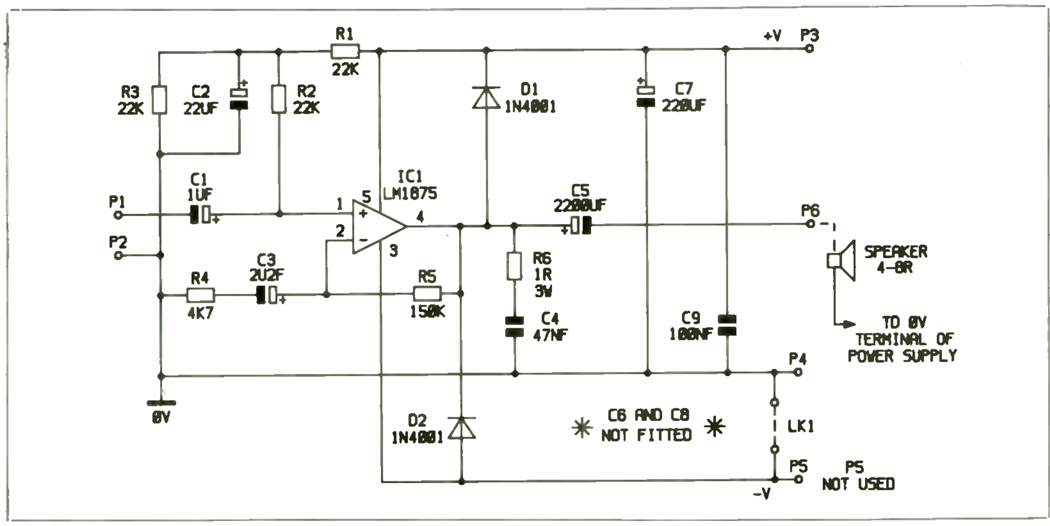


Figure 3. Amplifier for single rail supply.

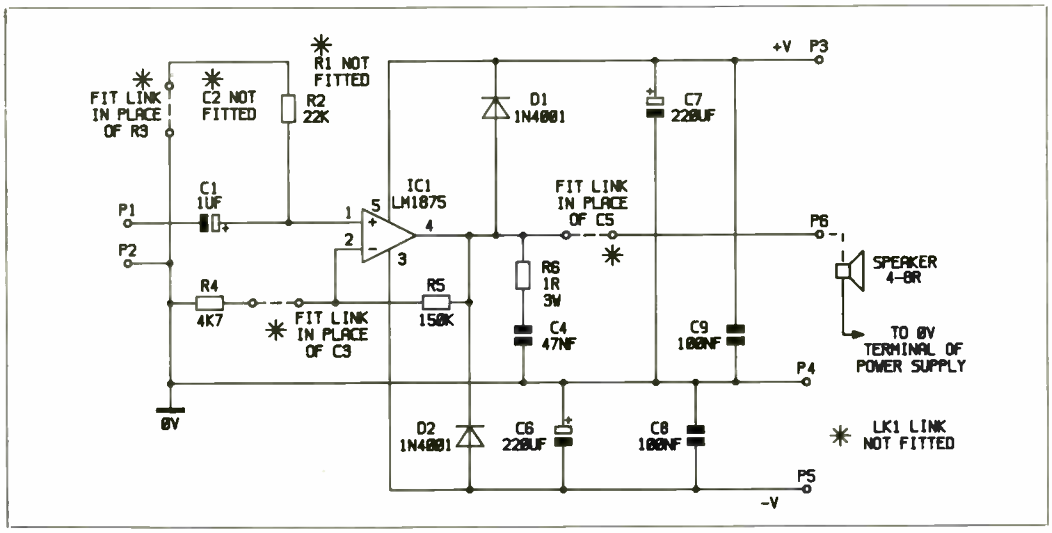


Figure 4. Amplifier for split rail supply.

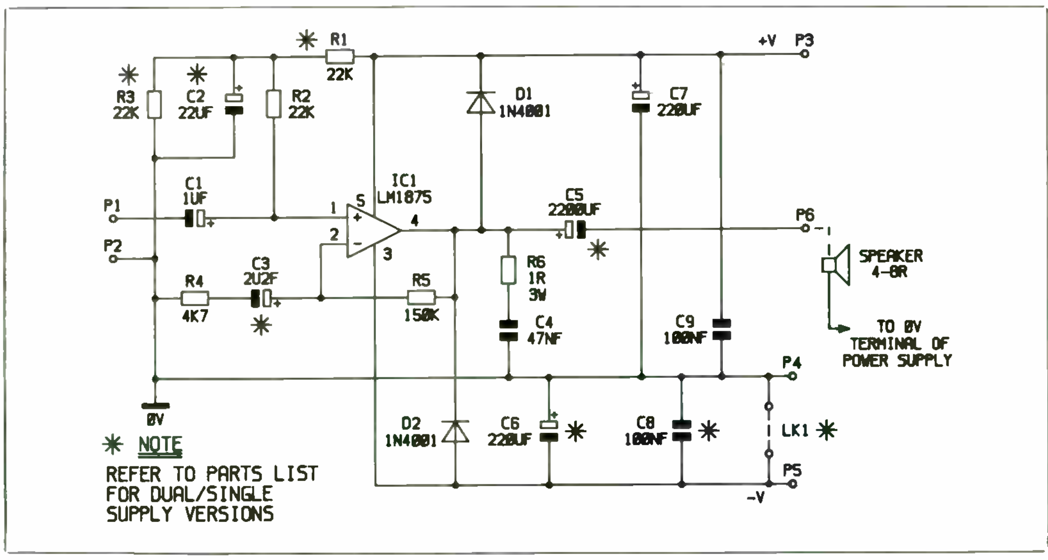


Figure 5. Combined circuit to which PCB is designed.

Power Supply Voltage:	20V - 60V DC	(±10V - ±30V DC)
Power Supply Current:	(quiescent)	85mA (at 60V)
Voltage Gain:	(set by value of R4 and R5)	30dB
Full Power Bandwidth:	(4Ω load)	20Hz - 250kHz (−3dB)
Output Load Impedance:		4Ω to 8Ω

Table 2. Specification of prototype.

heatsink to facilitate the conduction of heat away from the device. If a mica washer is used, the compound should be applied on both the IC and heatsink sides of the washer. A larger heatsink may be necessary for the split rail version of the amplifier.

For connection information, refer to Figure 3 or Figure 4 as appropriate. The power supply is connected to P3(+V), P4(0V) and P5(−V); if the amplifier is powered from a single rail supply P5 is not used. Heavy gauge wire should be used for the power supply and output connections and all leads should be kept as short as possible. The signal input is applied between P1 and P2 using screened cable (XR12N) and the output is taken from P6, the load earth being connected directly to the 0V terminal of the power supply. Finally, Table 2 gives the specification of the prototype amplifier that was built on the PCB (GE13P).

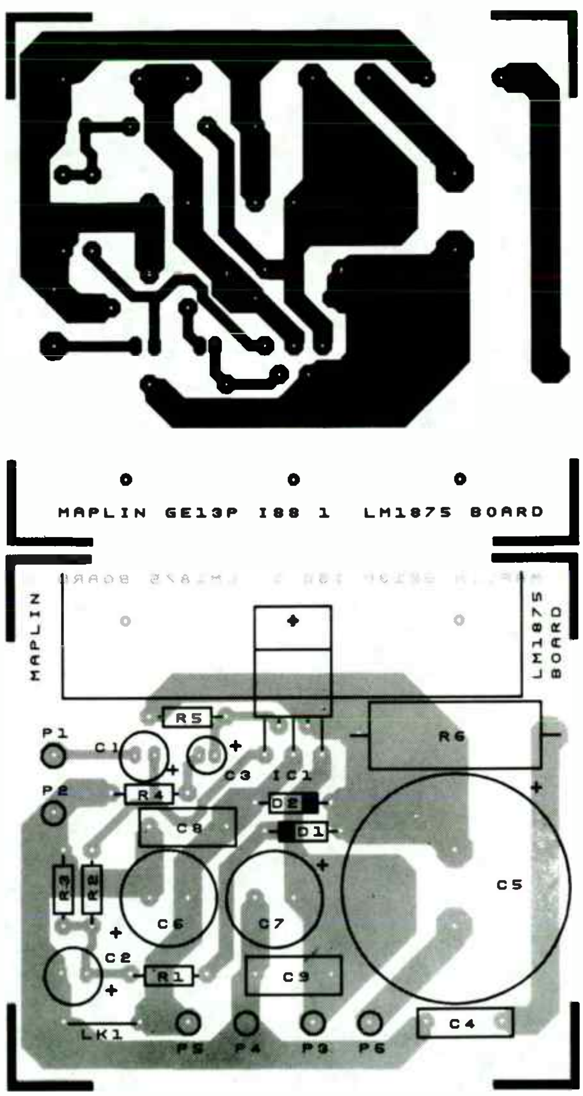


Figure 6. Track and layout of PCB.

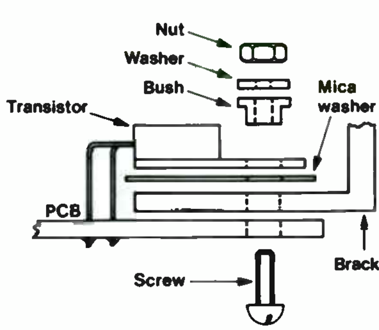


Figure 7. Mounting IC1.

SINGLE RAIL PARTS LIST

Resistors: All 0.6W Metal Film (unless specified)

R1,2,3	22k	3	(M22K)
R4	4k7	1	(M4K7)
R5	150k	1	(M150K)
R6	1R 3W Wirewound	1	(W1R)
LK1	Link Fitted		

Capacitors

C1	1μF 100V PC Electrolytic	1	(FF01B)
C2	22μF 63V PC Electrolytic	1	(FF07H)
C3	2μ2F 100V PC Electrolytic	1	(FF02C)
C4	47nF Polyester	1	(BX74R)
C5	2200μF 63V Snap-in	1	(JL38R)
C6	Not Fitted		
C7	220μF 63V PC Electrolytic	1	(FF14Q)
C8	Not Fitted		
C9	100nF Polyester	1	(BX76H)

Semiconductors

IC1	LM1875	1	(UH78K)
D1,2	1N4002	2	(QL74R)

Miscellaneous

PC Board	1	(GE13P)
Bracket	1	(YQ36P)
Pins	1 Pkt	(FL21X)
M3 Bolt x 12mm	1 Pkt	(BF52G)
M3 Nut	1 Pkt	(JD61R)
M3 Washer	1 Pkt	(JD76H)

SPLIT RAIL PARTS LIST

Resistors: All 0.6W Metal Film (unless specified)

R1	Not Fitted		
R2	22k	1	(M22K)
R3	Linked Out		
R4	4k7	1	(M4K7)
R5	150k	1	(M150K)
R6	1R 3W Wirewound	1	(W1R)
LK1	Link Not Fitted		

Capacitors

C1	1μF 100V PC Electrolytic	1	(FF01B)
C2	Not Fitted		
C3	Linked Out		
C4	47nF Polyester	1	(BX74R)
C5	Linked Out		
C6,7	220μF 63V PC Electrolytic	2	(FF14Q)
C8,9	100nF Polyester	2	(BX76H)

Semiconductors

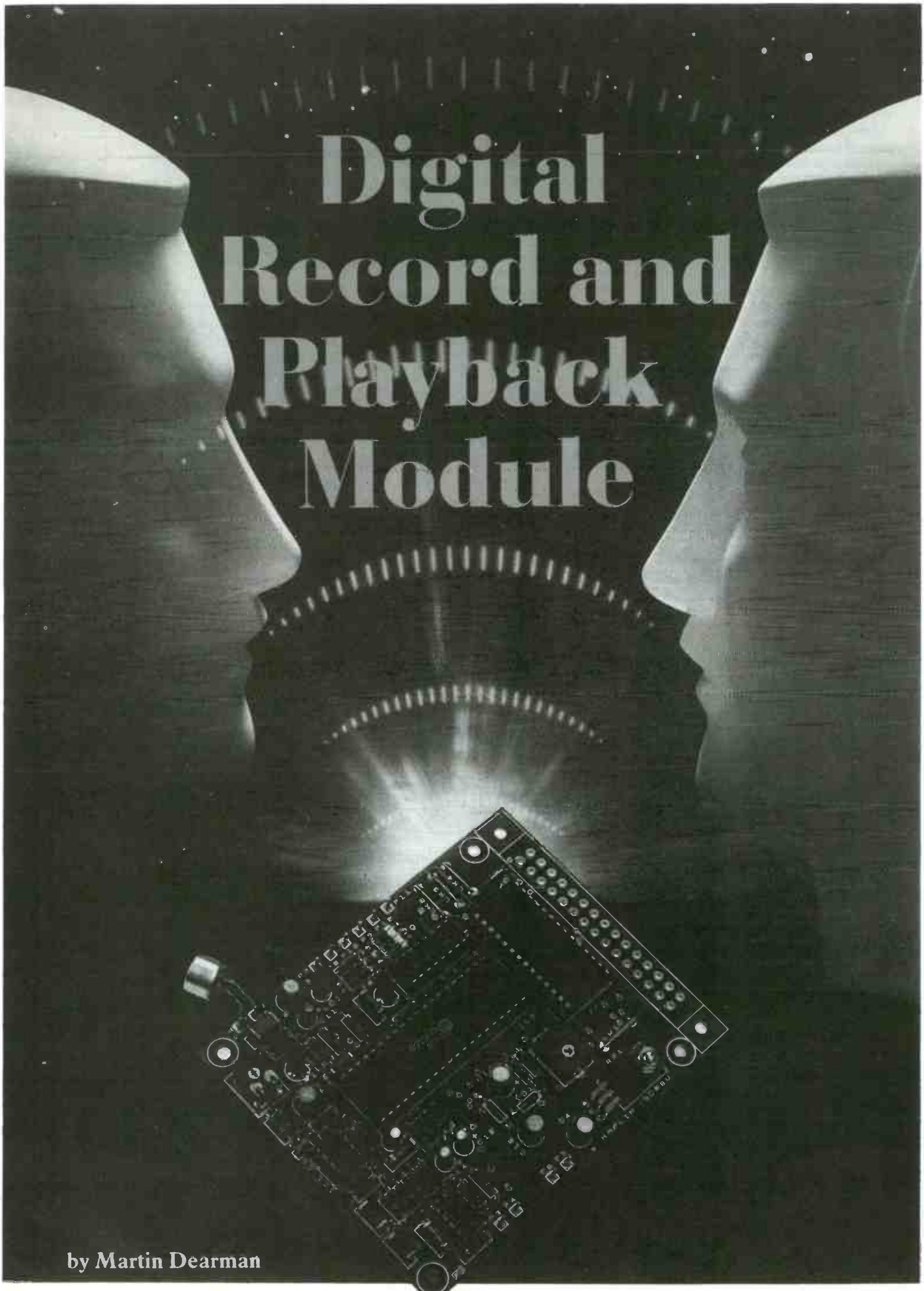
IC1	LM1875	1	(UH78K)
D1, 2	1N4002	2	(QL74R)

Miscellaneous

PC Board	1	(GE13P)
Bracket	1	(YQ36P)
Pins	1 Pkt	(FL21X)
M3 Bolt x 12mm	1 Pkt	(BF52G)
M3 Nut	1 Pkt	(JD61R)
M3 Washer	1 Pkt	(JD76H)
Mounting Kit	1	(WR23A)

The following item is available separately.
LM1875 PCB **Order As GE13P.**

Digital Record and Playback Module



by Martin Dearman

This project is based around the UM5100 digital voice recorder and playback integrated circuit where speech is digitally recorded into memory and then played back. Digital recording has the advantage over tape recording, in that there is no mechanical wear and tear in the tape head or tape. Applications include voice message pads, security systems and telecommunications, and it can also be used in a vehicle, as it will run from a 12V supply. For memory, either an 8Kbyte CMOS Static RAM (SRAM), type 6264, or a 32Kbyte CMOS SRAM, type 62256, can be used and with the 32Kbyte SRAM supplied, record and playback durations of between 5 and 20 seconds are possible. The module can be further expanded with an EPROM programmer board, and another option will be a replay only board for playing back pre-recorded messages stored on an EPROM (both of these add-ons will be published in a future issue).

Circuit Description

Figure 1 shows a block diagram of the record and playback module, and Figure 2 shows the circuit diagram. Speech is

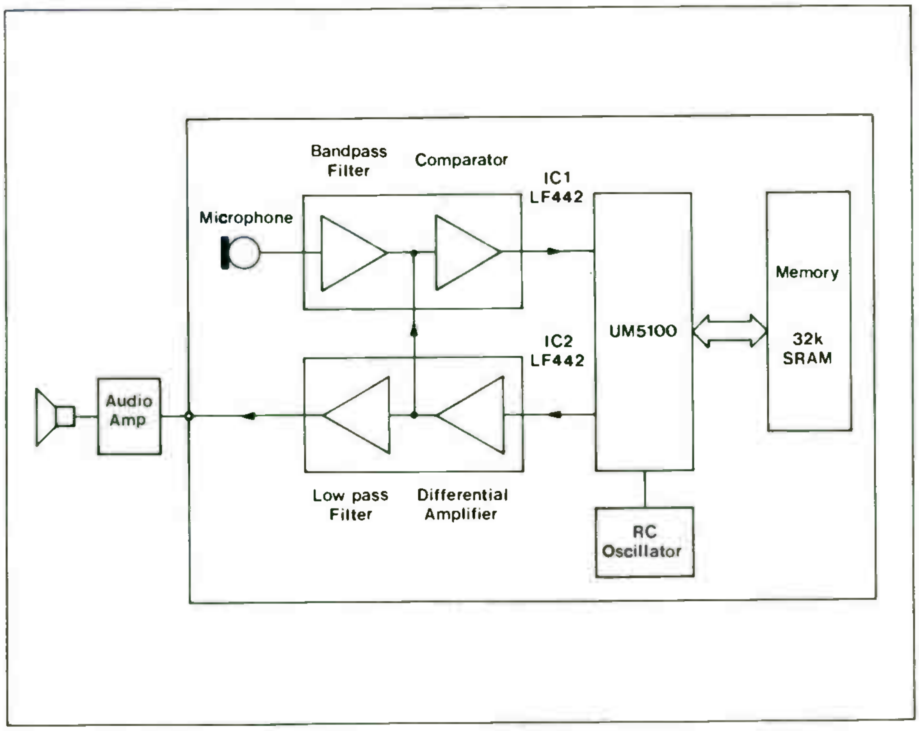


Figure 1. Block schematic of the system.

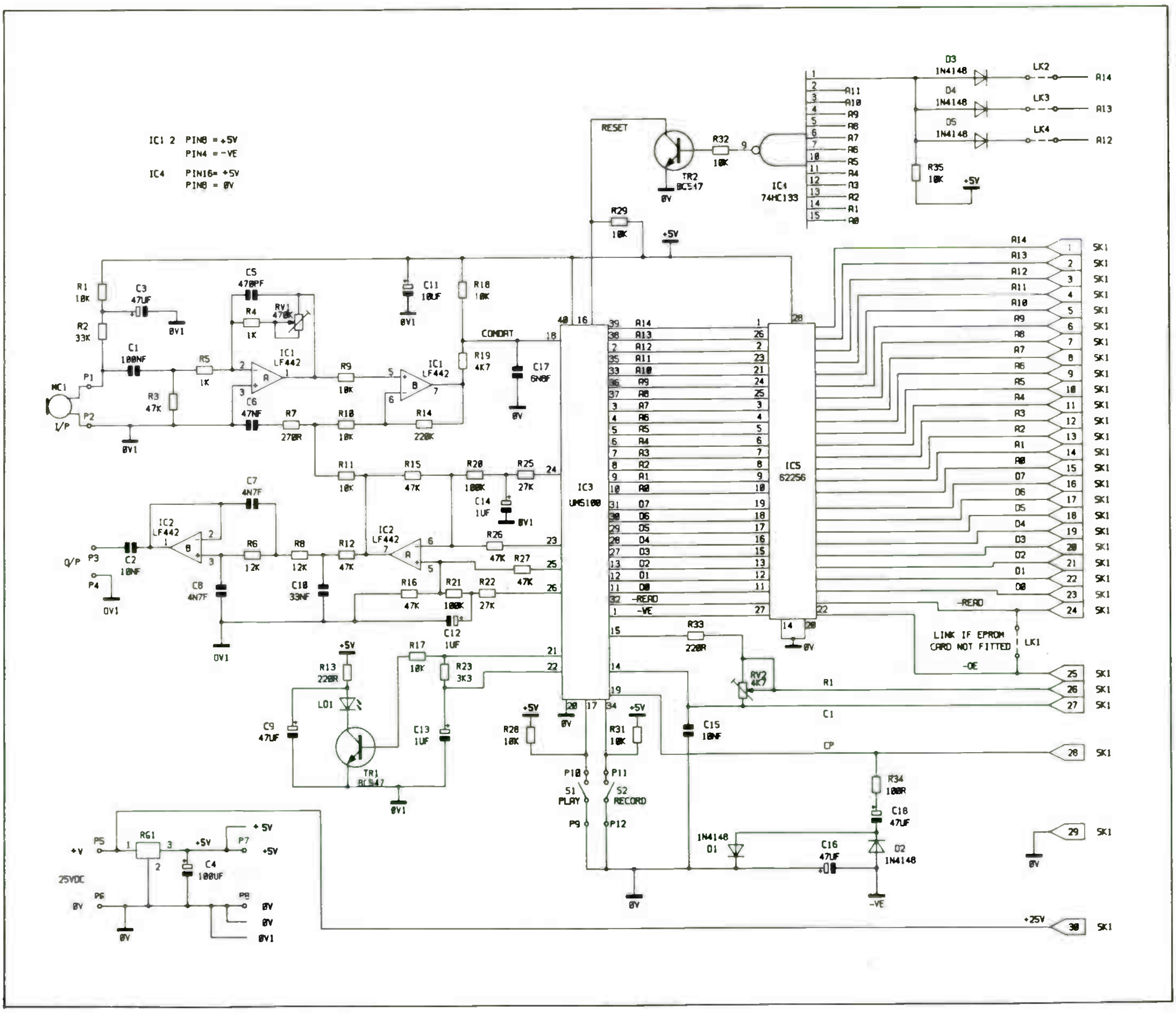


Figure 2. Circuit of the record/playback module.

received at the electret microphone and amplified by IC1a, which has a variable resistor RV1 in its feedback path, thus the gain of IC1a can be altered to suit the sensitivity required from the microphone. IC1a is also a bandpass filter (consisting of components C1, R3, R5, IC1a, C5, R4, RV1) and is used to reduce two problems from which an analogue to digital circuit can suffer. These two problems are called aliasing error and quantisation noise. Aliasing error occurs when the frequency being sampled (converted) is greater than half of the sampling frequency. The error occurs because the analogue to digital converter circuit (ADC) needs to sample the input signal at twice the frequency of the input signal (at least); i.e. to sample a 10kHz sinewave, a minimum 20kHz sampling rate will be needed to correctly convert the input signal. If, for example, the input signal now consists of 10kHz and 20kHz sinewaves mixed together, the ADC will correctly convert the 10kHz sinewave and it will attempt to convert the 20kHz sinewave, but it will not be able to manage it successfully as it is not being sampled at a high enough rate. The bandpass filter has a frequency response characteristic such that it will reduce or entirely remove these unwanted higher frequencies as can be seen in the frequency response graph of Figure 3. Quantisation error occurs when there are too few bits being used to adequately represent the input signal. To reduce quantisation error, the input signal will need to have its amplitude increased and this is done by the bandpass filter which exhibits voltage gain at the frequencies being sampled. The speech signal is then fed to IC1b, which is a voltage comparator and compares part of the output signal (pins 23, 24, 25 and 26 of the UM5100 IC) with the input signal arriving at pin 5 of IC1b. Part of this signal also reaches the output pin P3, so that the speech can be externally monitored. The speech signal now enters the voice processor IC3, which converts the analogue speech to a digital representation of this signal.

The digital signal, now in a binary format, is placed into IC5, a static RAM IC, via the 8 bit data bus (pins 11, 12, 13 and 27 to 31 on the UM5100 IC). The UM5100 also generates the address that the RAM IC requires, starting with address 0 and incrementing (adding one) to this address every time a conversion has taken place, until the highest address of the RAM IC has been reached, 32767 or 111111111111111 with a 32k byte memory device. When the RAM IC is full, i.e. address 32767 has been reached, the UM5100 IC will stop converting the analogue speech signal, and be reset. Reset occurs when pin 16 of the UM5100 is at +5V DC, and this happens when address lines A0 to A14 (when using the 32k byte RAM IC) are all high, i.e. at a logic '1'. The 15 address lines A0 to A14, are logically ANDed together by components D3, D4, D5, R35, IC4, R32, TR2 and R29. Links 2 to 4 (LK2 to LK4) are inserted to suit the size of RAM IC used, see Table 1 for link settings.

RAM Size	LK2	LK3	LK4
8k	Unmade	Unmade	Made
32k	Made	Made	Made

Table 1. Link settings.

Playback of the digital speech information in the RAM IC will occur when pin 17 of the UM5100 IC is shorted to ground. This speech information is read (fetched) from the RAM via the data bus, then converted back to an analogue signal by the UM5100, and fed out of the IC on pins 23 to 26. The four signals coming out of the UM5100 IC are combined into one signal by differential amplifier IC2a. The signal is then low pass filtered by IC2b, to remove unwanted clock and noise signals, and output to pin P3. This signal will need to be amplified by an external amplifier, as the average level is only 250mV RMS. There is also a LED (LD1) indicator fitted that will light when speech is being received and played back by the UM5100. The record and playback module can be made to replay continuously by keeping pin 17 of the UM5100 shorted to ground.

PCB Assembly

The PCB is a double-sided, plated through hole, fibre glass type. Removal of a misplaced component is therefore quite difficult, so please double-check each component type, value and its polarity where appropriate, before soldering. The PCB has a printed legend to assist you in correctly positioning each item, see Figure 4. The sequence in which the components are fitted is not critical. However, it is easier to start with the smaller components. Begin with the metal film 0.6W resistors, then mount the five diodes D1 to D5, taking care to insert them the right way round as they are polarised; the cathode is indicated by a band at the end of the diode body. Next the four link wires, LK1 to LK4, can be fitted and the pins P1 to P12 have to be inserted from the solder side of the PCB. Next insert all the polyester capacitors, then the two variable preset resistors RV1 and RV2, then fit the 470pF ceramic capacitor. The nine electrolytic capacitors are polarised devices, so take care in inserting them into the PCB the correct way round; the negative lead is indicated by a minus sign down one side of the capacitor. There are five IC sockets to be fitted; make sure the notches on the IC sockets match up with the notches in the legend on the PCB. A little trick to hold the sockets in place

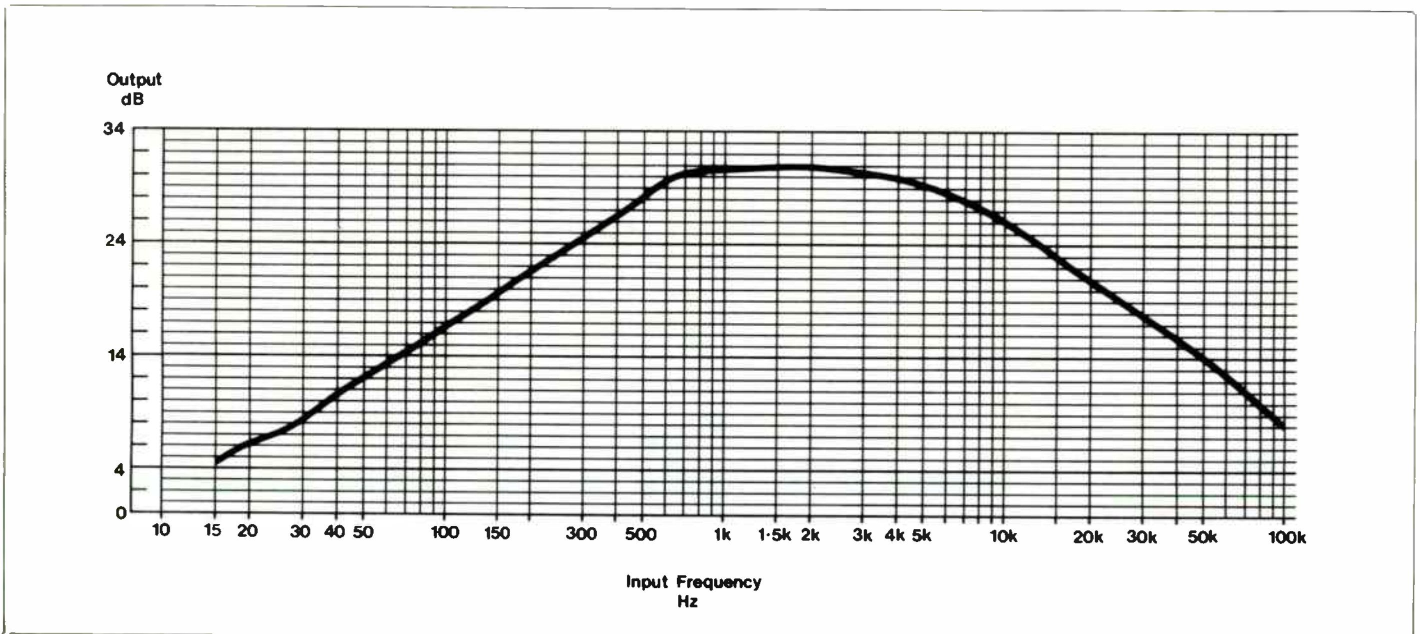


Figure 3. Bandpass filter response.

DIGITAL RECORD AND PLAYBACK MODULE

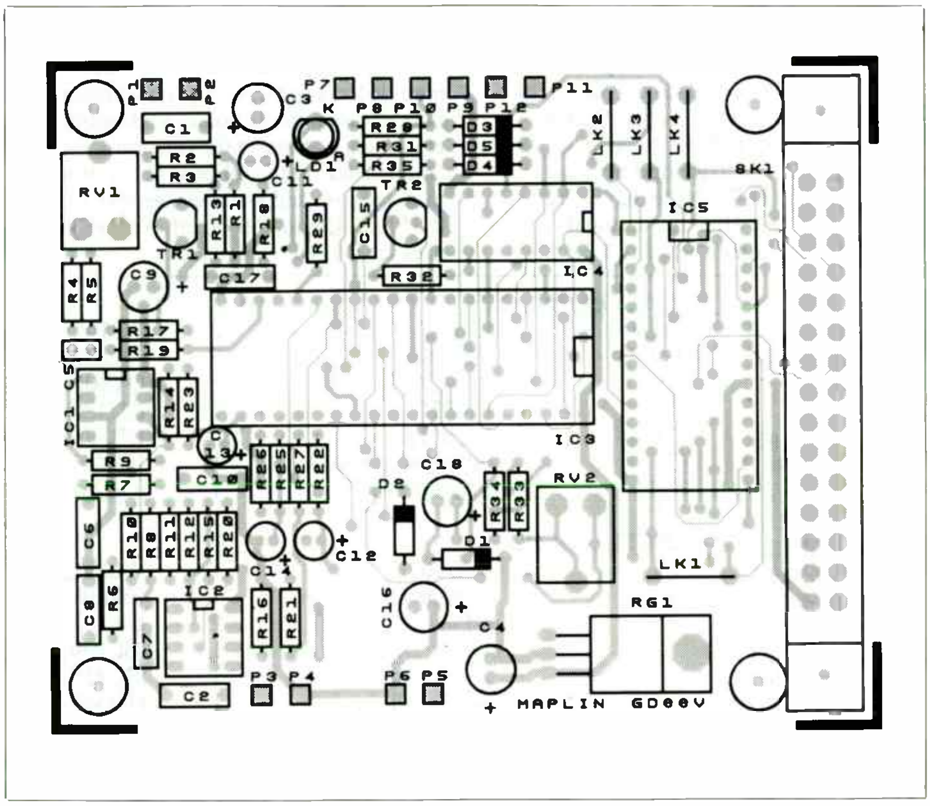


Figure 4. Layout of the PCB.

during soldering, is to bend two of the sockets legs over once it has been inserted into the PCB. This will hold the socket in place until all the other leads have been soldered, then straighten out the two previously bent legs and solder them. The ideal pair of legs to bend are the two at each end of the socket and diagonally opposite each other. Next fit the two

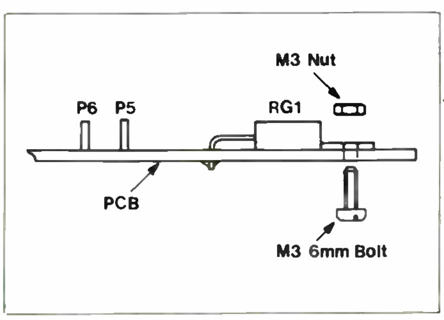


Figure 5. Mounting the regulator.

transistors TR1 and TR2, taking care to match the body shape of the transistor with the outline on the PCB, then the LED is inserted into the PCB; the cathode is indicated by a flat side on the body and by the shorter of the two leads. The regulator IC is fitted next and is bolted to the PCB using an M3 nut and bolt (see Figure 5). The leads of the regulator have to be bent at an angle to get them into the PCB with the M3 nut and bolt as shown. Mount the electret microphone as shown in Figure 6, taking great care to wire it the correct way as it is a polarised device; the 0V (ground) pin is connected to the microphone case.

Testing

All of the tests necessary can be made with the minimum of equipment. You will need an electronic digital (or analogue

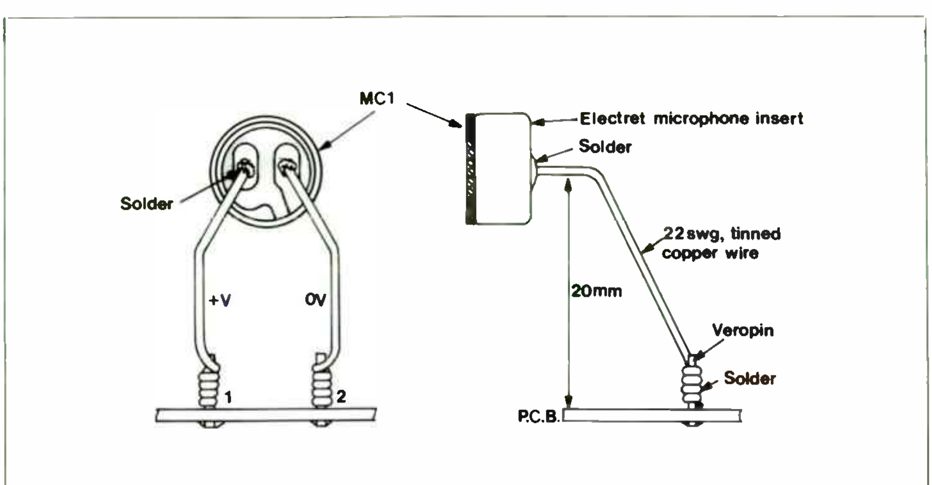


Figure 6. Mounting the electret microphone.

moving coil) multimeter and a stabilised DC power source, that can supply up to 50mA at 7.5 to 25V DC. The lower voltage would be preferable at this stage, due to the power dissipation in the 78M05 +5V voltage regulator being less at 7.5V DC, the higher voltage of 25V DC will be required when the plug-in EPROM programmer PCB is used (this will appear in a later issue). Connect the power source to P6 and P5, with 0V to P6 and the positive to P5, and note the average current drain is about 10mA. Also an amplifier will be needed, the LM386 amplifier module (kit number LM76H)

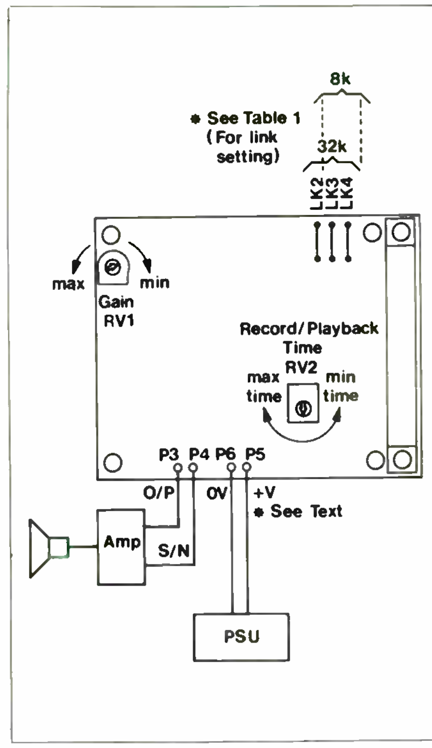


Figure 7. Controls and power connections.

being ideal for this task (see 'Data File' in issue 29). Connect the amplifier to P3 and P4, with 0V to P4 (see Figure 7). Now you are ready to record a voice. To activate recording mode, P11 will have to be momentarily shorted to ground by connecting P11 to P12, if P11 is left connected to P12 then recording will be continuous, the UM5100 will notice that P11 is shorted to ground when it is reset, which occurs when the RAM IC is full, then the UM5100 will put its converted speech signal into the lowest memory location of the RAM IC, and of course the data previously in the memory device will be overwritten. Please note that the optimum speaking distance from the electret microphone is 100mm. The recording level sensitivity can be adjusted by rotating variable preset resistor RV1; the direction of rotation for minimum and maximum sensitivity is also shown in Figure 7. The recording and playback duration can be adjusted by variable preset resistor RV2 and the recording and playback duration has a range of 5 to 20 seconds. There is a trade off of course, for the longer duration times the quality of the speech deteriorates. The highest quality

DIGITAL RECORD AND PLAYBACK MODULE

speech occurs at the shortest duration of recording and playback time, i.e. 5 seconds. If you have an oscilloscope or better still a frequency counter, this record and playback time can be determined by measuring the frequency of the signal at pin 19 of the UM5100 voice processor IC. The formula for working out the time is 8 divided by the frequency at pin 19, multiplied by the memory capacity in bytes, i.e. with 32k bytes of RAM and a frequency, at pin 19 of the UM5100 IC, of 19.21kHz, then the record and playback time is equal to (8/19.21kHz) x 32 x 1024 bytes = 13.65 seconds. To playback the speech recording, P10 will have to be taken momentarily to ground by connecting P10 to P9. Note that socket SK1 is only fitted when the optional EPROM programmer board is used.

Uses

The digital record and playback module has a variety of uses, including a burgler alarm in the home, a telephone answering system, in the car as an annunciator, in the office as an electronic message pad, and as a message system for the blind. Comments on other possible uses are invited from readers.

RECORD/PLAYBACK MODULE PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified)

R1,9,10,11,17,18, 28,29,31,32,35	10k	11	(M10K)
R2	33k	1	(M33K)
R3,12,15,16,26,27	47k	6	(M47K)
R4,5	1k	2	(M1K)
R6,8	12k	2	(M12K)
R7	270Ω	1	(M270R)
R23	3k3	1	(M3K3)
R13,33	220Ω	2	(M220R)
R14	220k	1	(M220K)
R20,21	100k	2	(M100K)
R19	4k7	1	(M4K7)
R22,25	27k	2	(M27K)
R34	100Ω	1	(M100R)
RV1	470k Hor Enclosed Preset	1	(UH08J)
RV2	4k7 Hor Enclosed Preset	1	(UH02C)

CAPACITORS

C1	100nF Poly Layer	1	(WW41U)
C2,15	10nF Poly Layer	2	(WW29G)
C3,9,16,18	47μF 16V Minelect	4	(YY37S)
C4	100μF 16V Minelect	1	(RA55K)
C5	470pF Ceramic	1	(WX64U)
C6	47nF Poly Layer	1	(WW37S)
C7,8	4n7F Poly Layer	2	(WW26D)
C10	33nF Poly Layer	1	(WW35Q)
C11	10μF 16V Minelect	1	(YY34M)
C12-14	1μF 63V Minelect	3	(YY31J)
C17	6n8F Poly Layer	1	(WW27E)

SEMICONDUCTORS

TR1,2	BC547	2	(QQ14Q)
D1-5	1N4148	5	(QL80B)
IC1,2	LF442CN	2	(QY30H)
IC3	UM5100	1	(UJ48C)
IC4	74HC133	1	(UB30H)
IC5	62256/43256 100ns	1	(UH40T)
RG1	μA78M05UC	1	(QL28F)

MISCELLANEOUS

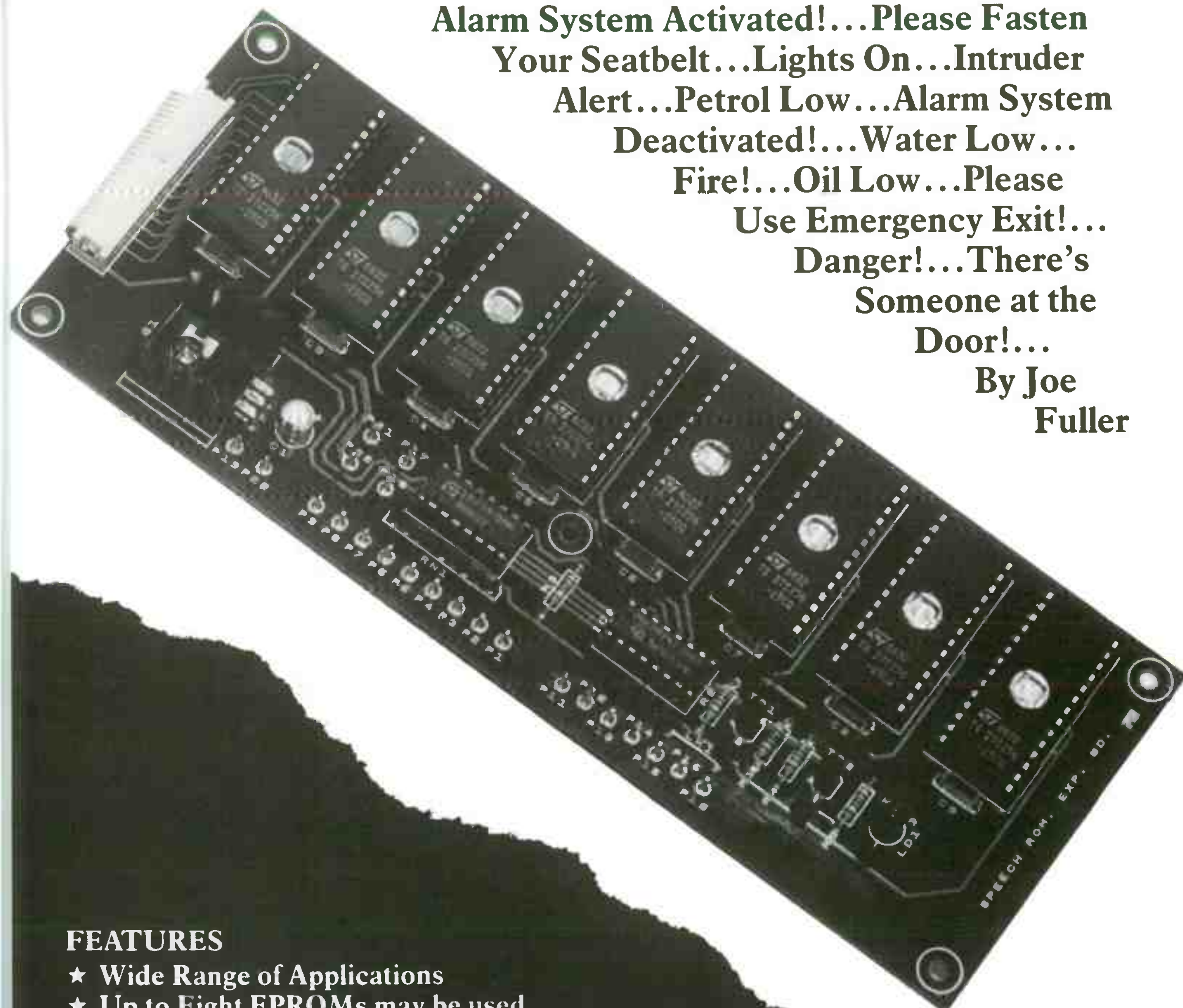
LD1	LED Red	1	(WL27E)
MC1	Submin Omni Insert	1	(FS43W)
	8-Pin DIL Socket	2	(BL17T)
	16-Pin DIL Socket	1	(BL19V)
	28-Pin DIL Socket	1	(BL21X)
	40-Pin DIL Socket	1	(HQ38R)
	Pin 2145	1 Pkt	(FL24B)
	Bolt M3 × 6mm	1 Pkt	(BF51F)
	Nut M3	1 Pkt	(JD61R)
	TC Wire 0·71mm 22swg	1 Reel	(BL14Q)
	PCB	1	(GD88V)
	Instruction Leaflet	1	(XU26D)
	Constructors' Guide	1	(XH79L)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.
The above items are available as a kit, which offers a saving over buying the parts separately.
Order As LM80B (Record/Playback Kit).
Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

ROM EXPANSION MODULE FOR DIGITAL SPEECH PLAYBACK MODULE

Alarm System Activated!...Please Fasten Your Seatbelt...Lights On...Intruder Alert...Petrol Low...Alarm System Deactivated!...Water Low... Fire!...Oil Low...Please Use Emergency Exit!... Danger!...There's Someone at the Door!...

By Joe Fuller



FEATURES

- ★ Wide Range of Applications
- ★ Up to Eight EPROMs may be used
- ★ Plugs into Playback Module
- ★ Octal or Binary EPROM Selection
- ★ Internal or External Address Latch
- ★ Status Lines & LED Indicator
- ★ Can be used with 8K 16K or 32K EPROMs

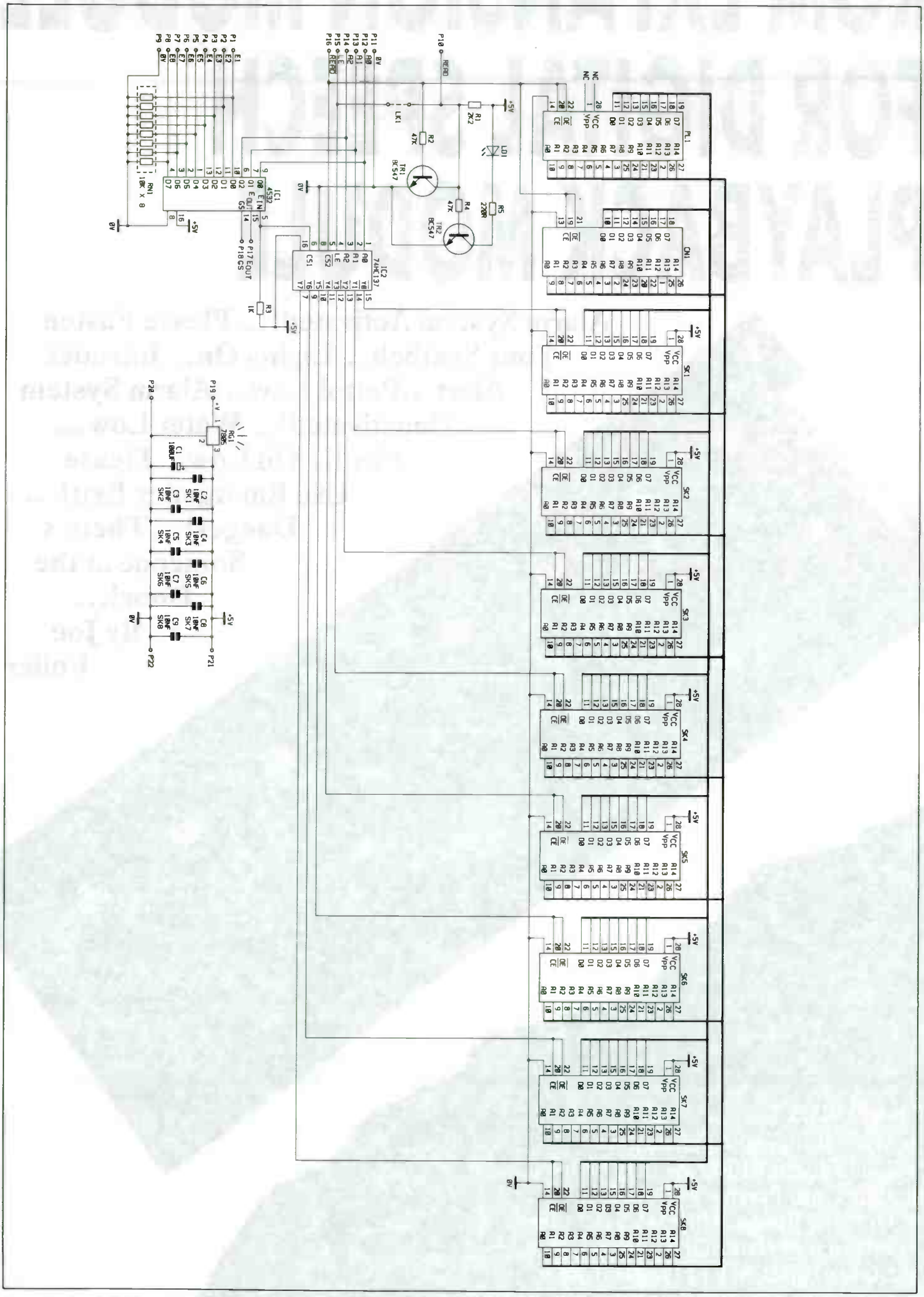


Figure 1. Circuit diagram of Speech ROM Expansion Module.

Introduction

In issues 30 and 31 of 'Electronics', constructional details were given for a Digital Record and Playback Module, EPROM Programmer Card and Playback Only Module. These modules allow the recording and playback of words, phrases and sentences using digital technology; speech can be permanently stored in EPROM for recall at any time. Due to the enormous success of this series of projects a further module has been developed to increase the versatility of the system still further. In many applications it may be required to playback more than one phrase, for example, in a home or factory security and alarm system, with ham radio for repeating call signs, an annunciator device or even your own version of that famous talking car from the TV series 'Knight Rider'! If you have missed any of the issues order them now.

Speech ROM Expansion Module

The Speech ROM Expansion Module is intended for use in a wide range of applications where selection of speech phrases is required, the speech is held in EPROMs which are plugged into the module. The expansion module itself plugs into the Playback Only Module, this does not require any modifications to the playback module. To avoid any possibility of overloading the playback module's on-board regulator a separate regulated 5V supply is provided on the expansion module. Up to eight EPROMs can be accommodated on the expansion module, although any number less than this is permissible. The EPROMs used must all be of the same memory capacity i.e. 8K, 16K or 32K and *not* a mixture, otherwise very odd things will happen!

Note that it is strongly advised that the EPROMs used are CMOS 'C' versions, i.e. 27C64, 27C128 and 27C256. This is to keep the supply current low and hence minimise power dissipation in RG1. If, however, it is required to use standard NMOS EPROMs (2764, 27128 and 27256) then RG1 should be mounted off-board, on an external heatsink of sufficient size to conduct away the heat produced. Alternatively, a separate regulated 5V supply may be used and RG1 omitted from the board. Power consumption of the EPROM expansion module with eight CMOS EPROMs fitted is approximately 7 to 10mA whilst in standby and approximately 22 to 25mA whilst being accessed by the playback module. To reduce current consumption during playback, TR2, R4, R5 and LD1 may be omitted if required. LD1 serves as a visual indication of READ status. Current consumption with eight NMOS EPROMs fitted (dependent on type) is approximately 320 to 330mA whilst in standby and approximately 400 to 410mA whilst being accessed by the playback module. Clearly CMOS EPROMs consume much less power than NMOS!

Depending on the capacity of the EPROMs used, the link options on the playback module must be set accordingly, this will be described later in the article. The phrases will of course need to be recorded in the first place, this is achieved using the Digital Record and Playback Module in conjunction with the EPROM Programmer Card. As there are so many possible applications it was decided to make the module as flexible as possible, to this end, there are a number of different options open to the constructor. Selection of the EPROM, 1 to 8 (SK 1 to 8 respectively), can be achieved in either of two ways, Binary or Octal. In Binary mode the EPROM can be selected by feeding the module with a 3 bit binary word with a value of 0 to 7, which will select EPROM 1 to 8 (0 = SK 1, 1 = SK 2, etc.). In Octal mode the EPROM can be selected by taking one of eight input lines high (logic 1), which will select EPROM 1 to 8 (1 = SK 1, 2 = SK 2, etc.), if two or more lines are taken high, the most significant one (highest) will have priority over the other lines. Since the playback module accesses the EPROM continuously whilst it is 'speaking' the EPROM selected should not change, otherwise speech will become garbled. To avoid this an address latch is used, in the Internal latch mode, whenever the 'play' input on the playback module is taken low and the module starts to speak, a control signal latches the EPROM address

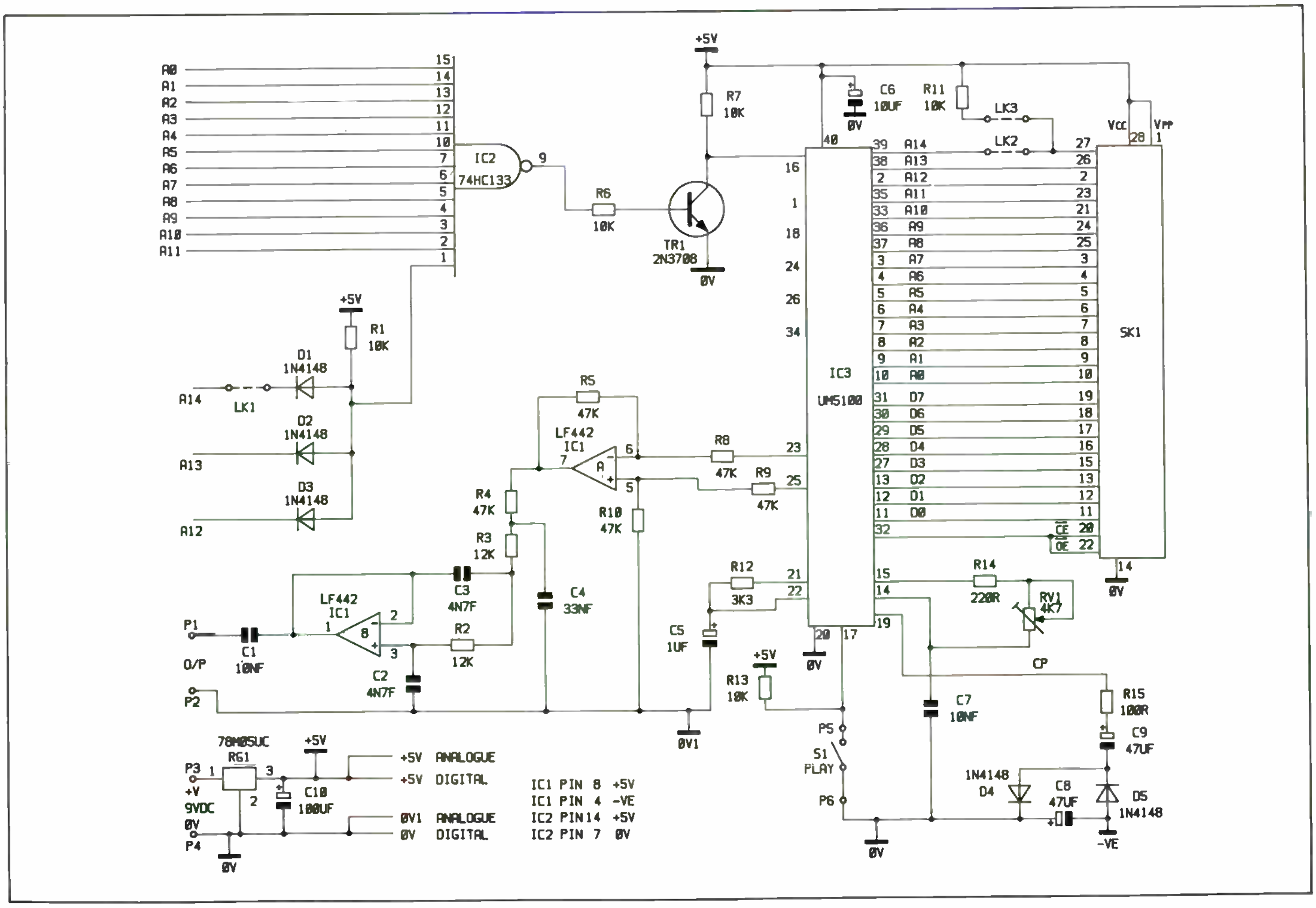


Figure 2. Circuit diagram of Playback Module.

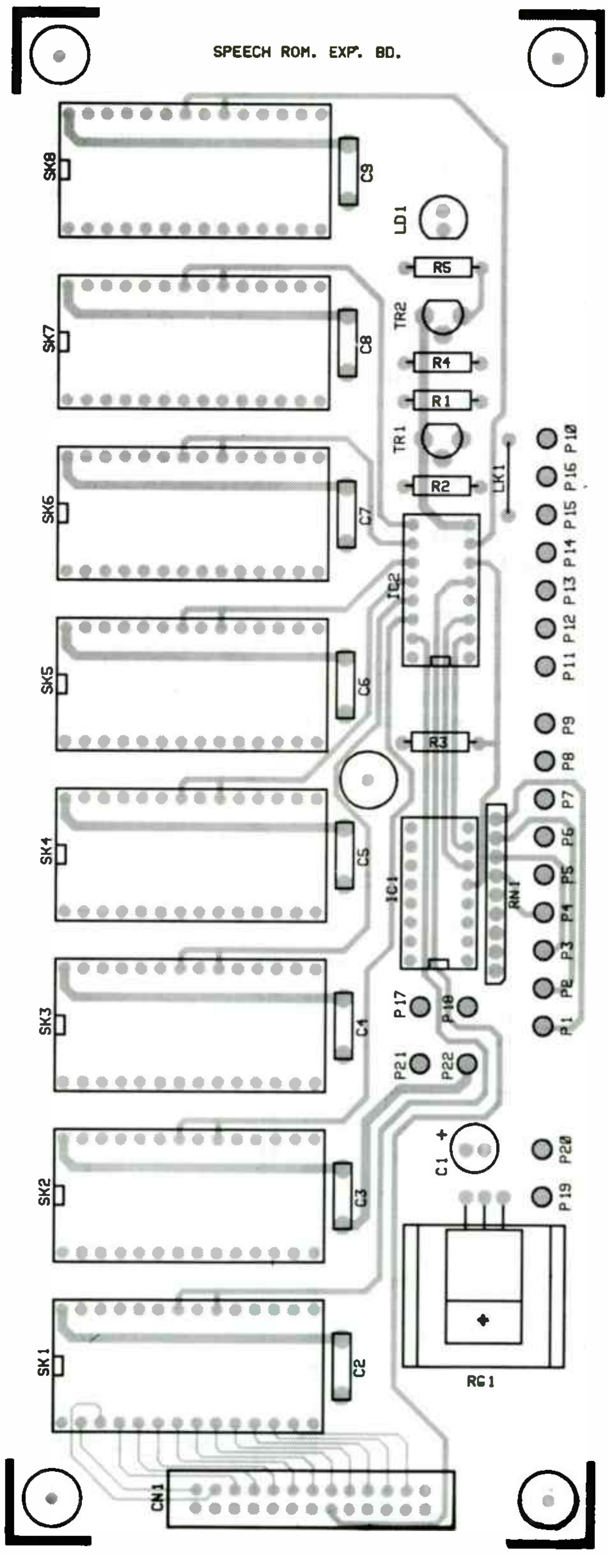


Figure 3. PCB layout.

and prevents it from changing during speech. If a new address is fed into the module it will be ignored until speech has finished. A secondary use of this is that the address need only be provided momentarily whilst the 'play' input is taken low. In External latch mode the address latch is under external control and for this reason the address should only be changed after speech has finished, to indicate whether speech has finished two status lines are provided, one active high and one active low. The READ line will be high during speech and the NOT READ will be low during speech, these lines, in conjunction with the LATCH and ADDRESS lines, may be used to facilitate control from a computer port. So as power consumption is kept as low as possible, the EPROMs are deselected when the playback module is not speaking. Connection to the playback module is via a 28 pin DIL IDC header plug, IDC cable and a transition header, this makes interconnection very simple. Note: Whilst the DIL header is 28 pin, the transition header and IDC cable are only 26 way, this is because 2 pins are not connected. For this reason please read carefully the construction details when assembling the cable to ensure correct location of the DIL header. (The speech ROM expansion kit includes a pre-assembled IDC cable form.)

Expansion Module Circuit

The circuit shown in Figure 1, at first glance seems quite complex, but in reality it is fairly simple. Connection to the playback module is via PL1, IDC cable and CN1. PL1 is a 28 pin DIL header plug, this plugs into SK 1 on the playback module, see Figure 2 for the circuit of the playback module. Pins 1 and 28 are connected to +5V and since the expansion module has its own localized +5V supply, no connection to these pins is made. This allows use of 26 way IDC cable and a 26 way IDC transition header (CN1). All the other pins are connected, these carry address and data information, A14 to A0 and D7 to D0 respectively, device control signals OE and CE, and last but not least the 0V line. These lines with the exception of the device control signals are 'bussed' to EPROM sockets SK1 to SK8, so the sockets are effectively wired in parallel. Only one EPROM is allowed to place information on the data bus at a time, this is achieved using the device control pins 22 and 20 (OE and CE) on SK1 to SK8. Pins 1 and 28 (V_{pp} and V_{cc}) are connected to the +5V line, and pin 14 (0V) to the 0V line. IC2, a 74HC137, is a 3 to 8 line decoder/demultiplexer and latch, this device is used to select the required EPROM. A 3 bit binary word is applied to pins 1, 2 and 3 (A0 to A2), and a low to high transition on pin 4 (LE) causes the binary address on A0 to A2 to be latched. The output from the latch is fed to the decoder/demultiplexer, where the binary input is decoded to a 1 of 8 octal output on pins 15, 14, 13, 12, 11, 10, 9 and 7 (Y0 to Y7), these outputs are fed to the OE and CE pins on SK1 to SK8. The outputs are active low and are under control of pins 5 and 6 (CS2 and CS1), when CS2 is low and CS1 is high the outputs are active, with any other conditions on CS2 and CS1 the outputs are inactive (logic 1). CS1 is pulled high via R3. In most cases the Internal latch mode will be used (LK1 fitted), when the 'play' line on the playback module is taken low, the NOT READ line from the UM5100 will go low, this signal is found on pins 22 and 20 (OE and CE) of PL1. The NOT READ signal is fed to P16 status output and the CS2 input on IC2. The CS2 input is used to deselect the EPROMs when they are not being accessed by the UM5100. NOT READ is also inverted by TR1 to provide the READ signal, which fed to IC2 LE input, where it is used to latch the EPROM address. READ is also fed to P10 status output and is used to switch TR2, which drives D1. D1 lights when the UM5100 is accessing the EPROMs. When the External latch mode is used (LK1 not fitted) IC2's address latch is operated by an external signal applied to P15 LE. Status signals are still available on P16 and P10. IC1, a 4532BE, is a priority encoder, this device converts a 1 of 8 octal input on pins 10, 11, 12, 13, 1, 2, 3 and 4 (D0 to D7) to a 3 bit binary word output pins 9, 7 and 6 (Q0, Q1 and Q2). The octal input to the module is via P1 to P8 (D0 to D7). If more than one input is high, the most significant code is generated, for example, if D1 and D3 were taken high, the output would be 011 (binary). The outputs Q0, Q1, Q2, EOut and GS are active if pin 5 (EI) is high. EI is pulled high via R3. If any of the inputs (D0 to D7) are high then pin 14 (GS) will go high, if all of the inputs (D0 to D7) are low then pin 15 (EOut) will go high. EOut and GS are routed to P17 and P18 for external use. The outputs Q0, Q1 and Q2 are fed to IC2's inputs A0, A1 and A2 to provide the EPROM address and also to P12 (A0), P13 (A1) and P14 (A2) for external use, these pins also double as binary inputs when IC1 is removed. The +5V supply is provided by RG1 a 5V 1A regulator, this device is mounted on a vaned heatsink to aid heat dissipation.

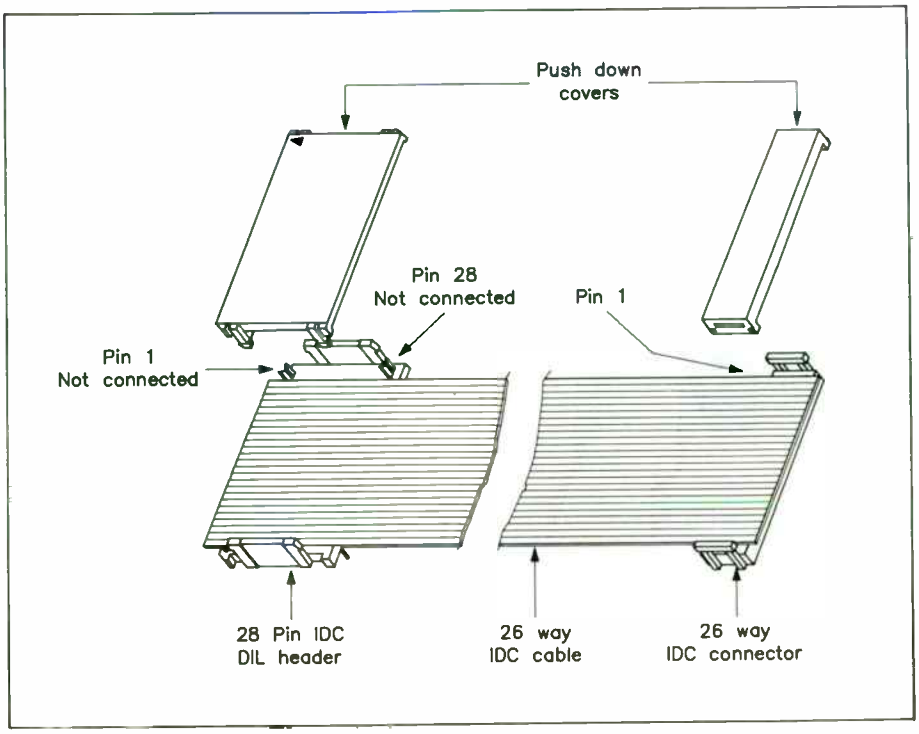


Figure 5. Assembly of IDC cable, DIL header and transition header.

Capacitors C1 to C9 provide supply rail decoupling, C2 to C9 are mounted adjacent to sockets SK 1 to SK 8. The +5V rail is available for external use on P21; care should be exercised so that the power dissipation in RG1 is not excessive.

Construction

Assembly of the module is very straightforward and should not present any difficulties. As the PCB is double-sided with plated through holes, removal of misplaced components is quite difficult so please double-check each component type, value and its polarity where appropriate, before soldering! The PCB has a printed legend to assist you in locating where each component goes, see Figure 3 and refer to the parts list.

The sequence in which the components are fitted is not critical, but the following order will probably be found to be the easiest. First insert the pins (22 off!) into the track side of the board, then solder them in. Identify and fit the resistors and the capacitors, note C1 is a polarised electrolytic and must be inserted with correct polarity. Next fit the IC sockets ensuring that the orientation indicator lines up with the corresponding mark on the PCB legend, but do not fit any ICs or EPROMs. Insert the LED, transistors and fit the regulator RG1 and heatsink, see Figure 4. Referring to Figure

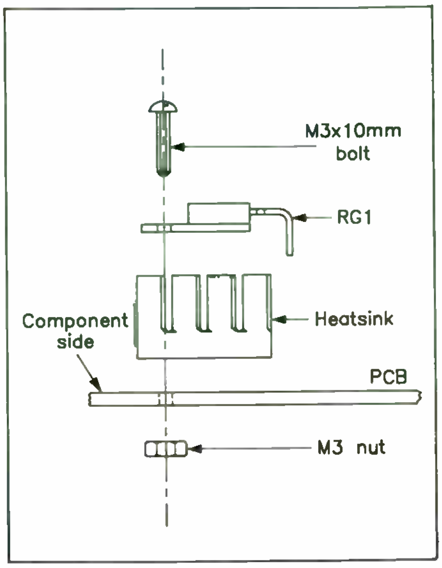


Figure 4. Assembly of regulator and heatsink.

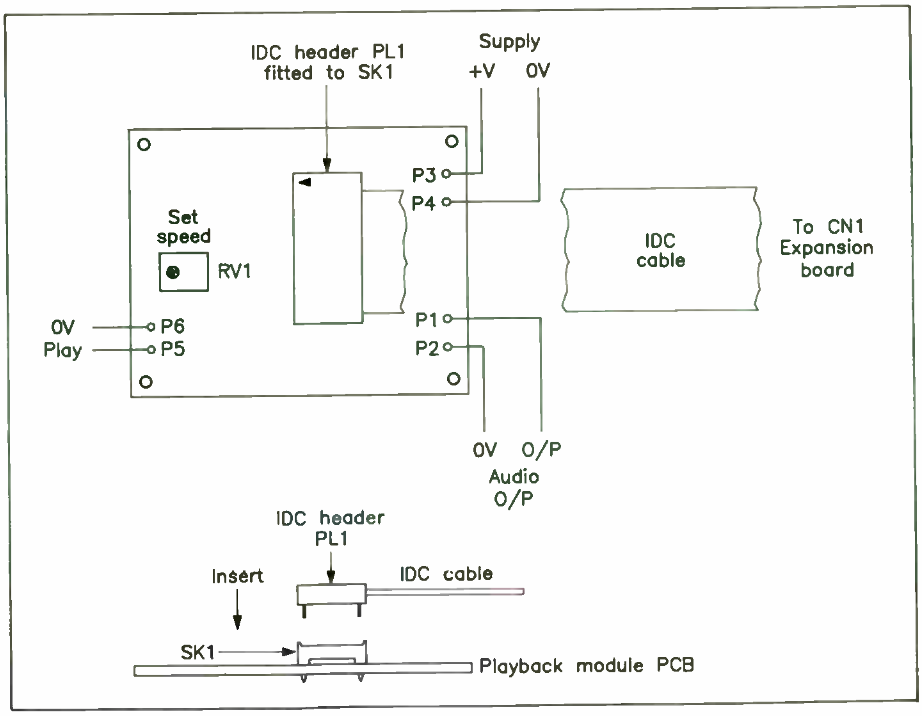
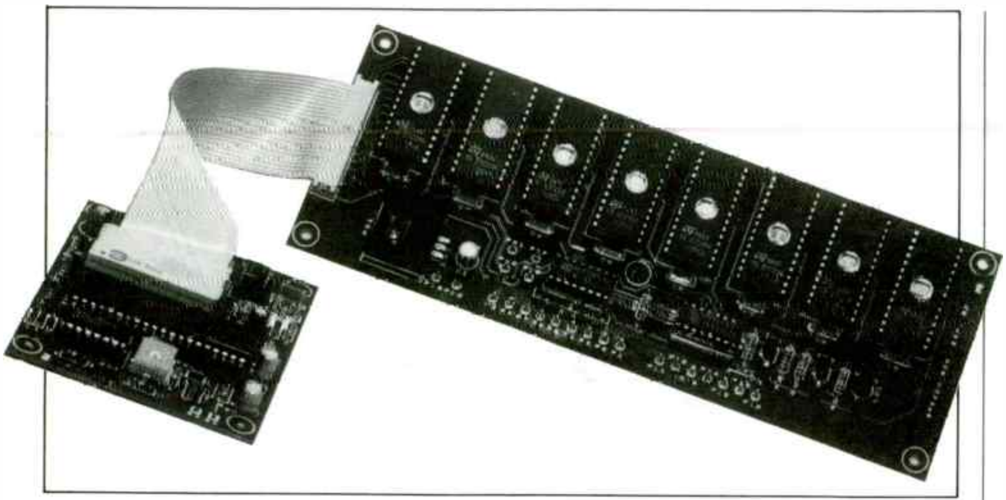


Figure 6. Connecting to Playback Module.



The ROM Expansion board connected to the Playback Module.

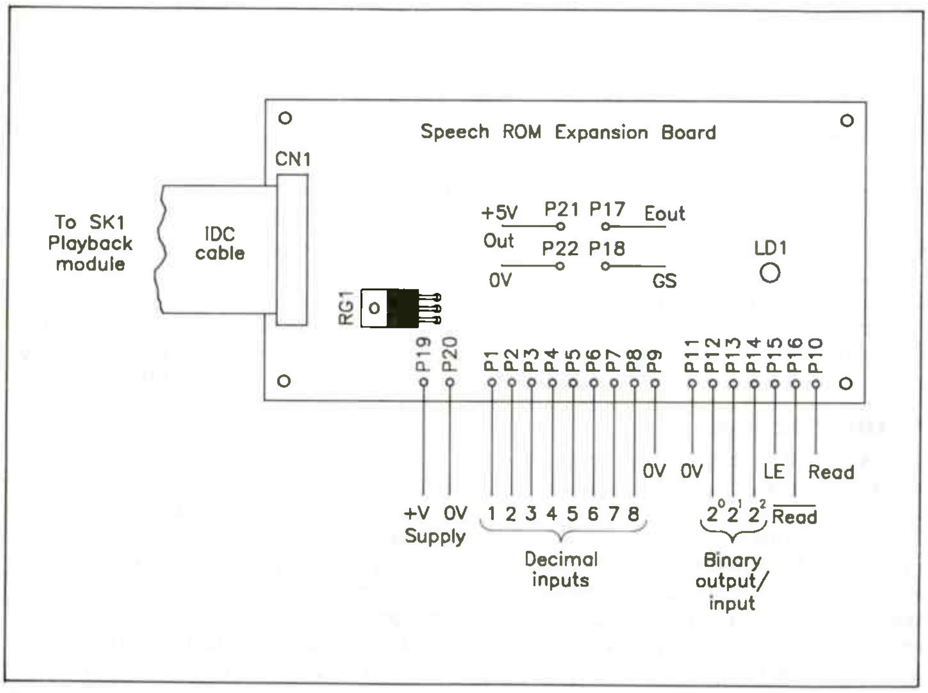


Figure 7. Connections to Speech ROM Expansion Module.

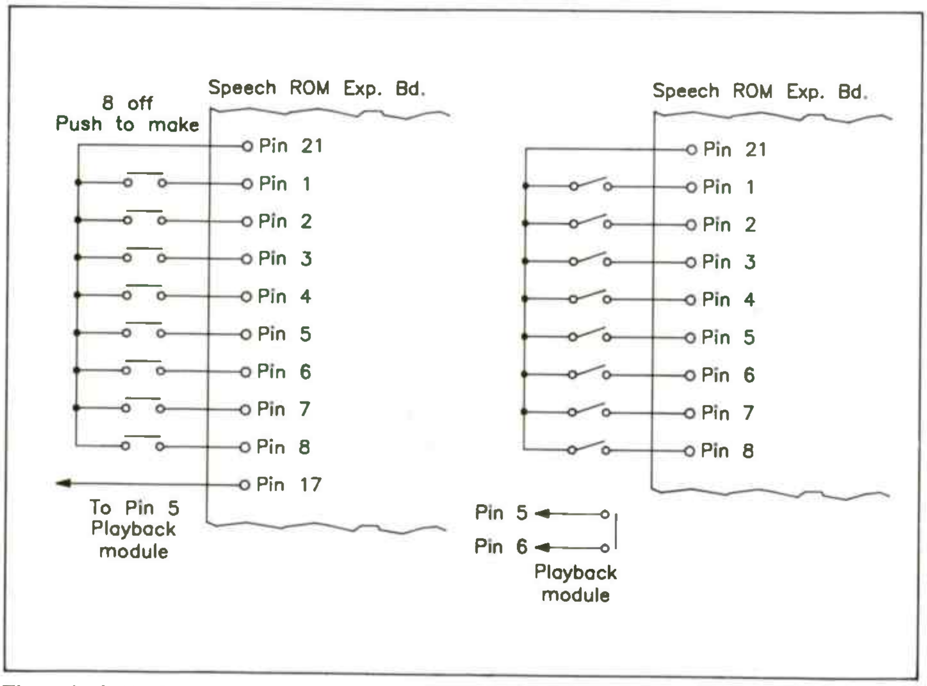


Figure 8a & 8b. Connecting switches to Speech ROM Expansion Module.

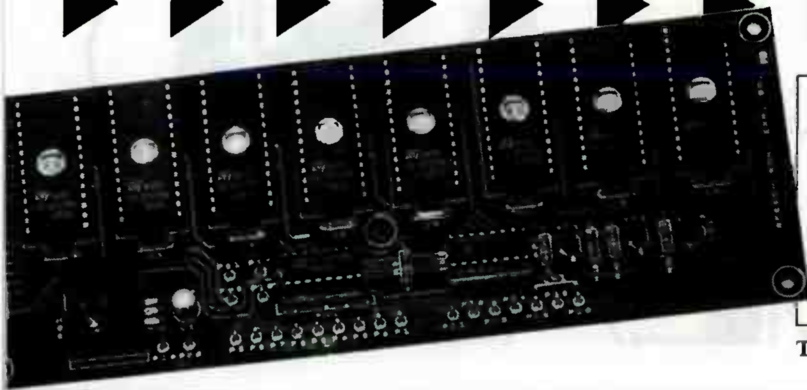
5, make up the IDC cable, ensuring correct location of the 28 pin DIL IDC header plug on the 26 way IDC cable. The PCB IDC transition header may now be soldered to the PCB. LK1 is either inserted or left out depending on whether internal (LK1 fitted) or external (LK1 not fitted) latch mode is required. Before proceeding any further, check over the board, paying special attention for splashes of solder across adjacent joints and incorrectly placed components. Check also that the component leads are properly trimmed.

Testing

The initial testing is to check that the +5V supply is functioning correctly and present on the supply pins of the ICs and sockets, this is done with the EPROM expansion module unplugged from the playback module and *without* any of the ICs or EPROMs plugged into the sockets! Connect a 7·5V to 12V DC supply to P19 (+V) and P20 (0V), and using a multimeter (analogue or digital) check there is +5V ±0·2V present on P21 (+5V out) with respect to 0V (e.g., P22). Check pin 16 of IC1 and IC2, pins 1 and 28 of SK1 to SK8, for +5V. Disconnect the supply and insert IC1, IC2. Insert some EPROMs programmed with speech into the vacant sockets, ensuring correct orientation and plug the IDC DIL header into SK1 on the playback board, see Figure 6. Set the EPROM capacity selection links on the playback board to suit the EPROMs used, see Table 1. Remember, the playback module, as well as the EPROM expansion module, requires a power supply to operate; the supply can be common to both modules however. Connect a suitable amplifier to the playback board. Apply power and you should be greeted by silence. Using a flying lead, e.g., miniature crocodile lead, pull one of the octal inputs (P1 to P8) high (+5V). Momentarily connect pins 5 and 6 on the playback module. D1 should light and the unit should utter speech from the selected EPROM. When speech has finished D1 should extinguish. Now select another EPROM using the octal input and initiate playback, again speech should be heard, but should be from the new EPROM selected. Figure 7 and Table 2 show the module pin functions. Figures 8a and 8b show two ways of connecting switches to select EPROMs in octal. Figure 8a uses push to make switches and the connection from P17 automatically initiates playback, whilst Figure 8b uses SPST switches and a separate push to make switch to initiate playback.

Using the Speech System

The speech system has many different applications and the modules have been made as flexible as possible to cater for a wide range of configurations. If you have used the speech system in an imaginative or ingenious way, please send in your ideas on how you have used the modules so we can print suggested applications.



EPROM	LK1	LK2	LK3	D2
8K	UNMADE	UNMADE	MADE	REMOVED
16K	UNMADE	UNMADE	MADE	INSERTED
32K	MADE	MADE	UNMADE	INSERTED

Table 1. Selecting links on Playback Module.

Octal mode – IC1 fitted

Pin	Name	Description
P1	D0	Octal address in LSD
P2	D1	Octal address in
P3	D2	Octal address in
P4	D3	Octal address in
P5	D4	Octal address in
P6	D5	Octal address in
P7	D6	Octal address in
P8	D7	Octal address in MSD
P9	0V	Zero volt linc
P10	READ	Status output, high during speech
P11	0V	Zero volt line
P12	A0	Binary address out LSB
P13	A1	Binary address out
P14	A2	Binary address out MSB
P15	LE	Status output, high during speech (LK1 fitted)
		Latch enable input (LK1 not fitted)
P16	NOT READ	Status output, low during speech
P17	EOut	Octal status, high on all inputs low
P18	GS	Octal status, high on any input high
P19	+V	Positive DC supply input
P20	0V	Zero volt line
P21	+5V	+5V DC output
P22	0V	Zero volt line

Binary mode – IC1 not fitted

Pin	Name	Description
P1	D0	not used
P2	D1	not used
P3	D2	not used
P4	D3	not used
P5	D4	not used
P6	D5	not used
P7	D6	not used
P8	D7	not used
P9	0V	Zero volt line
P10	READ	Status output, high during speech
P11	0V	Zero volt line
P12	A0	Binary address in LSB
P13	A1	Binary address in
P14	A2	Binary address in MSB
P15	LE	Status output high during speech (LK1 fitted)
		Latch enable input (LK1 not fitted)
P16	NOT READ	Status output, low during speech
P17	EOut	not used
P18	GS	not used
P19	+V	Positive DC supply input
P20	0V	Zero volt line
P21	+5V	+5V DC output
P22	0V	Zero volt line

Table 2. Pin functions of Speech ROM Expansion Module.

SPEECH ROM EXPANSION MODULE PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified)			
R1	2k2	1	(M2K2)
R2,4	47k	2	(M47K)
R3	1k	1	(M1K)
R5	220Ω	1	(M220R)
RN1	10k SIL Resistor	1	(RA30H)
CAPACITORS			
C1	100µF 10V Minelect	1	(RK50E)
C2-9	10nF Poly Layer	8	(WW29G)
SEMICONDUCTORS			
TR1,2	BC547	2	(QQ14Q)
RG1	µA7805UC	1	(QL31J)
IC1	4532BE	1	(QW89W)
IC2	74HC137	1	(UB31J)
MISCELLANEOUS			
D1	LED Red	1	(WL27E)
PL1/CN1	Speech ROM Cable	1	(JP04E)
SK1,8	28-Pin DIL Socket	8	(BL21X)
	16-Pin DIL Socket	2	(BL19V)
	Slotted Heatsink	1	(FL58N)
	Nut M3	1 Pkt	(BF58N)
	Bolt M3 × 10mm	1 Pkt	(HY30H)
	Pin 2145	1 Pkt	(FL24B)
	PCB	1	(GE23A)
	Instruction Leaflet	1	(XU28F)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	27C64 EPROM	As Req.	(UH43W)
	27C128 EPROM	As Req.	(UH95D)
	27C256 EPROM	If Req.	(UH44X)
	28-Way IDC DIL Header Plug	If Req.	(JP40T)
	26-Way IDC DIL Header Plug	If Req.	(FA49D)
	26-Way IDC Cable	If Req.	(XR75S)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.
The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.
Order As LP05F (Speech ROM Expansion Kit).
Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

AUDIO AND MODULATOR

Design by Chris Barlow

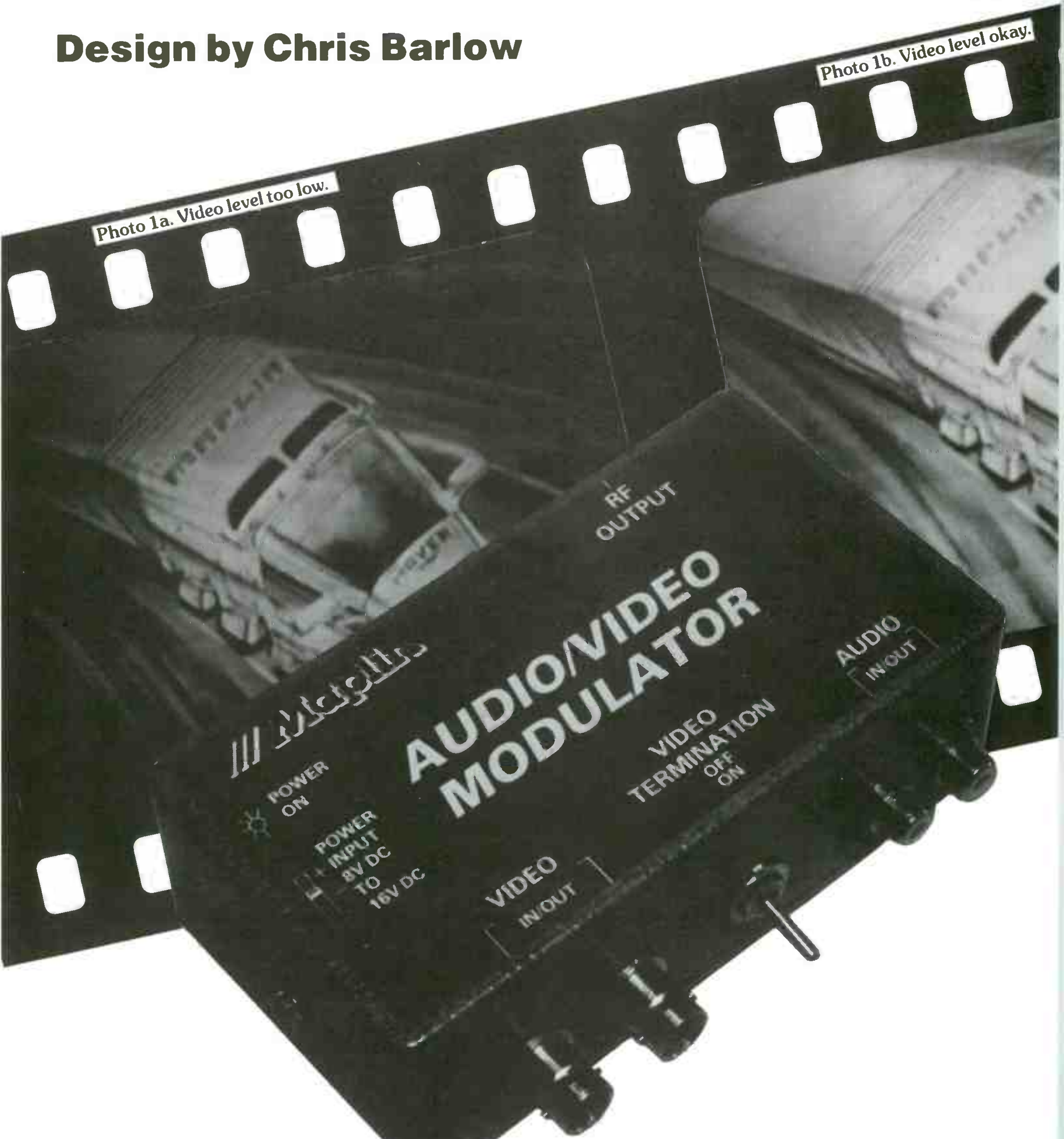


Photo 1a. Video level too low.

Photo 1b. Video level okay.

VIDEO

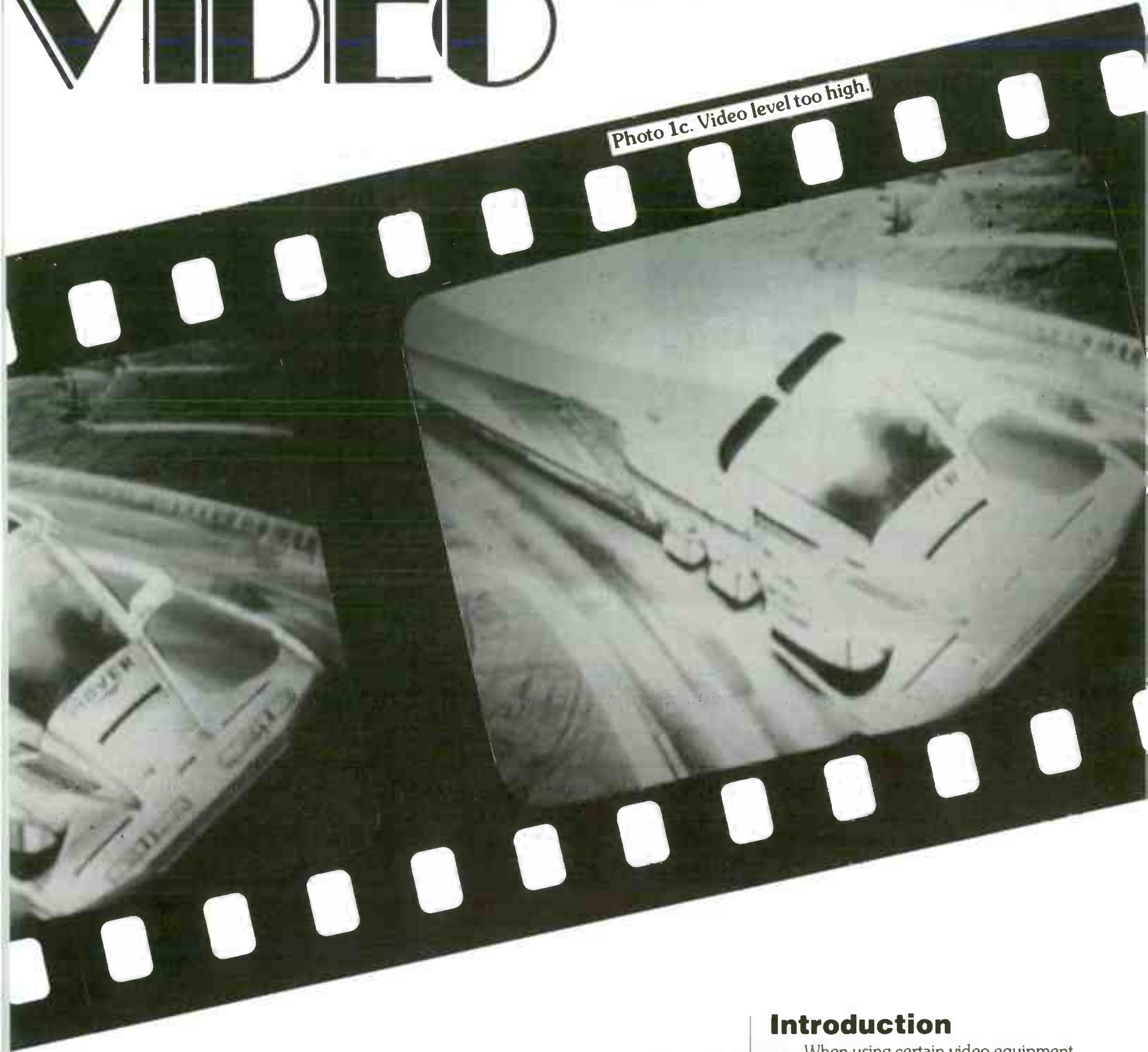


Photo 1c. Video level too high.

★ Easy construction
★ Minimum of tools and test gear required
★ No alignment equipment needed
★ Colour or black and white
★ 6MHz sound sub-carrier
★ Good modulation linearity

Introduction

When using certain video equipment an ordinary television receiver can not be connected directly to the video signal. Some TV sets do have a direct video input socket (SCART), but most domestic sets only have an aerial input for reception of UHF TV stations. To solve this problem, a UHF modulator is required, which superimposes the video and audio signals on to a high frequency carrier wave. To simplify the construction and alignment of the project a pre-tuned modulator module (UM1286) has been employed in the design. From the composite video and mono sound signals the modulator produces an RF output suitable for connection to the aerial input of a UK UHF TV set. The carrier frequency is chosen to fall on an unused television channel (channel 36). The UM1286 has an integral 6MHz RF oscillator for the sound sub-carrier signal and a wide linear video bandwidth to cater for the chrominance sub-carrier. A few of the many possible

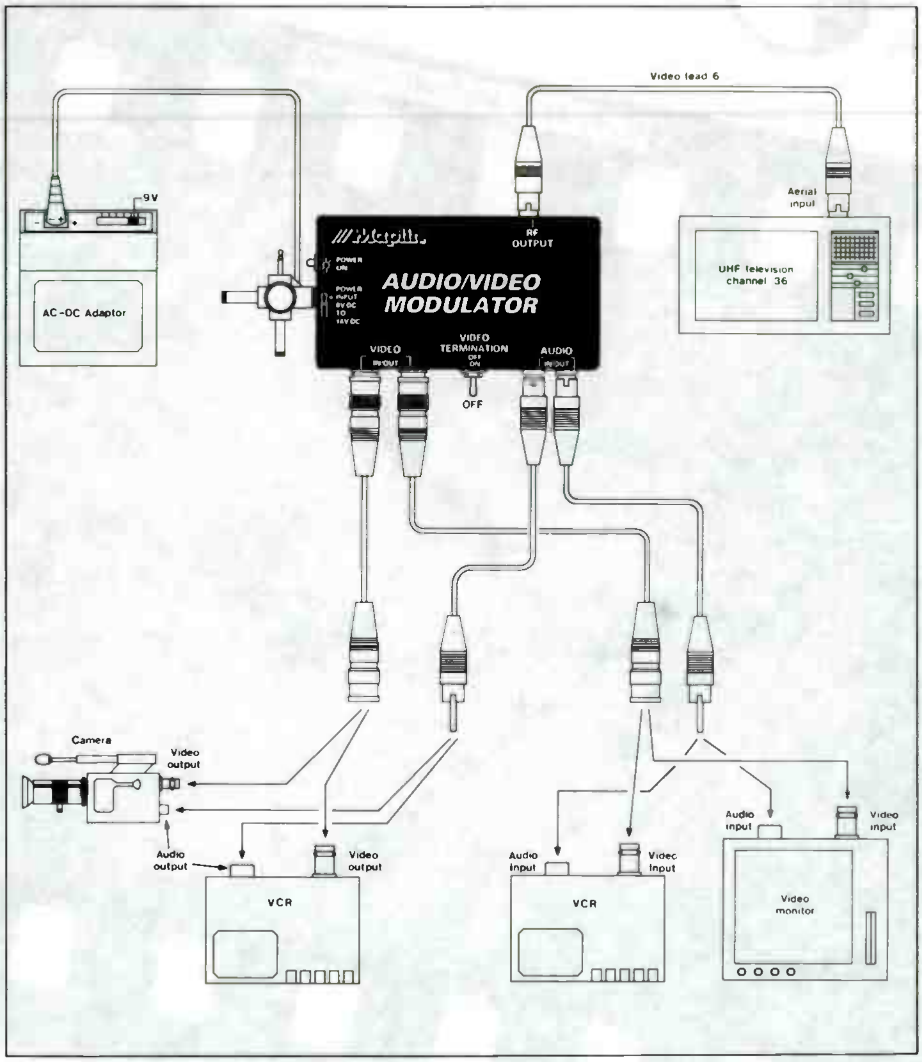


Figure 1a. Audio and video connections.

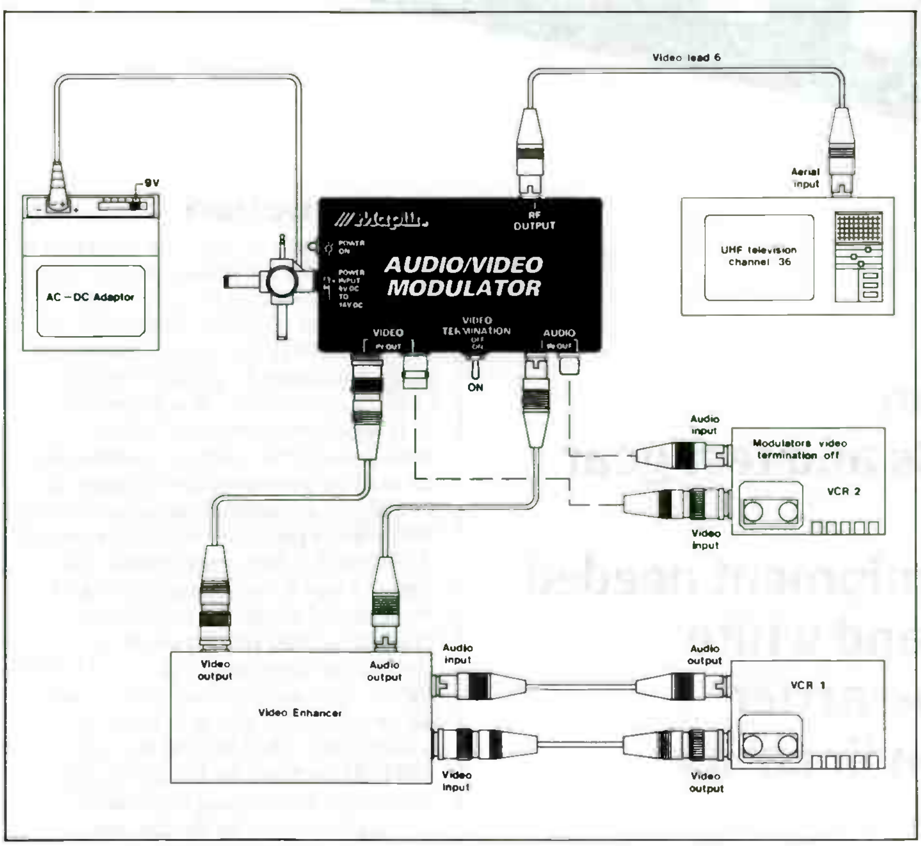


Figure 1b. Video enhancer connections.

configurations of audio/video equipment connections to and from the finished boxed unit are shown in Figures 1a, 1b, and 1c.

Circuit Description

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

The DC power is applied to PL2, positive voltage to pin 1 and negative to pin 4 (0V). This supply must be within the range of 8V to 16V and have the correct polarity, otherwise damage will occur to the semiconductors and polarised components. To prevent this, a diode D2 has to have the positive supply voltage applied to its anode before the DC power can pass to the rest of the circuit.

Resistor R9 and capacitor C6 provide the main decoupling for the +V supply rail, with C5 giving additional high frequency decoupling. Further supply decoupling is provided by R15, C15 and C16 in the +V1 audio supply rail. The red LED power on indicator, LD1 has its anode connected to pin 2 of PL2 and its cathode to pin 3. Resistor R8 provides current limiting to the LED thus restricting the drain to only a few mA.

The circuit incorporates two voltage regulators; an 11V Zener diode, ZD1 and a +5V regulator IC, RG1. ZD1 in conjunction with R7 limits the voltage supply to the video buffer, this rail is decoupled by C3 and C4. The +5V output from RG1 is used to power the UM1286, MD1 (pin C) and also provides a voltage reference to RV2 the sound sub-carrier oscillator fine tuning control. Capacitors C7 and C8 are used to decouple this +5V supply, with C9 decoupling the fine tune input of MD1 (pin A).

For the audio circuit to function correctly a half +V1 supply reference is necessary. This is provided by half of IC1. The voltage reference applied to the input of this op-amp is derived from the two resistors R13 and R14 which form a potential divider. The op-amp is merely used as a zero gain buffer to provide a low impedance half supply, its input being decoupled by C12, C13 and its output by C14. The other half of this IC is used as an audio amplifier which drives the sound input of the UM1286, MD1 (pin B). Resistors R11 and R12 are used to set the gain of the op-amp with RV3 adjusting the level of audio signal applied to its input. The incoming signal from pin 6 of PL1 is AC coupled to this control via C10 with the input being loaded by R10 and C11. Pin 5 of PL1 is used as the ground or screen connection for the audio line.

The video signal is applied to pin 1 of PL1 and its ground is connected to pin 2. The input impedance of the video amp is approximately one million ohms (1MΩ). However, this input can be reduced to 75Ω by operating switch S1 on pins 3 and 4 of PL1. When the switch is closed a 75Ω resistor, R1 is placed across the video input, this is known as a termination load.

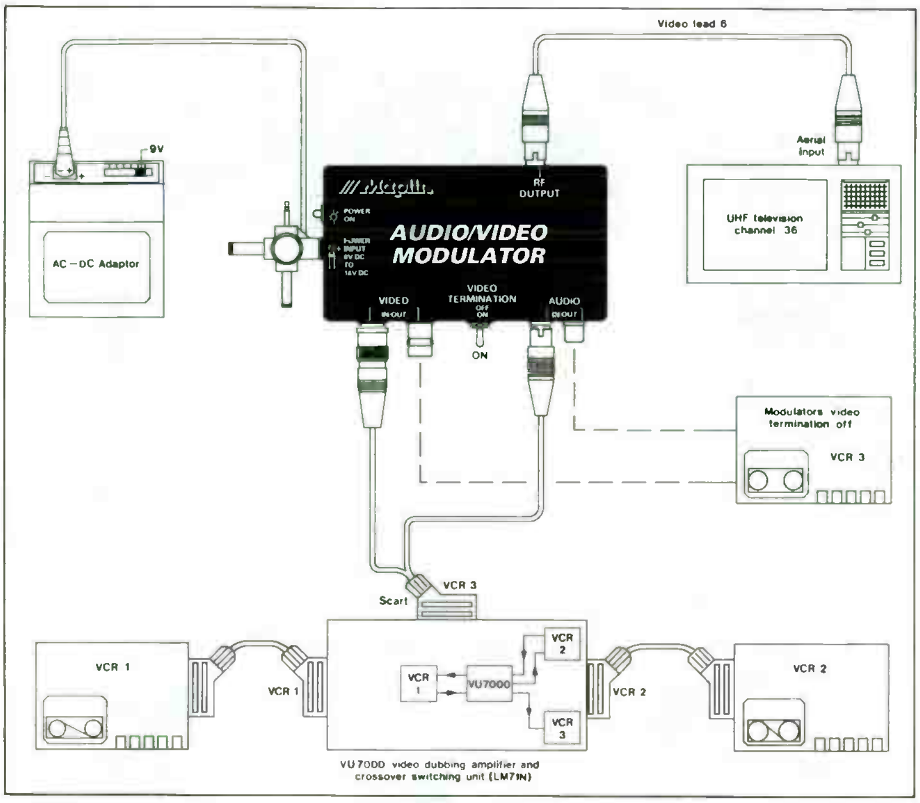


Figure 1c. VU7000 connections.

The video signals are AC coupled via C1 in to the gate of the Field Effect Transistor (FET) TR1, with diode D1 and resistor R2 used to maintain the correct bias level. TR1 and TR2 form a broad band buffer amplifier, with its gain set by the value of the negative feedback resistor R5. Resistor R4 is used as the source load for TR1 and the preset RV1 as the collector output load in TR2. The DC bias for TR2 is derived from R3, TR1 and a small amount of frequency compensation is provided by C2 and R6.

The video output from the amplifier is tapped off by the wiper of RV1 and is fed to the video input pin (D) of the UM1286 modulator MD1. Inside MD1 the audio signal is converted into a 6MHz FM modulated subcarrier. It is then mixed with the video signal and fed to the AM modulator where the UHF carrier is combined to produce the final modulated RF output.

PCB Assembly

The PCB is a single-sided fibreglass type, chosen for maximum reliability and stability. However, removal of a misplaced component is quite difficult so please double-check each component type, value

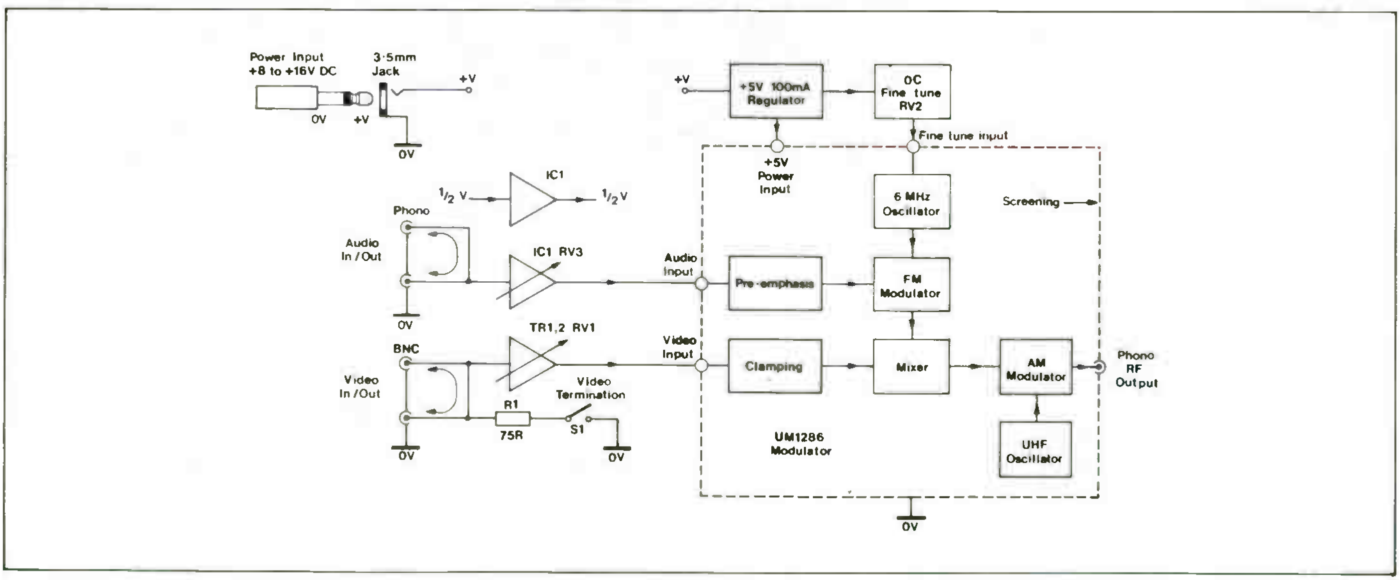


Figure 2. Block diagram.

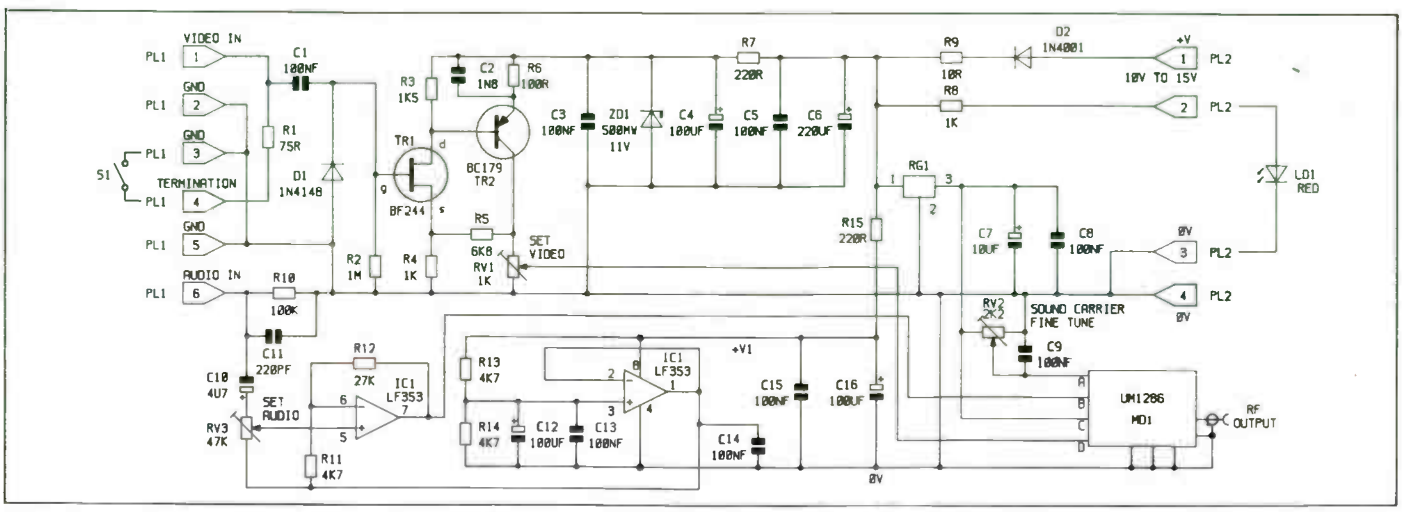


Figure 3. Circuit diagram.

and its polarity where appropriate, before soldering! The PCB has a printed legend to assist you in correctly positioning each item, see Figure 4.

The sequence in which the components are fitted is not critical. However, the following instructions will be of use in making these tasks as straightforward as possible. It is usually easier to start with the smaller components, such as the resistors. Next mount the ceramic and electrolytic capacitors. The polarity for the electrolytic capacitors is shown by a plus sign (+) matching that on the PCB legend. However, on some capacitors the polarity is designated by a negative symbol (−). in which case the lead nearest this symbol goes away from the positive sign on the legend. All the diodes have a band at one end. Be sure to position them according to the legend, where the appropriate markings are shown. Next install the two transistors and the voltage regulator, matching each case to its outline on the legend. When fitting the eight pin IC socket ensure that you match the notch with the block on the board. Install IC1 making certain that all the pins go into the socket and the pin one marker is at the notched end. Next install the three preset resistors RV1, 2, 3 and set them all to their halfway positions. When fitting the 'Minicon' connectors ensure that the locking tags are facing inwards, see Photo 2. Using component lead off-cuts fit the wire links at the two positions marked LK on the PCB. Finally, mount the UM1286 modulator MD1, making certain that all four wire connections are in their correct positions (A, B, C and D). To secure MD1 to the PCB simply twist the four fixing tags through 90 degrees, and using a fair amount of solder, heat into place.

This completes the assembly of the PCB and you should now check your work very carefully making sure that all the solder joints are sound. It is also VERY IMPORTANT that the solder side of the circuit board does not have any trimmed component leads standing proud of the soldered track, as this may result in a short circuit when the unit is fitted into its metal die-cast box. Further information on soldering and assembly techniques can be found in the 'Constructors' Guide' included in the kit. Photo 3 shows the completed PCB in clear detail.

Wiring

If you purchase the hardware kit (Order Code LM79L) from Maplin it should contain a one metre length of hook-up wire. Once the PCB assembly has been fitted inside its die-cast box it becomes difficult to fault find on, for this reason it is advisable to make temporary connections to the PCB and chassis sockets, see Figure 5. At this stage the wires can be longer than required as they are cut to size during the final assembly. The starting point of each wire is taken from a terminal in the 'Minicon' connector PL1 or PL2. The terminals must be crimped then soldered to each wire before

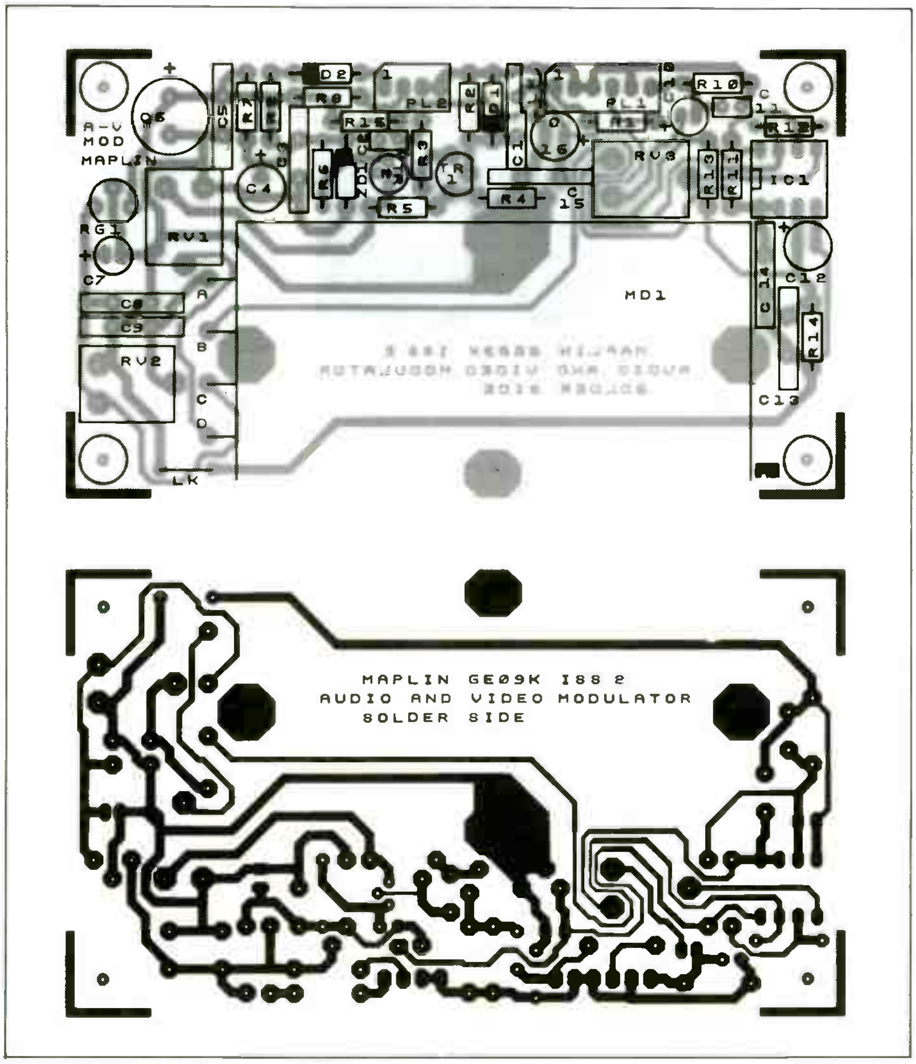


Figure 4. Track and layout of the PCB.

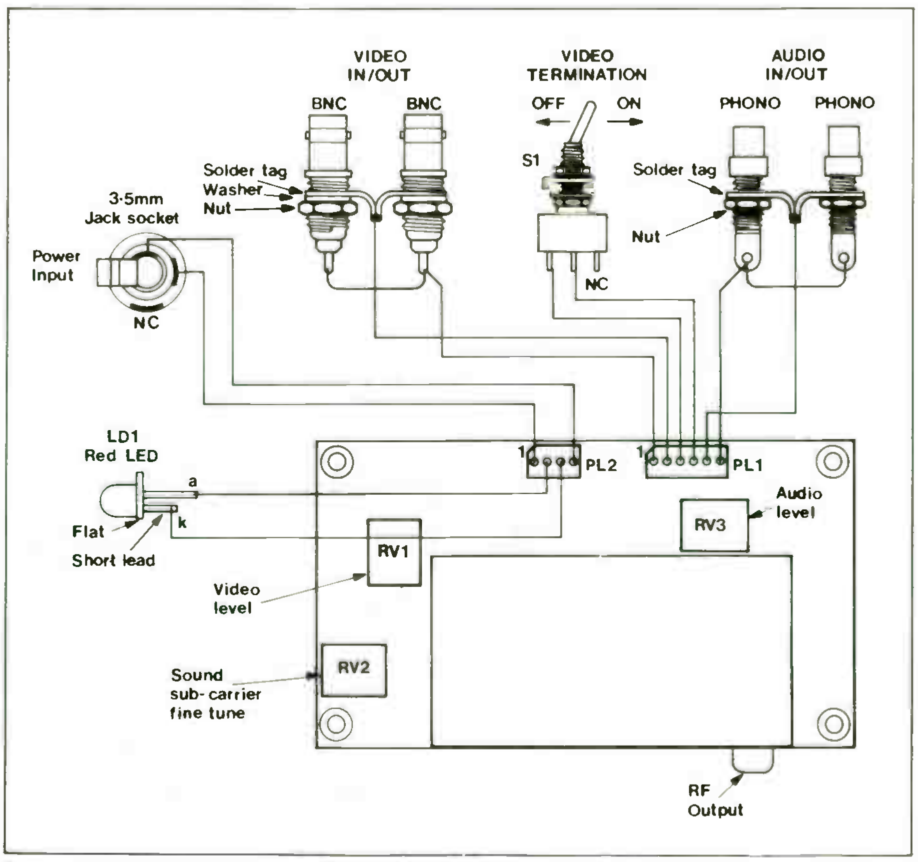


Figure 5. Wiring.

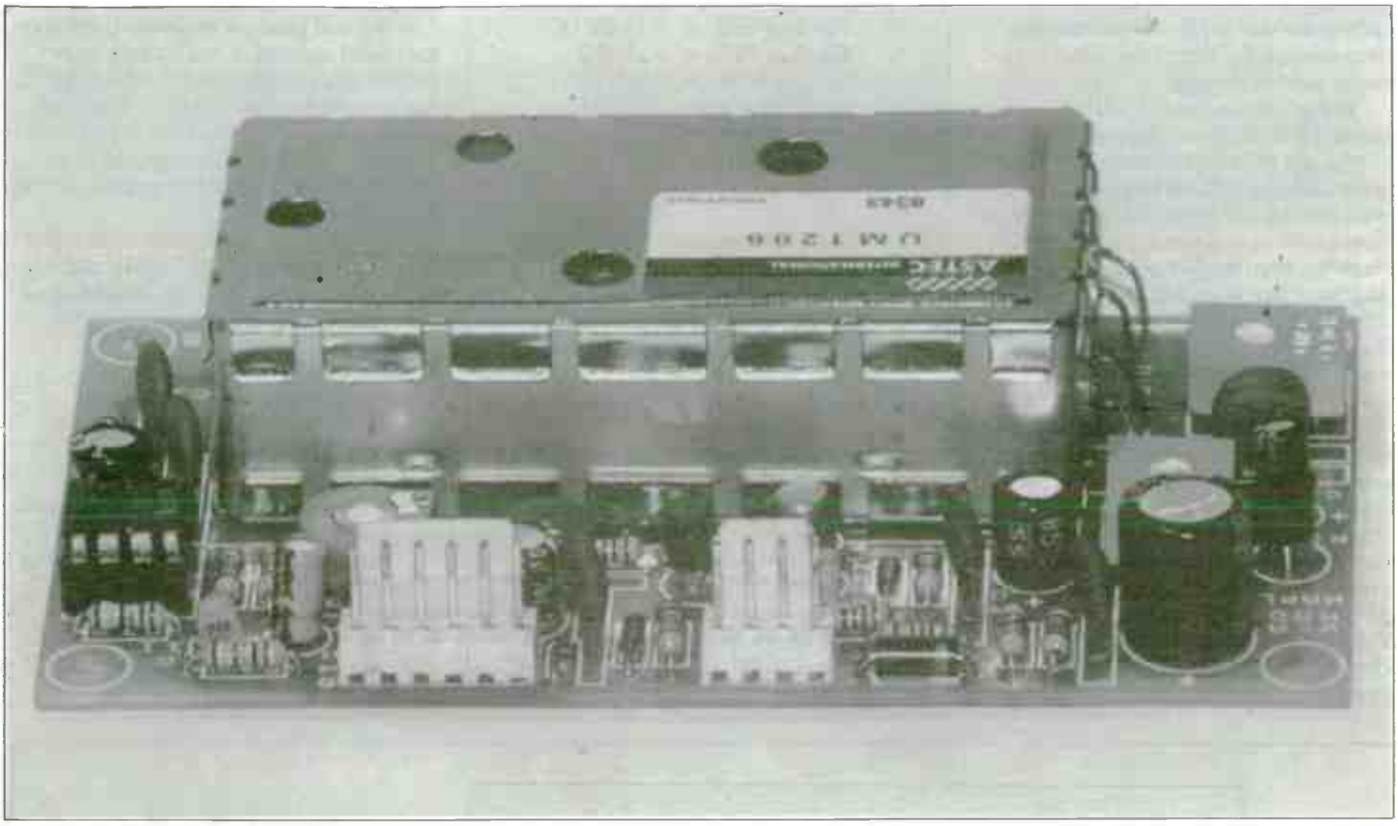


Photo 2. Minicon connectors facing inwards.

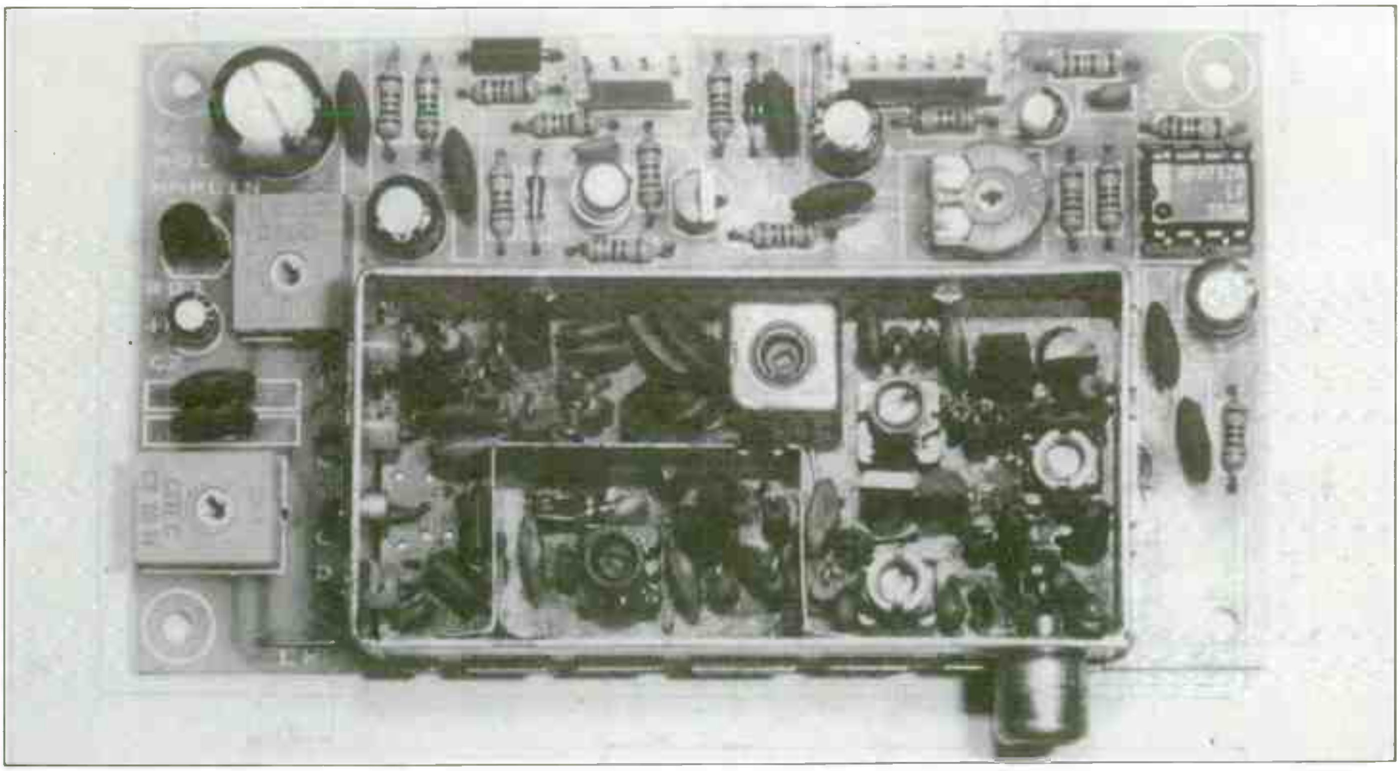


Photo 3. Completed PCB assembly (with modulator lid removed).

it is inserted into the 'Minicon' housing, a locking tag on the terminal will ensure that it stays securely in place.

Testing

All the tests can be made with a minimum of equipment. You will need a multimeter, a UHF TV set and an audio/video source. To power the unit you will require a +8V to +16V DC supply, the unregulated AC adaptor type XX09K set to its +9V output is adequate. The readings were taken on the prototype using a digital multimeter and some of the readings obtained may vary slightly depending on the type of meter you use.

Carefully lay out the PCB assembly on a non-conductive surface, such as a piece of dry paper or plastic. Position the chassis mounting components so they are clear of the circuit board and make sure the wires are as shown in Figure 5. The DC input jack socket is a type commonly used on Japanese radio equipment, where the centre pin is the positive connection and the negative contact is the threaded body. The first test is to measure the resistance at this socket. With your multimeter set to read ohms, connect its red positive test lead to the terminal with the wire going to pin 1 of PL2 and connect the black negative lead to the other terminal. You should get a reading of approximately 1·8kΩ and when the test leads are reversed, a much higher reading in excess of 20MΩ should be present. These readings are due to D2, the component which protects the rest of the circuit from reverse polarity damage.

In the following tests it will be assumed that the power supply used is the unregulated AC adaptor set to its +9V output. Select a suitable range on your meter that will accommodate a 300mA DC current reading and place it in the positive power line from the jack socket. Connect the 3·5mm jack plug of the mains adaptor to the power input, then plug the adaptor into the AC mains supply. The power indicator LD1 should light up, with a current reading of approximately 40mA being observed. Unplug the adaptor from the mains, then remove the test meter and reconnect the positive line to the jack socket.

Now set your multimeter to read DC volts. All voltages are positive with respect to ground, so connect your negative lead to a convenient ground point on the unit. When the modulator is powered up, voltages present on the PCB should approximately match the following:

Pin 1 of PL2	=	+14·5V DC
Pin 2 of PL2	=	+2V DC
Pin C of MD1	=	+5V DC
Pin 8 of IC1	=	+12V DC
Pin 1 of IC1	=	+6V DC
Cathode of ZD1	=	+11V DC

This completes the DC testing of the audio and video modulator, now remove your multimeter from the unit.

Next connect a phono to coax lead (Order Code FV90X) from the RF output of the modulator to the aerial input of a UHF television, see Figure 1a. Using a spare channel selector tune to approximately 36, where you should find a blank screen and a silent sound track. Connect an audio/video signal to the in/out of the modulator, if no other video connection is made to the unit then the termination switch must be on, see Figure 5. To set the audio level, adjust RV3 until the sound level is the same as an off air transmission (BBC, ITV, CH4). Next set the video level so that peak whites don't flare out and produce excessive buzzing on the sound channel. If this buzzing sound persists you can try tuning it out using RV2 the sound subcarrier fine tune. The final setting of the video level is up to you. However, the colour photographs in 1a, 1b and 1c should provide a guide in setting it up correctly.

DO NOT make any attempt to adjust the presets inside the UM1286 modulator, as these are factory set using sophisticated test equipment.

Final Assembly

The unit is designed to fit into a die-cast metal box type M5004 (Order Code LH71N) which is also available ready drilled (Order Code YT64U). However, if you wish to make up your own box, drilling details are given in Figure 6.

Next remove all the chassis mounting components from the wiring and disconnect the 'Minicon' plugs from the PCB assembly. The PCB will only just fit inside the box so the following procedure must be used:

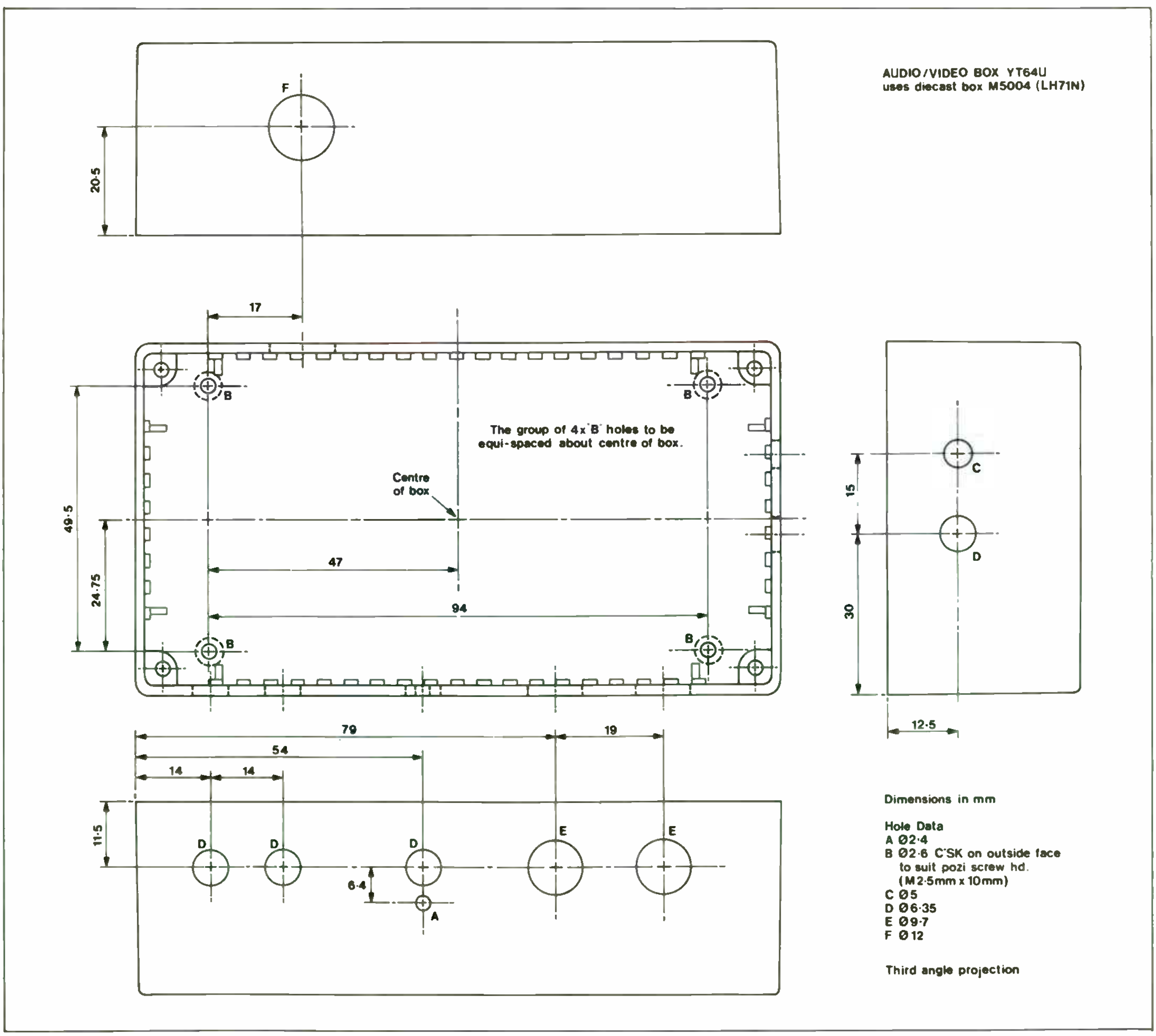


Figure 6. Box drilling.

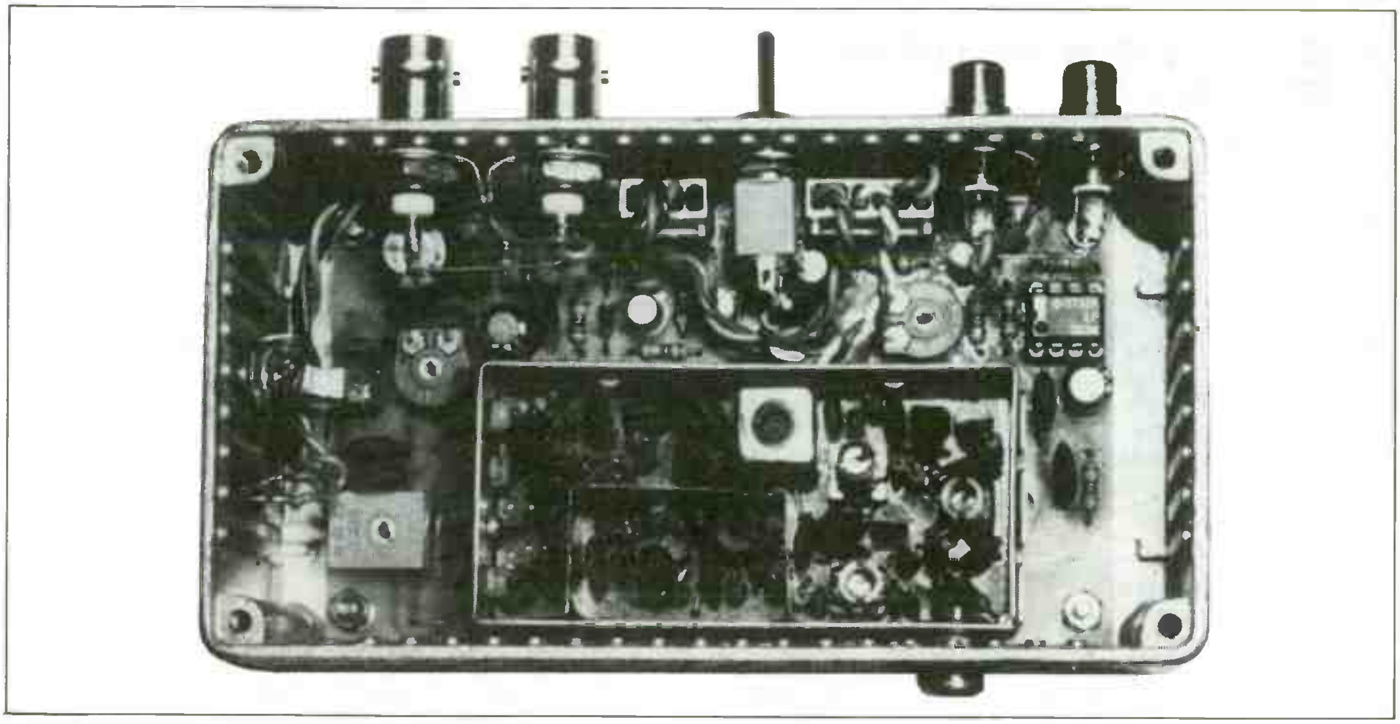


Photo 4. Completed module (with screening lid removed).

1. Remove the metal screening lid of the UM1286 modulator, see Photo 4.
2. Position the PCB at an angle to the box so that the phono socket of the modulator passes through the hole in the side.
3. Carefully position the PCB and secure in to place using the M2·5 hardware.
4. Refit the screening of the modulator.

Install the BNC and phono sockets ensuring that all are tightly secured with their solder tags facing each other, see Figure 5. Next fit the video termination switch, S1 and the power input jack socket. The red LED power indicator LD1 is held in position by a 3mm panel mounting clip which is simply pushed in to place.

This completes the assembly of the unit. Now refit the 'Minicon' plugs and rewire the chassis mounted components, see Figure 5. Before fitting the custom made stick-on top panel (Order Code JL74R) test out the unit to ensure that all is well. Finally fit the lid of the box using the screws provided and stick on the four small rubber feet. The unit is now ready for use.

Using the Modulator

The audio/video modulator has been designed to be tolerant to varying supply voltages and differing interconnecting lead lengths. The following information should assist you in setting up your system.

AC-DC adaptor model XX09K.
Minimum voltage setting = 6V.
Normal voltage setting = 9V.
Maximum voltage setting = 12V.
Rev change = Plus sign (+) on DC output plug to + on adaptor.

Phono to Coax lead length.
Minimum length = As short as you like.
Normal length = 1·2 metres (video lead 6).
Maximum length = 10 metres (good quality low-loss co-axial cable).

Phono audio lead length.
Minimum length = As short as you like.
Normal length = 1·5 metres (video lead 4) or 1·2 metres (plugpak 279).
Maximum length = 4 metres (good quality low noise cable).

BNC video lead length.
Minimum length = As short as you like.
Normal length = 1·5 to 1·8 metres (video lead 1, 3, or 5).
Maximum length = 4 metres (good quality low-loss cable).

Unterminated video input to modulator.
Video termination switch = ON
(see Figures 1b and 1c).

Terminated video input to/from modulator.
Video termination switch = OFF
(see Figure 1a).

HARDWARE PARTS LIST

MISCELLANEOUS

Modulator Box	1	(YT64U)
Stick-on Feet Small	1	(FE32K)
Front Panel	1	(JL74R)
LED Clip 3mm	1	(YY39N)
Pozi Screw M2·5 × 10mm	4	(JC68Y)
Nut M2·5	4	(JD62S)
Shakeproof Washer M2·5	4	(BF45Y)
Jack Socket 3·5mm	1	(HF82D)
Chassis Phono Socket	2	(YW06G)
BNC Round Skt 50Ω	2	(HH18U)
Hook-Up Wire Blue	1 Pkt	(BL01B)

The above items are available as a kit, which offers a saving over buying the parts separately.
Order As LM79L (Aud/Vid Mod Hard Kit).
Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

Specification of Prototype

Power Supply Voltage:	8V to 16V DC
Supply Current at 8V:	26mA
12V:	32mA
16V:	48mA
Audio Input Level:	1V Peak to Peak
Audio Input Impedance:	30kΩ
Video Input Level:	1V Peak to Peak
Video Input Impedance:	1MΩ (No Termination) 75Ω (Terminated)
RF TV Output:	Channel 36 (591.5MHz)
Sound Sub-Carrier:	6MHz
Video Bandwidth:	8MHz
Output Socket:	Phono

AUDIO/VIDEO MODULATOR PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified)

R1	75Ω	1	(M75R)
R2	1M	1	(M1M)
R3	1k5	1	(M1K5)
R4,8	1k	2	(M1K)
R5	6k8	1	(M6K8)
R6	100Ω	1	(M100R)
R7,15	220Ω	2	(M220R)
R9	10Ω	1	(M10R)
R10	100k	1	(M100K)
R11,13,14	4k7	3	(M4K7)
R12	27k	1	(M27K)
RV1	1k Hor Enclosed Preset	1	(UH00A)
RV2	2k2 Hor Enclosed Preset	1	(UH01B)
RV3	47k Hor Enclosed Preset	1	(UH05F)

CAPACITORS

C1,3,5,8,9,13,14,15	100nF 16V Minidisc	8	(YR75S)
C2	1n8F Ceramic	1	(WX71N)
C4,12,16	100μF 16V Minelect	3	(RA55K)
C6	220μF 16V PC Electrolytic	1	(FF13P)
C7	10μF 16V Minelect	1	(YY34M)
C10	4μ7F 35V Minelect	1	(YY33L)
C11	220pF Ceramic	1	(WX60Q)

SEMICONDUCTORS

D1	1N4148	1	(QL80B)
D2	1N4001	1	(QL73Q)
ZD1	BZY88C11/BZX55C11	1	(QH15R)
LD1	Miniature LED Red	1	(WL32K)
RG1	μA78L05AWC	1	(QL26D)
TR1	BF244A	1	(QF16S)
TR2	BC179	1	(QB54J)
IC1	LF353	1	(WQ31J)

MISCELLANEOUS

MD1	UM1286 Modulator	1	(BK66W)
PL1	6-Way Latch Plug	1	(YW12N)
PL2	4-Way Latch Plug	1	(YW11M)
S1	Sub-Min Toggle A	1	(FH00A)
	6-Way Latch Housing	1	(BH65V)
	4-Way Latch Housing	1	(HB58N)
	Latch Terminal	1 Pkt	(YW25C)
	8-Pin DIL Socket	1	(BL17T)
	PCB	1	(GE09K)
	Instruction Leaflet	1	(XU27E)
	Constructors' Guide	1	(XH79L)

OPTIONAL (Not in Kit)

	AC Adaptor Unreg. 300mA	1	(XX09K)
	Preset Trimmer	1	(BR49D)
	Video Lead 6	1	(FV90X)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As LM78K (Audio/Video Modulator Kit).

Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

Bob's MINI-CIRCUITS

Accented Metronome

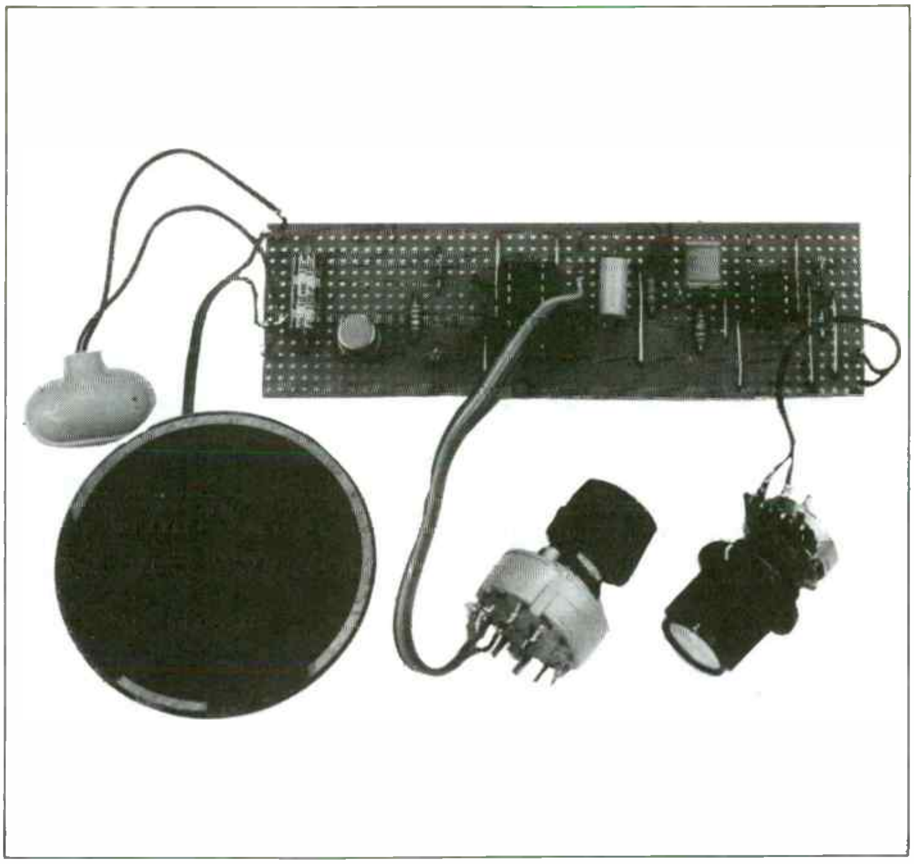
The conventional pendulum type metronome now seems to be something of a dying breed, it has been superseded by electronic devices that generate the regular train of 'click' sounds. Some electronic instruments now have a built-in metronome, and it is quite easy to produce a simple stand-alone unit for use with instruments that lack this facility. The design featured here has a frequency range of approximately 0·5 to 5 Hertz, or about 30 to 300 beats per minute in other words. Some mechanical metronomes have the ability to emphasise every 'ninth' beat, usually by ringing a bell on the accentuated beats. This unit has a similar feature, but it produces a low-pitched 'thud' sound on the accented beats instead of the usual 'click' sound. Every second, third, or fourth beat can be stressed, or this feature can be switched out altogether if desired. The unit can easily be modified to accentuate anything from every second beat to every ninth beat if required.

A low-frequency oscillator generates the procession of 'click' sounds, and this oscillator is a simple 555 astable type based on IC1. RV1 is the frequency (beat rate) control. R2 has been made very low in value so that the output signal from IC1 is a series of very brief pulses. This gives the required high-pitched 'click' sound. The loudspeaker is driven from the output via an emitter follower buffer stage (TR2). IC1 provides short negative output pulses, but what we require here is positive pulses. This is nothing to do with the sound produced, which is the required 'clicks' in either case. It is a matter of ensuring that the current to the loudspeaker is switched off most of the time, and that it is only driven during the brief output pulses. This gives a low current consumption, whereas the alternative of having the loudspeaker activated for most of the time would give a massive current consumption. TR1 acts as a simple inverter to provide the output stages with pulses of the correct polarity.

The accentuation is obtained by feeding the output pulses from IC1 to a divide by 'N' circuit. This is based on IC2 which is a decade counter and one-of-ten decoder. It is made to divide by two, three, or four by feeding the appropriate one-of-ten output to the reset input. The required division rate is set using S1. If no accentuation is required, S1 is set to the '0' position. The reset input is then connected to the '0' output, which holds the counter permanently in the reset state. When the accentuation is active the output pulses from output '0' are shaped by C3, D1, and D2 and mixed with the output pulses from IC1. Their longer pulse duration gives them a lower pitch than the ordinary output pulses, and they are also reproduced at a slightly higher volume level which helps to make them stand out still further.

The current consumption of the circuit is about 9 milliamps, which is mainly the current drawn by IC1. A small (PP3 size) battery is adequate as the power source, but if the unit is likely to receive a great deal of use, a higher capacity type would give lower running costs.

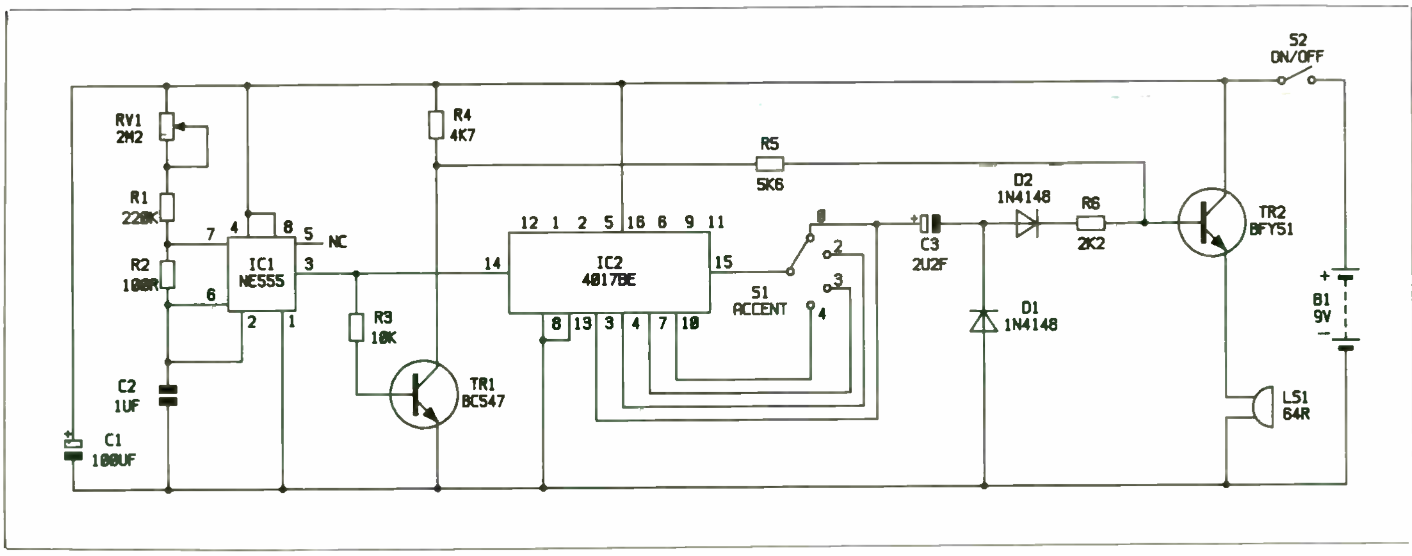
Construction of the unit does not provide any major difficulties, but bear in mind that IC2 is a CMOS device, and that it consequently requires the standard antistatic handling precautions to be observed. RV1 should be fitted with a



Accented Metronome.

IC2 Pin Number	Division Rate
4	2
7	3
10	4
1	5
5	6
6	7
9	8
11	9

Table 1. Division rates.



Accented Metronome Circuit.

large control knob so that it can be equipped with a calibrated scale of reasonable accuracy. Finding the calibration points is a matter of counting the number of beats in a given period of time in order to determine the beat rate, plus a certain amount of trial and error in order to get RV1 precisely set to the desired calibration rates.

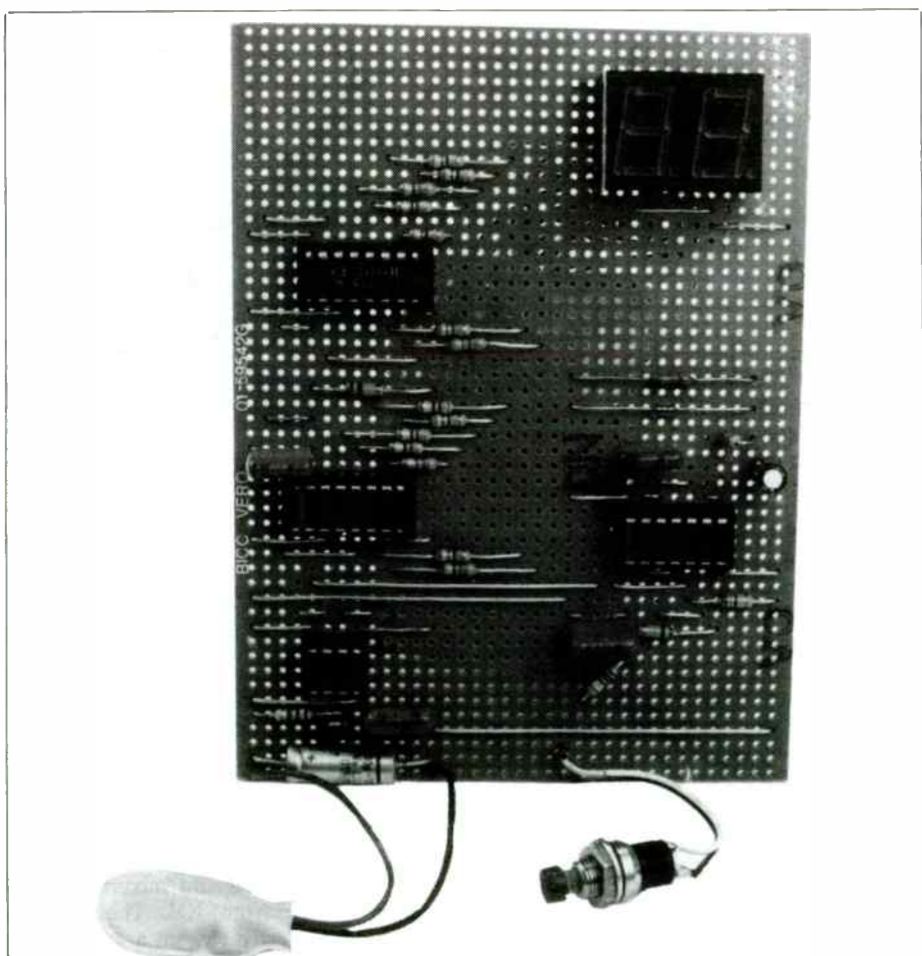
As pointed out previously, you can obtain accentuation on any beat from every second one to every ninth beat. It is just a matter of using a switch having the required number of ways and using the appropriate outputs of IC2. Table 1 shows which output pins provide which division rates. Whether you consider such rates as seven and nine worthwhile is your own decision!

Reaction Tester

This reaction testing game gives a digital readout of reaction time on an arbitrary scale of 0 to 99. In fact, the readings are approximately in hundredths of a second, but unless you have access to a suitable frequency meter it is not possible to set up the unit for really accurate results. Even without calibration, the unit provides an accurate relative indication of reaction times so that a number of people can see how their reactions rate against one another. The unit will also show how alcohol, fatigue, etc. affect ones reaction times. The influence of such factors on ones reaction time is probably greater than most people would imagine.

The unit is very easy to use. At switch-on the display registers '00', and after a delay of about ten seconds it starts to increment. The contestant must then operate a push-button switch as soon as possible so as to halt the count and display the reaction score. In order to use the unit again, it is just a matter of switching it off momentarily, in order to reset the circuit, so that a new sequence is started from the beginning.

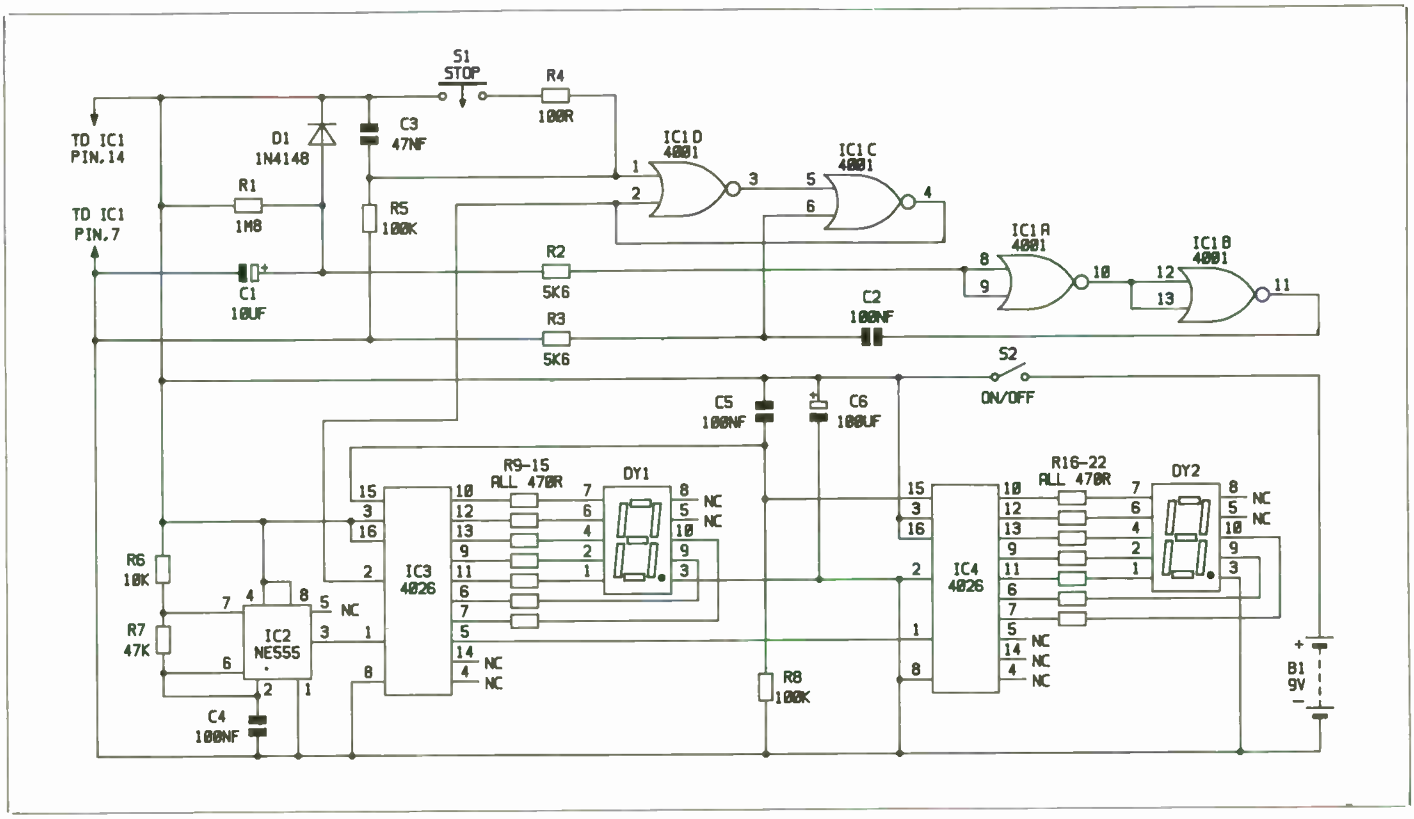
IC2 is a standard 555 astable which acts as the clock generator. If access to a frequency meter capable of accurate results at audio frequencies is available, R7 can be replaced by a 47k preset in series with a 22k fixed resistor. The preset is then adjusted for 100Hz at the output (pin 3), of IC2. The counter circuit is a simple two digit type based on CMOS 4026BE decade counter/seven segment decoders (IC3 and IC4). These drive seven-segment common-cathode displays via current limiting resistors R9 to R22. The circuit is only suitable for use with common-cathode displays (not common-anode types), and for good results reasonably



Reaction Tester.

efficient types should be used (any reasonably modern type should be suitable). The pin numbering shown in the circuit is correct for standard 0.5 and 0.56 inch devices, which are probably the best types to use. C5 and R8 provide a reset pulse for the counter at switch-on.

The count can be enabled/disabled via an internal gate of IC3, using a control signal on pin 2 of this device. This must be taken high initially in order to prevent the counter from operating. It must be taken low after the ten second delay period, and then high again when the push-button



Reaction Tester Circuit.

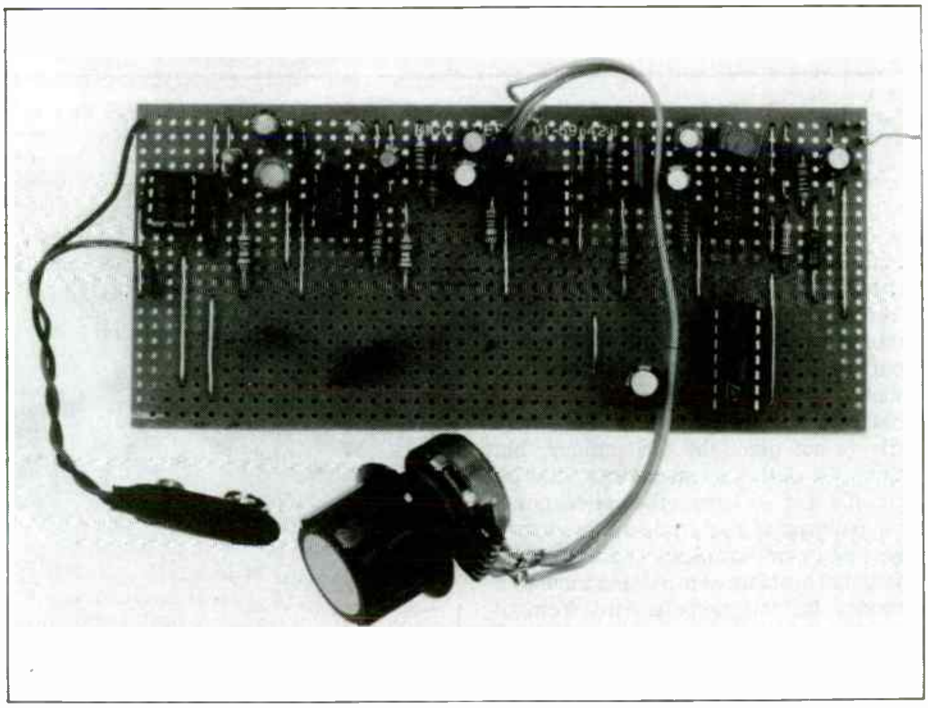
switch is operated. The control signal is generated by a simple set/reset flip-flop formed from two gates of IC1. C3 and R5 provide the flip-flop with a reset pulse at switch-on. The other two gates of IC1, plus a simple C – R circuit, form a simple timer. This provides a positive set pulse to the flip-flop at the end of the delay period, and the count commences. The delay time can be altered by changing the value of R1, and the delay is proportional to the value of this component. Operating S1 resets the flip-flop and 'freezes' the count. D1 ensures that timing capacitor C1 is largely discharged when the unit is switched off, so that it is almost immediately ready to start a new timing run when it is swtiched on again. If a separate reset switch is required, simply add a push-to-break switch in series with the on/off switch S2.

Construction of the unit should not present any major difficulties, but remember that IC1, IC3, and IC4 are all CMOS devices, and therefore require the usual anti-static handling precautions to be taken. Some LED displays are vulnerable to heat damage, and I would recommend the use of a socket for these components as well. Suitable sockets are not available, but it is not too difficult to cut a 20 pin DIL holder into two 10 pin SIL types. Provided they are given the correct 0.6 inch spacing the displays will then plug into them without any difficulty. The current consumption of the unit is largely dependent on the number of display segments that are switched on, but is in the region of 75 milliamps. This fairly high figure necessitates the use of a high capacity battery such as a PP9 type or six HP7 size cells in a plastic holder.

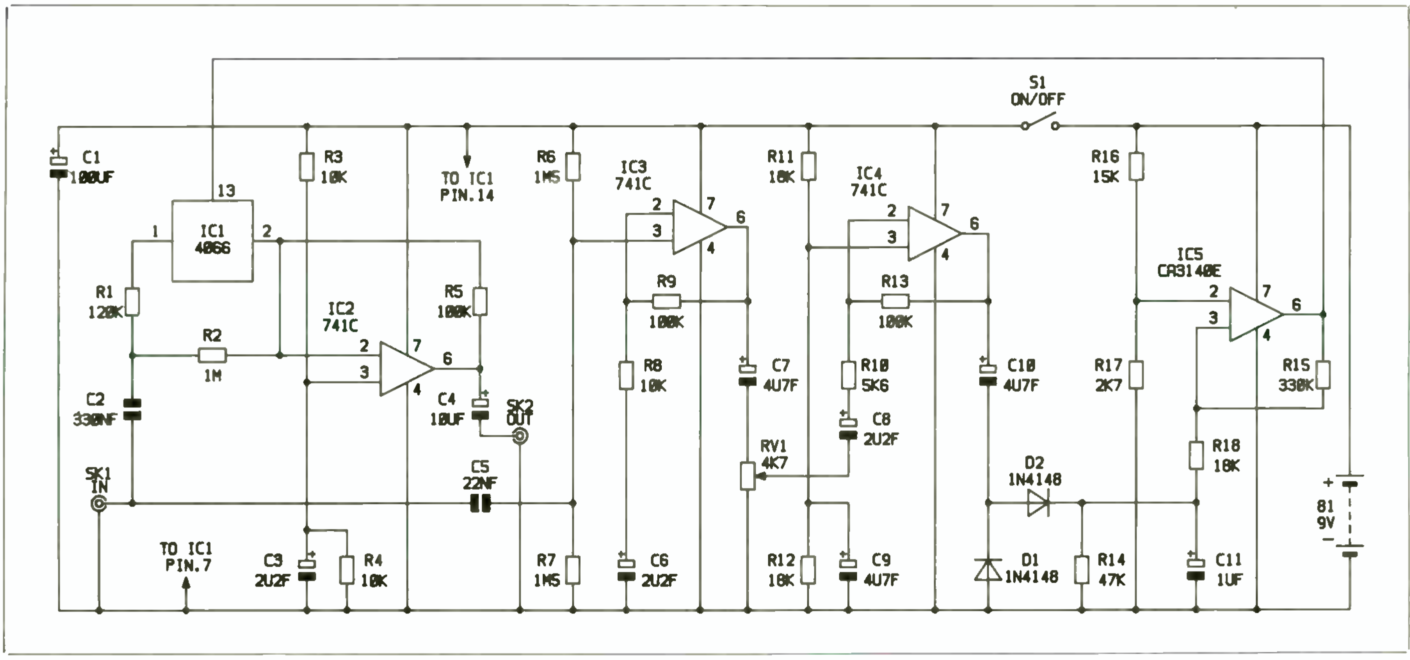
Basic Noise Gate

A number of computers have an audio output socket that enables their internal sound generator circuits to be connected to a hi-fi system, or other amplifier/speaker combination. Using such a set-up can provide much more convincing 'zaps' and 'pows', but results can often be a little disappointing. A common problem is with noise from the computer's digital circuits finding its way into the audio output signal. This results in annoying background 'buzzes' and 'hums' that can be surprisingly loud. There is no easy way around this problem, and computers are such prolific generators of electrical noise that a fairly high background noise level is perhaps only to be expected. Also, the basic signal to noise ratio of many computer sound generators is not very good anyway, even without any extra noise added by the computer.

One way of providing an improvement is to use a noise gate to process the audio output of the computer. The general idea of a noise gate is to let the signal pass unhindered when it is above a certain threshold level, but to switch it off (or



Basic Noise Gate.



Basic Noise Gate Circuit.

attenuate it) when it falls below a certain level. This system usually works well in a computer context where the 'zaps' and other sound effects are passed by the gate, but the background noise is cut off. Although the sound effects may be foreshortened very slightly by the noise gate, the nature of these sounds is such that this is unlikely to be apparent to the listener. Noise gates can be quite complex and expensive pieces of equipment, but for an application of this type something quite basic will give quite good results. The signals from most computer sound generators are quite simple types that do not merit such things as zero crossing switching.

In this circuit the main signal path is through an inverting mode amplifier based on IC2. R2 and R5 normally give this amplifier a gain of about −20dB, or a reduction in the signal by a factor of about ten in other words. However, by switching on electronic switch IC1 it is possible to shunt R1 across R2, and this boosts the voltage gain of the circuit to about unity. A noise gate action can be obtained by activating IC1 when the input level exceeds a certain threshold level. Note that the circuit does not provide a true gate action in that it does not fully mute the signal when it is in the 'off' state. This is a factor that is common to most noise gates though, and this method generally seems to give better results.

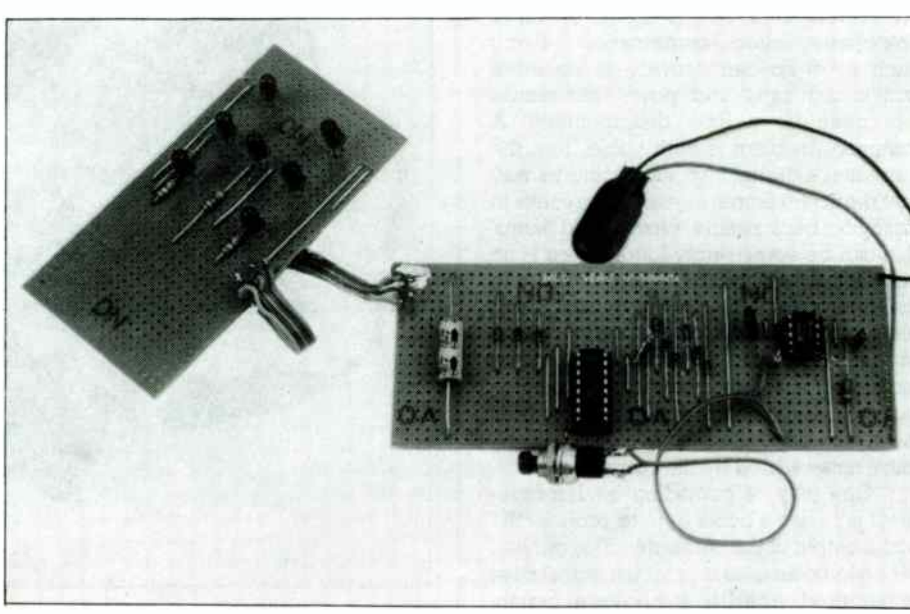
The control signal for IC1 is obtained by first amplifying the input signal using IC3. After the signal has passed through the threshold level control (RV1) it is then further amplified by IC4. The output of IC4 is rectified and smoothed to give a positive DC bias that is roughly proportional to the amplitude of the input signal. The attack time is quite short, but the decay time is controlled by the values of R14 and C11, and is easily changed. The specified values should give good results though. This signal drives a trigger circuit based on IC5. A certain amount of hysteresis is provided by R15, and this helps to avoid repeated switching of the circuit when the input signal is near the threshold level.

The setting of RV1 is not likely to be too critical, and it is just a matter of adjusting it for a low switching threshold, but not one that is so low that the noise is not suppressed reliably. A little experimentation should soon come up with a suitable setting. Signal threshold levels of as little as a few millivolts are possible with RV1 well advanced. The current consumption of the circuit is only about 5 milliamps or so, and a small (PP3 size) 9 volt battery should be adequate as the power source. Note that IC1 and IC5 are both MOS input types, and they consequently require the usual anti-static handling precautions.

Electronic Die

Producing a simple circuit that will provide an electronic simulation of a die is one of those things which seems very easy until you try it. What starts out as a very simple idea can grow by the minute until it develops into what is really a quite complex final design. One of the main problems is that the circuit must count from one to six, whereas most electronic counter circuits are designed to count from zero to nine. Resetting the count early is not generally too difficult, but getting rid of the unwanted zero can be hard. If a display having the conventional spot patterns is required, rather than a seven-segment display, there is the additional problem of providing a suitable decoder for this non-standard form of digital readout.

After trying a number of approaches this circuit was finally devised. It is based on two inexpensive integrated circuits plus eleven diodes which provide the



Electronic Die.

display decoding. The display and decoding are simplified as far as possible by having the LED's driven in three pairs plus one single diode. This is possible because a 'corner' LED is only switched on when the LED in the opposite corner is also activated. Similarly, the middle-left and middle-right LED's are either both on or both switched off. If you wish to obtain the standard spot patterns, it is obviously essential to have the seven LED's in a suitable arrangement, such as the one shown in Diagram 1.

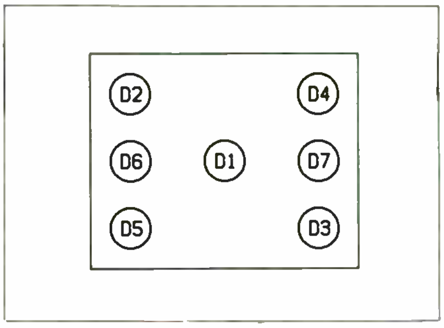
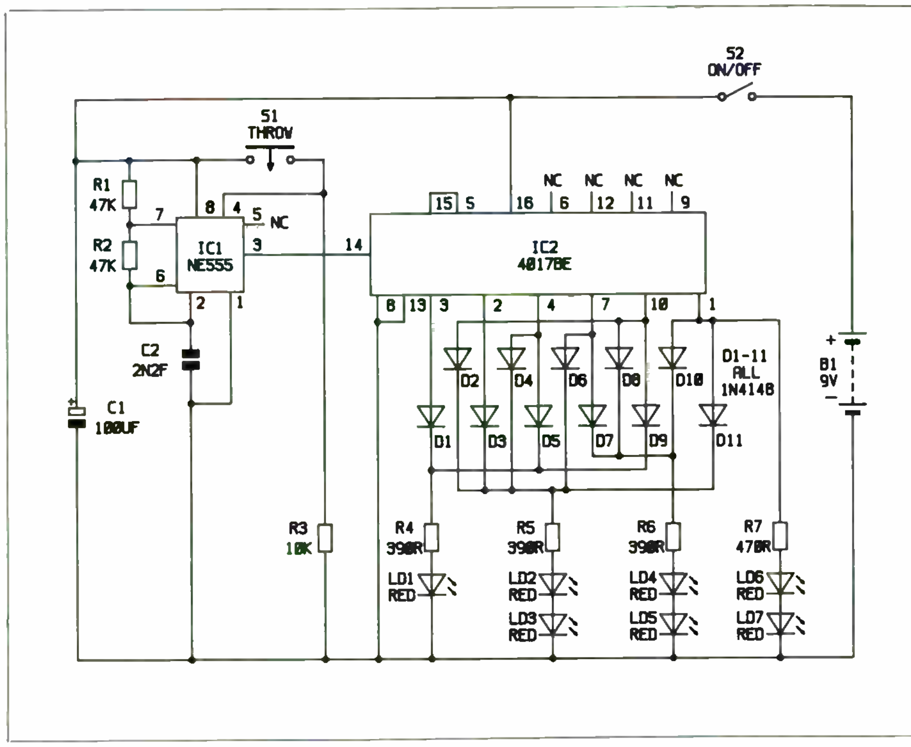


Diagram 1. LED pattern.



Electronic Die Circuit.

IC1 is the clock oscillator, and this is a standard 555 astable operating at a frequency of a few kilohertz. However, it only oeprates whilst push-button switch S1 is operated. In practice S1 is pressed for a second or two and then released in order to 'throw' the die. The high clock frequency ensures that there is no way of predicting or controlling the number produced by the counter when the count is 'frozen', and the number 'thrown' is therefore a pseudo-random one.

The counter is a CMOS 4017BE one-of-ten decoder (IC2). In this case, output 6 is connected to the reset input so that four of the outputs are effectively eliminated, and a one-of-six action is obtained. The outputs go high, in sequence, one at a time. In order to obtain the desired action, it is just a matter of getting each output to activate the appropriate LED's. This is achieved using OR gates, which are formed from diodes (D8 to D18). If we take D1 as an example; this is the centre spot of the die, and it must therefore be switched on when the counter is at 1, 3, or 5. The outputs of the counter are conventionally numbered from 0 to 5 rather than 1 to 6, and D1 is therefore connected via diodes to what would normally be considered as outputs 0, 2, and 4 of IC2. No diodes are required for D6 and D7 as these are only driven from a single output (they are only switched on when a six is 'thrown').

The pairs of LED's are connected in series rather than in parallel as this ensures that they receive the same current, and it also makes more effective use of the limited output current that can be provided by IC2. I used ordinary 5 millimetre diameter red LED's on the prototype, but due to the farily low LED current it is advantageous to use a high brightness type, although there is probably no point in going to the expense of 'ultra-bright' or 'super-bright' types. The current consumption of the circuit depends on the number of LED's that are switched on, but it is usually around 20 milliamps. A fairly high capacity battery such as a PP9 is needed in order to supply this economically.

When constructing the unit, bear in mind that IC2 is a CMOS device and that it therefore requires the standard anti-static handling precautions. Take reasonable care to ensure that the diode decoder stage is wired up correctly. If you want to check that the decoder is correct and the proper counting action is being obtained, try adding a capacitor of a few microfarads in value in parallel with C2. When S1 is operated the count will proceed at a rate which is slow enough for the LED patterns to be clearly seen. This will show up any fault in the decoding so that it can be easily located and rectified. With S1 pressed and the counter operating at full speed all seven LED's will appear to light up continuously. What in fact is happening is that the display is running through 1 to 6 counts so rapidly that the human eye cannot perceive the flashing on and off of the LED's.

REACTION TESTER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	1M8	1	(M1M8)
R2,3	5k6	2	(M5K6)
R4	100Ω	1	(M100R)
R5,8	100k	2	(M100K)
R6	10k	1	(M10K)
R7	47k	1	(M47K)
R9 to R22 inc.	470Ω	14	(M470R)
CAPACITORS			
C1	10μF 25V PC Electrolytic	1	(FB22Y)
C2,4,5	100nF Polyester	3	(BX76H)
C3	47nF Polyester	1	(BX74R)
C6	100μF 10V Axial Electrolytic	1	(FB48C)
SEMICONDUCTORS			
IC1	4001BE	1	(QX01B)
IC2	NE555	1	(QH66W)
IC3,4	4026BE	2	(QX15R)
Display 1,2	0.5in Common Cathode LED	2	(FR41U)
D1	1N4148	1	(QL80B)
MISCELLANEOUS			
S1	Push to Make Switch	1	(FH59P)
S2	SPST Ultra-min Toggle	1	(FH97F)
B1	9 Volt PP9 Battery	1	(FM05F)
	Battery Connector	1	(HF27E)
	DIL IC Holder 8 pin	1	(BL17T)
	DIL IC Holder 14 pin	1	(BL18U)
	DIL IC Holder 16 pin	2	(BL19V)
	DIL IC Holder 20 pin	1	(HQ77J)

METRONOME PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	220k	1	(M220K)
R2	100Ω	1	(M100R)
R3	10k	1	(M10K)
R4	4k7	1	(M4K7)
R5	5k6	1	(M5K6)
R6	2k2	1	(M2K2)
RV1	2M2 Lin Pot	1	(FW09K)
CAPACITORS			
C1	100μF 10V Axial Electrolytic	1	(FB48C)
C2	1μF Polyester Layer	1	(WW53H)
C3	2μ2F 100V Axial Electrolytic	1	(FB15R)
SEMICONDUCTORS			
IC1	NE555	1	(QH66W)
IC2	4017BE	1	(QX09K)
TR1	BC547	1	(QQ14Q)
TR2	BFY51	1	(QF28F)
D1,2	1N4148	2	(QL80B)
MISCELLANEOUS			
S1	4-way 3-pole Switch	1	(FH44X)
S2	SPST Ultra-min Toggle	1	(FH97F)
LS1	66mm Dia. 64 ohm Speaker	1	(WF57M)
B1	PP3 9V Battery	1	(FK62S)
	Battery Connector	1	(HF28F)
	8 pin DIL IC Holder	1	(BL17T)
	16 pin DIL IC Holder	1	(BL19V)

NOISE GATE PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	120k	1	(M120K)
R2	1M	1	(M1M)
R3,4,8	10k	3	(M10K)
R5,9,13	100k	3	(M100K)
R6,7	1M5	2	(M1M5)
R10	5k6	1	(M5K6)
R11,12	18k	2	(M18K)
R14	47k	1	(M47K)
R15	330k	1	(M330K)
R16	15k	1	(M15K)
R17	2k7	1	(M2K7)
R18	18k	1	(M18K)
RV1	4k7 Lin Pot	1	(FW01B)
CAPACITORS			
C1	100μF 10V PC Electrolytic	1	(FF10L)
C2	330nF Polyester	1	(WW47B)
C3,6,8	2μ2F 100V PC Electrolytic	3	(FF02C)
C4	10μF 50V PC Electrolytic	1	(FF04E)
C5	22nF Polyester	1	(WW33L)
C7,9,10	4μ7F 63V PC Electrolytic	3	(FF03D)
C11	1μF 100V PC Electrolytic	1	(FF01B)
SEMICONDUCTORS			
IC1	4066BE	1	(QX23A)
IC2,3,4	μA741C (8 pin DIL)	3	(QL22Y)
IC5	CA3140E	1	(QH29G)
D1,2	1N4148	2	(QL80B)
MISCELLANEOUS			
S1	SPST Ultra-min Toggle	1	(FH97F)
SK1,2	3.5mm Jack Socket	2	(HF82D)
B1	9 Volt PP3 Battery	1	(FK62S)
	Battery Connector	1	(HF28F)
	8 pin DIL Holder	4	(BL17T)
	14 pin DIL Holder	1	(BL18U)

ELECTRONIC DIE PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1,2	47k	2	(M47K)
R3	10k	1	(M10K)
R4,5,6	390Ω	3	(M390R)
R7	470Ω	1	(M470R)
CAPACITORS			
C1	100μF 10V Axial Electrolytic	1	(FB48C)
C2	2n2F Mylar	1	(WW16S)
SEMICONDUCTORS			
IC1	NE555	1	(QH66W)
IC2	4017BE	1	(QX09K)
D1 to D7 inc.	High Brightness Red LED	7	(WL84F)
D8 to D18 inc.	1N4148	11	(QL80B)
MISCELLANEOUS			
S1	Push to Make Switch	1	(FH59P)
S2	SPST Ultra-min Toggle	1	(FH97F)
B1	9 Volt PP9 Battery	1	(FM05F)
	Battery Clips	1	(HF27E)
	DIL IC Holder 8 pin	1	(BL17T)
	DIL IC Holder 16 pin	1	(BL19V)

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