MPS

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EDUCATIONAL SUPPLEMENT

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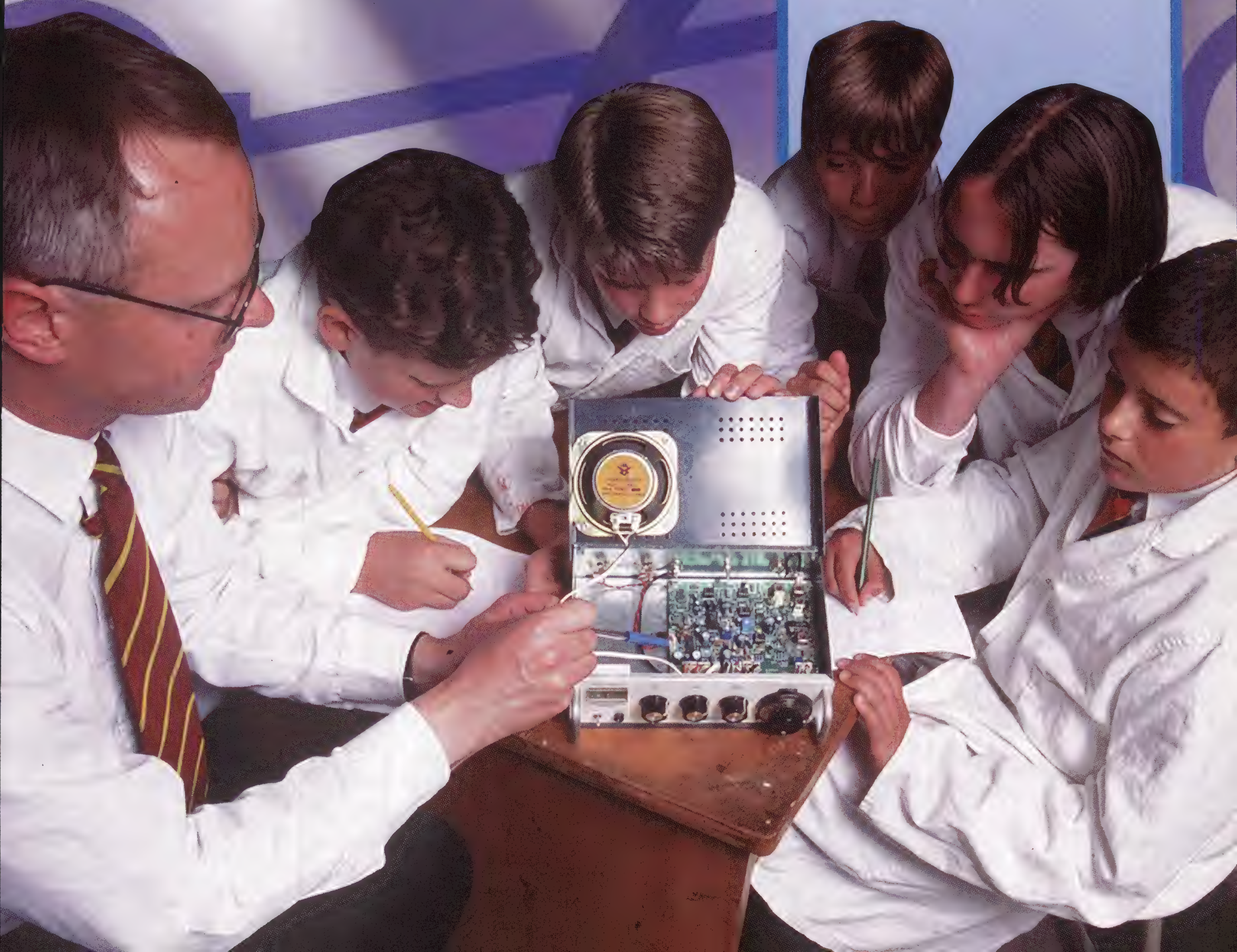


Mini-Circuits FOR EDUCATION

Two-Tone Train Horn

This is a simple sound effects unit for model railway enthusiasts. On pressing the push-button switch, a two tone horn sound is produced of the type associated with diesel locomotives. In other words, an initial tone lasting about one second in duration, followed by a tone 50% higher in pitch, and also having a duration of about one second. If preferred, the horn can be triggered automatically at a certain point on the track (just before a level-crossing, for instance). Automatic triggering is possible using a reed switch under the track, and a magnet fitted in a piece of the rolling stock.

The circuit, shown in Figure 1, is based on three 555 timers. Two of these operate as monostables which control the timing of the tones, and the third actually generates the tone. IC3 acts as the tone generator, and it operates in a standard 555 astable mode. The output of IC3 drives a high impedance loudspeaker via a simple low-pass filter (R6 & C5). The filter provides a more realistic sound by removing the higher frequency harmonics in the output signal. Note that IC3 should be a standard 555 and not a low power type. Low power versions of the 555 are not very good at driving low impedance loads, and will not give good results in this circuit. LS1 must be a high impedance (50Ω or greater) loudspeaker, and not an 8Ω type.

IC1 is a standard 555 monostable which has its trigger input taken high by R2 under standby conditions. The trigger input is taken low when S1 is operated, and an output pulse is then generated at pin 3 of IC1. R1 and C2 set the pulse duration at about 2 seconds or so. This pulse is used to control the gate input of IC3. Normally the gate input at pin 4 is held low and no oscillation is produced. During the output pulse from IC1 the gate input is taken high, and a tone is generated by the circuit.

IC2 is the second monostable, and this is triggered at the same time as IC1. It has a shorter output pulse duration which is set at just over one second by R3 and C3. The output pulse from IC2 is coupled to the modulation input of IC3 via VR1. During the initial second or so after triggering, the output of IC2 will be high, and it will pull the output frequency of IC3 lower. IC3 will remain switched on for a little over a second once the output pulse from IC2 has ceased. With IC2's output low, the tone from IC3 is pulled higher in pitch. VR1 is adjusted to give the correct difference between the pitches of the two tones.

Low power 555s are used for IC1 and IC2 in order to minimise the current consumption of the circuit. Under quiescent conditions the current consumption is about 8mA, but it increases to about 20 to 25mA when the horn is sounding. A fairly high capacity battery is needed, such as six AA (HP7) size cells in a plastic holder. Connections to the holder are made via a standard PP3 battery clip.

Construction of the unit is very straightforward. Although the lower power 555s use CMOS technology, they do not require any special handling precautions. If you require manual and automatic triggering, simply wire the reed switch and the push-button switch in parallel. In fact it is possible to trigger the circuit from several reed switches at strategic points around the track by simply wiring them all in parallel. VR1 is adjusted by trial and error to obtain what is judged to be the most realistic effect. When triggering the unit manually make sure that you only operate S1 momentarily. If it is held down for a second or more the timing of the circuit will be affected, and the correct effect will not be produced. If desired, the duration of the sound effect can be changed by altering the values of R1 and R3. The total duration of the sound is proportional to the value of R1. R3 should be maintained at about half the value of R1.

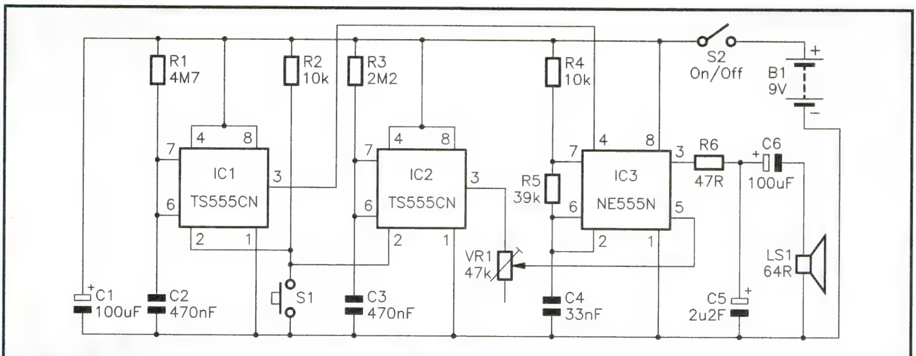
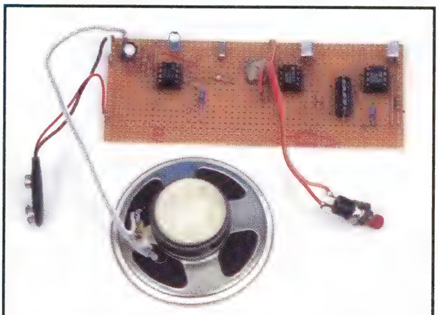


Figure 1. Two-tone train horn circuit diagram.



Prototype two-tone train horn.

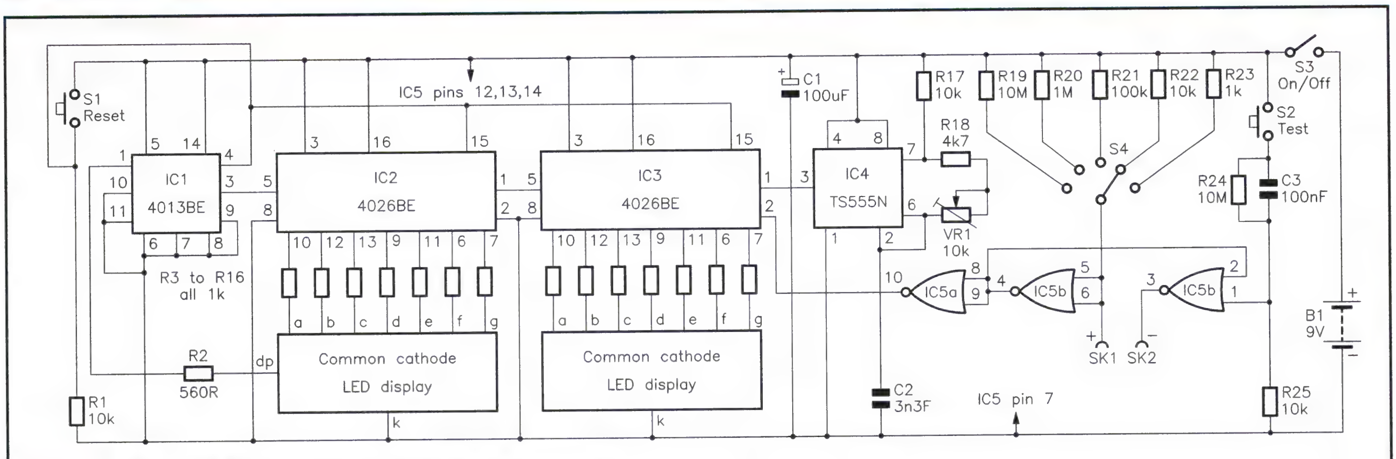


Figure 2. Simple Digital capacitance meter circuit diagram.

Simple Digital Capacitance Meter

This digital capacitance meter provides an interesting alternative to a simple analogue capacitance meter. The cost is comparable to an analogue equivalent, and the resolution and accuracy of the two digit display is at least as good as that provided by a small panel meter. The unit covers a useful spread of capacitance values in its five measuring ranges. These have full-scale values of 990pF, 9·9nF, 99nF, 990nF, and 9·9µF. An overflow indicator is included.

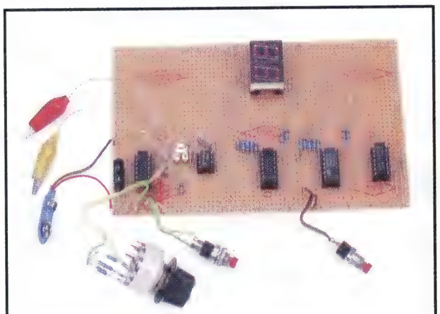
In order to keep the unit as simple as possible the control logic has been kept to a bare minimum. In effect, the user provides some of the control logic by pressing a push-button switch when a reading is required, and operating a second button to reset the display to zero before the next reading is taken. The circuit diagram is shown in Figure 2. Looking at the operation of the circuit in broad terms, IC5 acts as a monostable which has the test capacitance as the capacitive element of the C-R timing circuit. IC4 acts as a clock oscillator which feeds into a two digit counter based on IC2 and IC3. The output pulse from the monostable controls the gate input of the counter circuit, and the count only proceeds during an output pulse from the monostable. The higher the test capacitance, the longer the monostable pulse duration, and the higher the count. There is a linear relationship between the test capacitance and the number of clock pulses registered by the counter. In practice the clock frequency is chosen so that the counter directly indicates the test capacitance.

Looking at the circuit in a bit more detail, the monostable is based on two CMOS NOR gates (IC5b and IC5c). The low self-capacitance of this configuration ensures good accuracy with small test capacitances. IC5a acts as an inverter at the output of the monostable. This gives a better output waveform and also provides output pulses of the correct polarity for the gate input of IC3. The fourth gate in IC5 is left unused. S4 provides five switched timing resistances which give the unit its five ranges. R19 provides the 990pF range – R23 provides the 9·9µF range. S2 is used to trigger the monostable and take a reading. R24 and C3 provide 'debouncing' for S2.

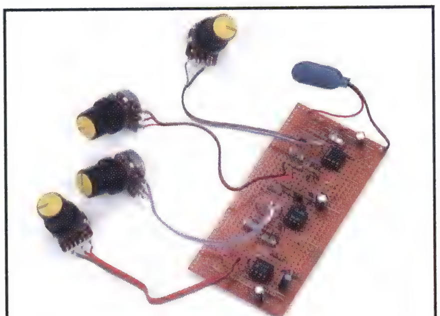
The clock oscillator is a standard 555 astable. A low power 555 is used in order to keep the current drain from the battery as low as possible. VR1 enables the clock frequency to be adjusted, and this is the calibration control. The counter is a straightforward design based on two CMOS 4026BE decade counters and display drivers. The carry out output of IC2 drives the input of a 'D' type flip/flop (IC1). The 4013BE is actually a dual flip/flop, but in this circuit only one section is utilized. This acts as a sort of data latch which switches on the overflow indicator if the count goes beyond '99'. With a two digit display and right-hand decimal points, it is not really possible to use the decimal point segments for their intended purpose. Therefore, the decimal point of one display is used as the overflow indicator, and the other one is simply left unused. It is still quite easy to convert readings into their corresponding capacitance values. S1 is used to reset both the main display and the overflow indicator. The current consumption of the circuit varies depending on the number of display segments that are switched on, but it is in the region of 50mA. This requires the use of a fairly high capacity battery, such as six AA (HP7) size cells in a holder.

When constructing this project bear in mind that, apart from IC4, the integrated circuits are CMOS types. They therefore require the standard antistatic handling precautions. The displays must be common cathode LED types. IC3 drives the units display (i.e. the right-hand display). A holder for the display is made by cutting a 20-pin DIL holder into two 10-pin SIL types, or 'Soldercon' pins can be used. SK1 and SK2 can be a couple of 1mm sockets mounted on the front panel of the unit, and many capacitors will readily connect to these. However, a couple of test leads terminated in small crocodile clips will be needed in order to make the connections to some types of capacitor. Alternatively, a pair of crocodile clip leads can simply be hard wired direct to the circuit board.

A close tolerance capacitor is needed in order to calibrate the unit. The unit can be calibrated on any range, and the value of the calibration capacitor should be at least half the full-scale value. For example, an 8·2nF capacitor could be used to calibrate the unit on the 9·9nF range (R20 switched into circuit). A series of readings would be taken, and RV1 would be adjusted by trial and error to obtain a consistent readings of '82' on the display. One final point is that capacitors should always be discharged before connecting them to any capacitance meter.



Prototype digital capacitance meter.



Prototype simple graphic equaliser.

Simple Graphic Equaliser

A full-blown graphic equaliser covers the entire audio range in about eight to ten bands, with each level control covering roughly one octave. These days many audio devices incorporate a sort of cut down version of graphic equaliser. These are frequently found in 'ghetto blasters', and even personal stereo units. They usually have four or five level controls with each one covering a couple of octaves or so. This obviously gives far less precise control than a full graphic equaliser, but, on the other hand, it is much better than simple bass and treble tone controls.

The circuit in Figure 3 is for a simple four band graphic equaliser. The approximate centre frequencies of the controls are 80Hz, 400Hz, 1·8kHz, and 8kHz. These respectively control the bass, lower middle, upper middle, and treble frequencies. Each control can provide a maximum of about 12dB of boost and cut at its centre frequency. The frequency response is essentially flat with all four controls centred, and the voltage gain is then approximately unity.

IC1 acts as a buffer stage at the input of the circuit, and it provides an input impedance of about 50kΩ. The buffer stage is followed by a series of four response shaping circuits, one for each band. All four stages utilize the same configuration, and this is based on an operational amplifier in the inverting mode. R4, R5 and C3 provide a half supply bias for the non-inverting inputs of all four stages.

If we consider the operation of the first stage (which is based on IC3a and covers the lowest frequency band), R3 and R6 are a negative feedback network which sets the voltage gain at unity. However, frequency selective negative feedback is provided by R7, R8, VR1, C4, and C5. If we ignore C5 for the moment, C4 significantly shunts R6 at high frequencies when the wiper of VR1 is at the top end of its track. This gives increased feedback at high frequencies, and high-frequency cut. With the wiper of VR1 at the bottom end of its track, C4 shunts R3 at high frequencies. This gives reduced negative feedback and high-frequency boost. R3 and R8

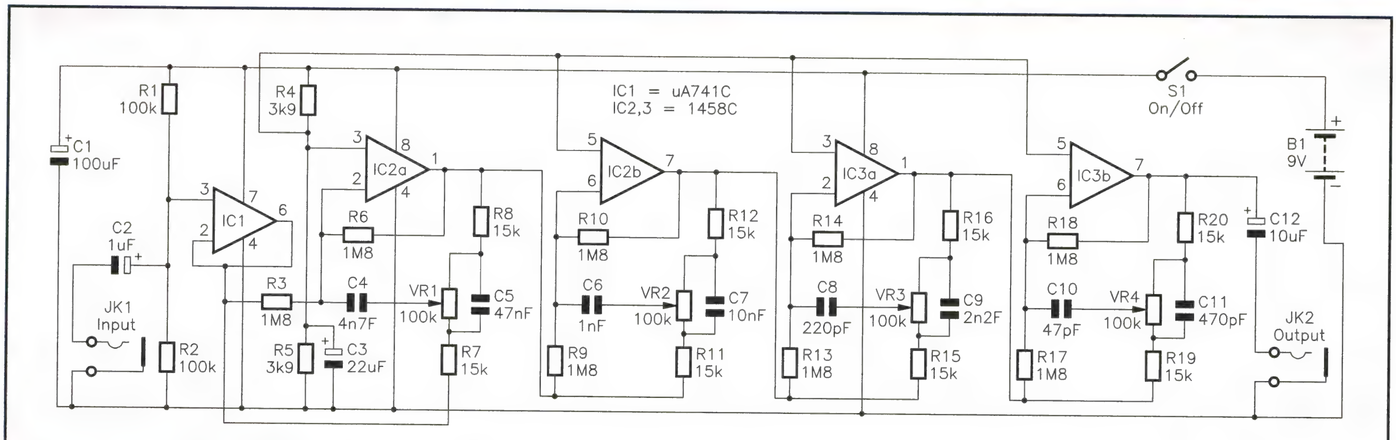


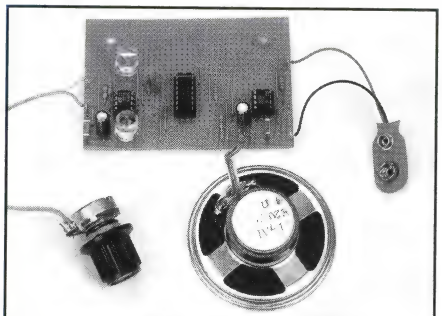
Figure 3. Simple graphic equaliser circuit diagram.

limit the effect of C4, and keep the maximum amounts of boost and cut within reasonable bounds. C5 is used to effectively short circuit VR1 at high frequencies, which nullifies C4 and leaves the circuit with its basic unity voltage gain. The circuit values are chosen so that C4 can introduce high-frequency boost or cut over the frequency range that is of interest, but C5 eliminates any doctoring of the frequency response at higher frequencies. The steadily reducing capacitance values used in the subsequent stages results in them covering progressively higher frequency ranges.

The component layout is not particularly critical since the circuit can only produce a modest amount of voltage gain. It should be borne in mind that setting a level control for 'cut' results in the relevant operational amplifier having less than unity voltage gain. This does not seem to produce any problems using 1458Cs for IC2 and IC3, but many operational amplifiers can become unstable when used at less than unity voltage gain. The LF353N for example, does not seem to work well in this circuit, with severe high-frequency instability occurring at some control settings. It is therefore advisable to use the humble 1458C for IC2 and IC3, rather than a more modern device, unless the alternative device is known to be stable when used at less than unity voltage gain. The current consumption of the circuit is only about 5mA, and a PP3 battery is therefore perfectly adequate as the power source.

Audio/Visual Metronome

The original metronomes were purely mechanical devices having clockwork mechanisms ('Maelzel's' metronomes). These are rapidly becoming collectors items, and modern metronomes are of the electronic variety. Mechanical metronomes have a swinging arm, rather like an inverted pendulum, and they produce a 'clicking' sound each time the arm reaches the limit of its swing. This gives both a visual and an audible indication of the beat rate.



Prototype audio/visual metronome.

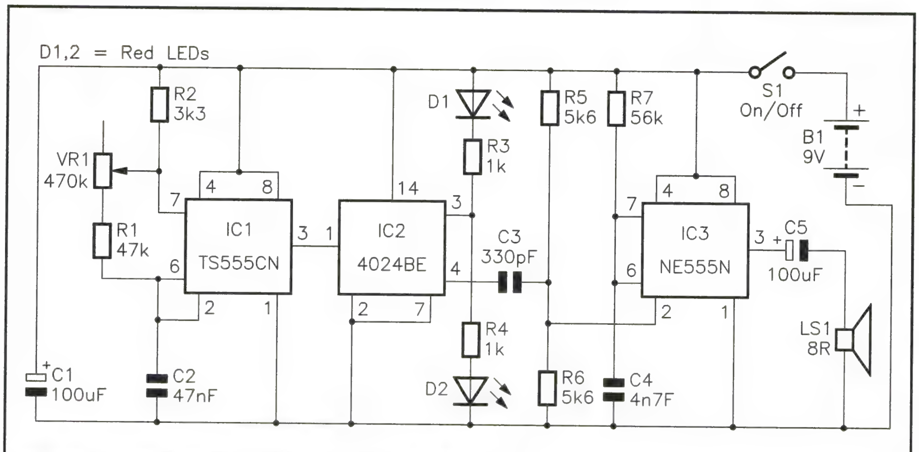


Figure 4. Audio/visual metronome circuit diagram.

This electronic metronome also produces a series of 'clicking' sounds to give an audible indication of the beat, and it provides a visual indication via two large LEDs. The LEDs are operated in anti-phase (i.e. as one switches on the other switches off), giving a form of visual indication that is roughly analogous to the swinging arm of a mechanical metronome. The beat rate can be varied from approximately 30 to 300 beats per minute.

The circuit in Figure 4 is based on two 555 timers and a CMOS 7-stage binary counter. IC1 is the clock generator, and it is a low power 555 timer used in the standard astable mode. An ordinary 555 can be used for IC1, but this will increase the current consumption of the circuit by about 8mA, with a much shorter battery life. The timing components are R1, R2, VR1, and C2. Although the 'click' rate is in the frequency range 0·5Hz to 5Hz, the clock oscillator has to operate over a much higher range of frequencies as it drives the speaker via 6 stages of the binary divider. It therefore operates at 64 times the output frequency, or in other words at around 32 to 320Hz. An advantage of this system is that it avoids the expense of a good quality, high value timing capacitor.

IC2 is the seven stage binary divider, a CMOS 4024BE. C3 couples the output from the sixth stage of IC2 to the input of a 555 based monostable circuit. The trigger input of IC3 is biased to about half the supply voltage by R5 and R6. Negative output transitions from pin 4 of IC2 briefly take the trigger input of IC3 below one third of the supply potential, and an output pulse is produced at pin 3 of IC3. R7 and C4 set the duration of the output pulse at a fraction of a millisecond, which gives a suitably high pitched 'click' sound. C5 couples the output pulses from IC3 to a moving coil loudspeaker. I would not recommend using a low power version of the 555 timer for IC3 as many of these seem to give erratic operation when driving low impedance loads. Also, the output stages of some low power 555s cannot supply high enough output currents to give good results in this application.

The output of IC2's seventh divider stage is used to drive the two LEDs, which are connected so that they operate out-of-phase. D2 is switched on when pin 3 of IC2 goes high – D1 is switched on when it goes low. As each LED only switches on at every other 'click', the LEDs are operating at half the 'click' frequency. Hence the LEDs are driven from stage seven of IC2 while the 'click' generator is driven from stage six.

The current consumption of the circuit is about 12mA. This necessitates the use of a fairly high capacity battery, such as six HP7 size cells in a plastic holder. Construction of the unit is fairly straightforward, and the component layout is not critical. Bear in mind though, that IC2 is a CMOS device which requires the standard antistatic handling precautions. Virtually any LEDs are suitable for D1 and D2, but large high efficiency LEDs will be much more conspicuous than small low efficiency types. A scale calibrated in beats per minute must be marked around VR1's control knob. The calibration points must be found by trial and error, with the beat rate being determined by counting the number of 'clicks' in a one minute period. At high beat rates adequate accuracy should be obtained by counting the number of 'clicks' in twenty seconds, and then multiplying by three to get the beats per minute.

Model Train Signal Lights

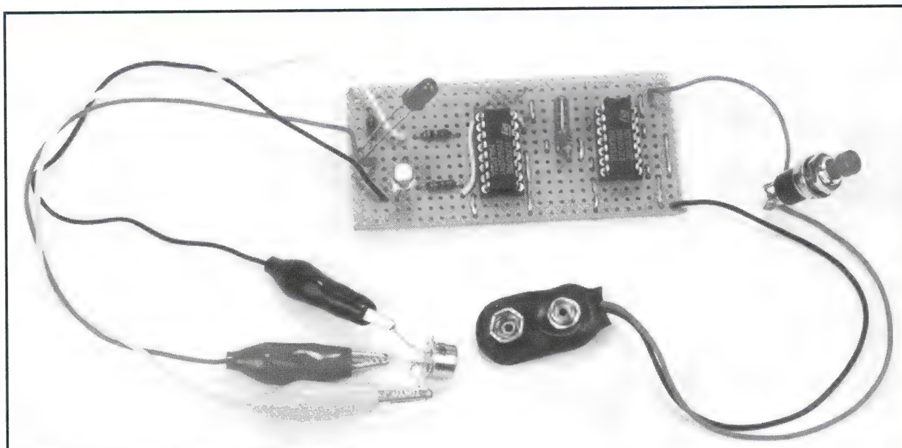
This is a circuit for a simple three-colour signal for a model railway. It operates automatically, changing from 'green' to 'red' as the train passes the signal. After a preset time the signal changes to 'amber', and after a further period it goes back to 'green' once again. This is a sort of simplified version of the real thing, where the signals change as the train passes by sensors along the track. In this case there is only one sensor, which is positioned beside the signal. The other changes are provided by a timing circuit, which is slightly less authentic, but makes the signal much easier to install.

The circuit, shown in Figure 5, is built around IC2, which is a CMOS decade counter and one-of-ten decoder. In this case only outputs '0' to '3' of the decoder section are utilized, the other seven outputs are simply ignored.

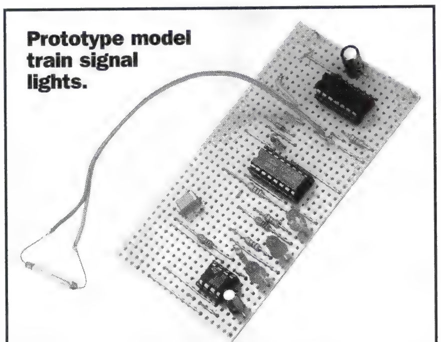
C3, R7, and D4 supply a reset pulse to IC2 at switch-on, so that it commences with output '0' high. This switches on D1, which is the 'green' signal LED. IC1 is a 555 timer which is used here as a low-frequency clock oscillator which provides a clock pulse to IC2 every three seconds or so. The first clock pulse results in the '0' output going low, and output '1' going high. This switches off D1, and switches on D2 (the 'red' signal LED). On the next clock pulse output '1' goes low and output '2' goes high. This results in D2 switching off, and the 'amber' LED (D3) turning on. On the next clock pulse output '4' goes high, but due to the coupling through R6 this resets IC2 so that output '4' immediately returns to the low state, and output '0' goes high. This takes the circuit back to its initial state, with D1 switched on, and a 'green' signal being produced.

Some control logic is needed, so that the circuit only goes through this sequence of events when it is triggered by the passing train. The circuit must halt once it has cycled back to a 'green' signal. This control logic is provided by IC3, which is a 4013BE dual 'D' type flip/flop. In this circuit only one section of the device is used. The inputs of the unused section of IC3 are connected to the 0V supply in order to protect them against static charges and to avoid spurious operations. The other section operates really as just a simple set/reset flip/flop, with the clock and data inputs simply being wired to earth. Like IC2, IC3 is supplied with a reset pulse at switch-on. This takes the Q output low, which in turn inhibits IC1 so that no clock signal is produced. R8 ties the 'set' input of IC3 to earth, but this input is pulsed high when sensor switch S1 is activated. This takes the Q output of the flip/flop high, and activates IC3. This results in the signal changing to 'red' immediately, and to 'amber' and then 'green' after a few seconds. IC3 is reset when output '4' of IC2 pulses high, so that once the signal returns to 'green', the Q output of IC3 inhibits IC1. This holds the signal at green until S1 is activated again. The sequence is then repeated, and will be repeated each time S1 is activated. The current consumption of the circuit is about 15mA, or about 7mA if a low power 555 is used for IC1.

Construction of the actual railway signal is obviously unusual. D1 to D3 must be mounted in a model signal, and it is not too difficult to improvise something reasonably convincing. Rather than controlling the LEDs directly, IC2 could be used to control them via common emitter switching transistors. This would enable a higher drive current to be used, and would also permit miniature filament bulbs to be used. S1 can be either a micro-switch or a reed type. In the case of a micro-switch, things must be arranged so that the actuator is operated by the passing train. For this application a reed switch mounted under the track is preferred. This is operated by a small bar magnet fitted in a piece of rolling stock. This method requires no direct contact with the train, which eliminates any slight risk of occasional derailments. Note that IC2 and IC3 are CMOS devices which require the usual antistatic handling precautions. The duration of the 'red' and 'amber' signals is easily altered as it is roughly proportional to the value of R2.



The assembled go/no go thyristor tester.



Prototype model train signal lights.

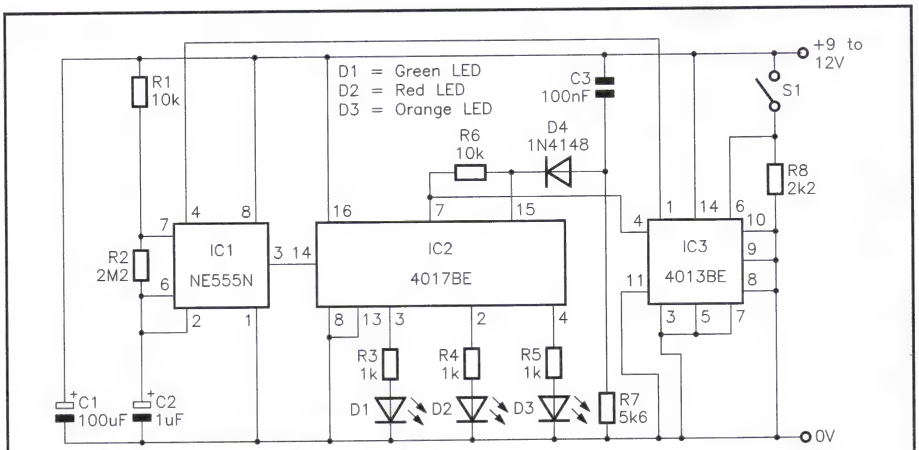


Figure 5. Model train signal lights circuit diagram.

Go/No Go Thyristor Tester

This circuit (Figure 6) was designed to give a quick go/no go test of thyristors that you might find in 'bargain packs', etc. Thyristors are also known as silicon controlled rectifiers. They are like a diode, in that current can only flow one way through it. However, the thyristor has an additional terminal, known as the gate; if sufficient current is applied to the gate, then the device will stay permanently latched on. The only way to turn the device off is to either short-circuit the anode-cathode junction, or reduce the anode-cathode current below the 'holding' current, which is the minimum current necessary to keep the device on. The former method was used in this circuit. It is also possible to test thyristors using a multimeter, but this circuit has the advantage of being less 'fiddly' to use, and it also gives you an idea of how well the device under test switches from a non-conducting to conducting state.

Circuit operation is as follows: IC1a and b form a standard astable multivibrator, with a working frequency of about 2·5Hz; R1 and C1 set the frequency of the astable. Pulses from the astable are fed to the clock input of IC2, which is a '1-of-10 decoder'. As successive pulses are fed to IC2, each of its outputs will go high then low, in sequence. When the last output goes high/low, the sequence starts again. When output 1 of IC2 goes high – roughly to the supply voltage – this voltage will be fed to the gate of the device under test through R2. This turns on the thyristor, and LD1 will be illuminated. R4 is the current limiting resistor for LD1.

Now, two clock pulses later, output 3 of IC2 will go high, and this turns TR1 fully on, short-circuiting the anode-cathode junction of the device under test and, therefore, turning it off. LD1 will now be extinguished. When output 7 of IC2 goes high five clock pulses later, IC2 is reset and the whole sequence starts over again. S1 is the on/off switch, and must be pressed down long enough to see if the device under test works. C2 is a supply decoupling capacitor.

If, when testing a thyristor, LD1 is permanently on, or it does not come on at all, then the thyristor is probably suspect. When connecting a device to be tested, you can use either flying leads and clips, or sockets. Flying leads and clips were used on the prototype. A red lead and clip were used for connecting to the anode, a black lead and clip to the cathode, and a yellow lead and clip to the gate. Current consumption of the unit is about 11mA.

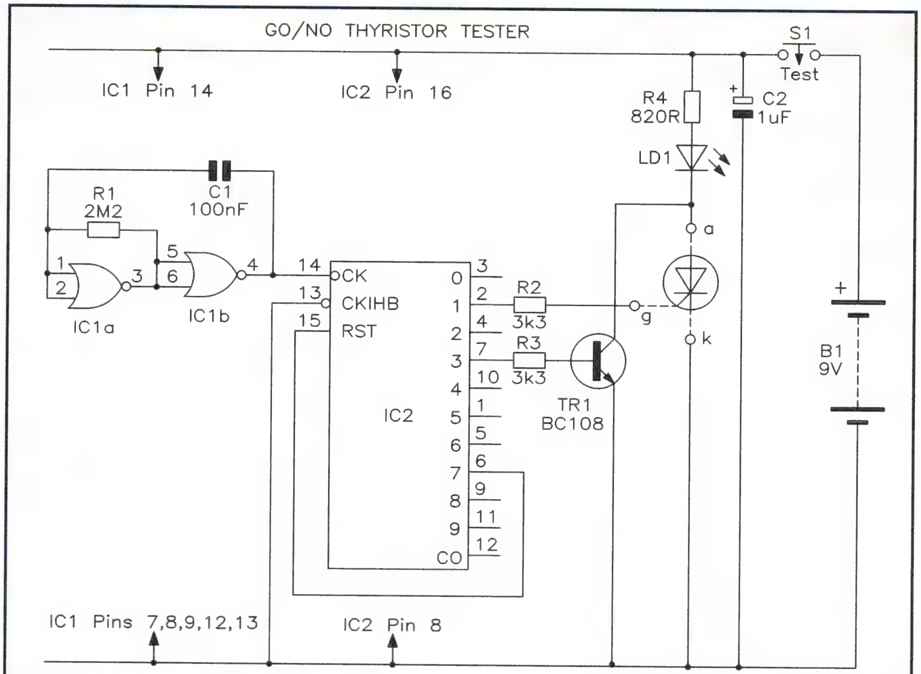


Figure 6. Go/no go thyristor tester.

Soil Moisture Tester

This circuit (Figure 7) was designed to give gardeners a quick indication of how wet or dry the soil is in their gardens or greenhouses. It can also be used to test how wet or dry the soil of house plants is. The usual way to determine the wetness or dryness of soil electronically is to measure the resistance of the soil, and then give some kind of visual or aural indication of its value. For a visual indication, you can use circuits that drive moving coil meters or bar graph displays. However, these can be costly. It was decided to use a circuit that gave an audible indication of soil resistance because it was cheaper, and with practice you can gauge the wetness of the soil quite quickly.

The circuit is described below. It is based around a well-known square wave oscillator circuit. IC1a is an integrator, with C2 being charged and discharged through RV1, the soil resistance, and R5. IC1b forms a Schmitt trigger circuit, whose switching points are determined by R3 and R4. When the soil is wet, its resistance will be low, and therefore C2 charges and discharges faster. Therefore, the frequency of oscillation of the circuit will be higher. When the soil is dry, the resistance between the probes will be higher, and C2 will charge and discharge at a slower rate, and the frequency of oscillation of the circuit will be lower. RV1 allows the frequency of operation to be varied when the circuit is in use. The frequency of operation can be varied between about 1·3kHz for very wet soil, down to 100Hz or less for very dry soil. R1 and R2 are biasing components for IC1a and IC1b, setting the non-inverting and inverting inputs to half of the supply voltage. C1 provides AC decoupling for R2. C3 feeds the output of IC1b to LS1. It may seem unusual not to have some kind of buffer circuit between the output of IC1b and the loudspeaker, but there is enough drive from the output of IC1b to drive a high impedance speaker at a reasonable volume. The current consumption of the unit is around 9mA.

To use the circuit, place the probes into the soil to be tested, press S1 and note the tone. A low tone means that your soil is dry and should be watered. A high tone means that your soil is wet and should not be watered.

There are no special construction requirements for this circuit. The probes were made using bolts, solder tags and nuts for fixing to whatever type of case you decide to use.

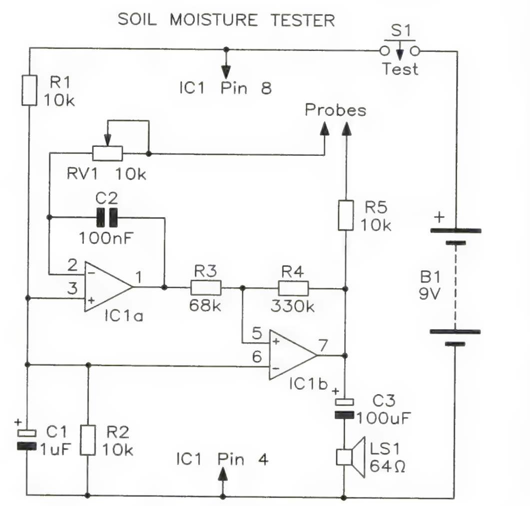
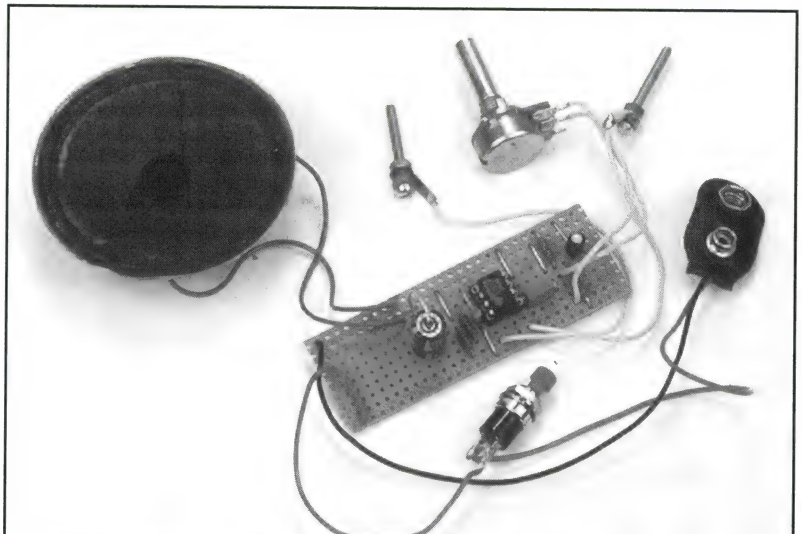


Figure 7. Soil moisture tester.



The assembled soil moisture tester.

Mini-Circuits PARTS LISTS

TWO-TONE TRAIN HORN

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

R1	4M7	1	(M4M7)
R2,4	10k	2	(M10K)
R3	2M2	1	(M2M2)
R5	39k	1	(M39K)
R6	47Ω	1	(M47R)
RV1	47k Miniature Horizontal Preset	1	(UH05V)

CAPACITORS

C1	100µF 10V Electrolytic	1	(FB48C)
C2,3	470nF Polyester Layer	2	(WW49D)
C4	33nF Polyester Layer	1	(WW35Q)
C5	2µ2F 100V PC Electrolytic	1	(FB15R)
C6	100µF 10V PC Electrolytic	1	(FF10L)

SEMICONDUCTORS

IC1,2	TS555CN	2	(RA76H)
IC3	NE555N	1	(QH66W)

MISCELLANEOUS

LS1	66mm Diameter 64Ω Speaker	1	(WF57M)
S1	Push to Make Switch (see text)	1	(FH59P)
S2	SPST Ultra Miniature Toggle	1	(FH97F)
B1	AA Size Cells	6	(FK55K)
	6 3 AA Battery Holder	1	(HQ01B)
	Battery Clip	1	(HF28F)
	8-Pin DIL Socket	3	(BL17T)

DIGITAL CAPACITANCE METER

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

R1,17, 22,25	10k	4	(M10K)
R2	560Ω	1	(M560R)
R3 to 16, R23	1k	15	(M1K)
R18	4k7	1	(M4k7)
R19,24	10M	2	(M10M)
R20	1M	1	(M1M)
R21	100k	1	M100K)
VR1	10k Miniature Horizontal Preset	1	(UH03D)

CAPACITORS

C1	100µF 10V Electrolytic	1	(FB48C)
C2	3n3F Polyester Layer	1	(WW25C)
C3	100nF Polyester Film	1	(BX76H)

SEMICONDUCTORS

IC1	4013BE	1	(QX07H)
IC2,3	4026BE	1	(QX15R)
IC4	TS555N	1	(RA76H)
IC5	4001BE	1	(QX01B)
Display 1,2	0·5in. Common Cathode 7-Segment Display	2	(FR41U)

MISCELLANEOUS

S1,2	Push to Make Switch	2	(FH59P)
S3	SPST Miniature Toggle Switch	1	(FH97F)
S4	6-Way 2-Pole Rotary Switch	1	(FF74R)
SK1	Miniature Red Crocodile Clip	1	(FM37S)
SK2	Miniature Black Crocodile Clip	1	(FK34M)
B1	AA Size Cells	6	(FK55K)
	6 3 AA Battery Holder	1	(HQ01B)
	Battery Clip	1	(HF28F)
	8-Pin DIL IC Socket	1	(BL17T)
	14-Pin DIL IC Socket	2	(BL18U)
	16-Pin DIL IC Socket	2	(BL19V)
	20-Pin DIL IC Socket	1	(HQ77J)

SIMPLE GRAPHIC EQUALISER

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

R1,2	100k	2	(M100K)
R3,6,9, 10,13, 14,17,18	1M8	8	(M1M8)
R4,5	3k9	2	(M3K9)
R7,8,11, 12,15, 16,19,20	15k	8	(M15K)
RV1,2,3,4	100k Linear Potentiometer	4	(FW05V)

CAPACITORS

C1	100µF 10V PC Electrolytic	1	(FF10L)
C2	1µF 100V PC Electrolytic	1	(FF01B)
C3	22µF 25V PC Electrolytic	1	(FF06G)
C4	4n7F Polyester	1	(WW26D)
C5	47nF Polyester	1	(WW37S)
C6	1nF Polyester	1	(WW22Y)
C7	10nF Polyester	1	(WW29G)
C8	220pF Polystyrene	1	(BX30H)
C9	2n2F Polyester	1	(WW24B)
C10	47pF Polystyrene	1	(BX26D)
C11	470pF Polystyrene	1	(BX32K)
C12	10µF 50V PC Electrolytic	1	(FF04E)

SEMICONDUCTORS

IC1	µA741C	1	(QL22Y)
IC2,3	MC1458CN	2	(QH46A)

MISCELLANEOUS

JK1,2	Standard ¼in. Jack	2	(HF91Y)
S1	SPST Ultra-Miniature Toggle Switch	1	(FH97F)
B1	PP3 Size Battery	1	(FK58N)
	PP3 Battery Connector	1	(HF28F)
	8-Pin DIL IC Socket	3	(BL17T)

AUDIO/VISUAL METRONOME

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

R1	47k	1	(M47K)
R2	3k3	1	(M3K3)
R3,4	1k	2	(M1K)
R5,6	5k6	2	(M5K6)
R7	56k	1	(M56K)
RV1	470k Linear Potentiometer	1	(FW07H)

CAPACITORS

C1,5	100µF 10V PC Electrolytic	2	(FF10L)
C2	47nF Polyester	1	(WW37S)
C3	330pF Ceramic	1	(WX62S)
C4	4n7F Polyester	1	(WW26D)

SEMICONDUCTORS

IC1	TS555CN	1	(RA76H)
IC2	4024BE	1	(QX13P)
IC3	NE555N	1	(QH66W)
D1,2	10mm Red LED	2	(UK28F)

MISCELLANEOUS

S1	SPST Miniature Toggle Switch	1	(FH97F)
LS1	77mm Diameter 8Ω Speaker	1	(YW53H)
B1	AA (HP7) Size Cells	6	(FK64U)
	Battery Clip	1	(HF28F)
	6 3 AA Battery Holder	1	(HQ01B)
	8-Pin DIL IC Socket	2	(BL17T)
	14-Pin DIL IC Socket	1	(BL18U)

MODEL TRAIN SIGNAL LIGHTS

RESISTORS: All 0·6W 1% Metal Film

R1,6	10k	2	(M10K)
R2	2M2	1	(M2M2)
R3,4,5	1k	3	(M1K)
R7	5k6	1	(M5K6)
R8	2k2	1	(M2K2)

CAPACITORS

C1	100µF 25V PC Electrolytic	1	(FF11M)
C2	1µF 100V PC Electrolytic	1	(FF01B)
C3	100nF Polyester	1	(WW41U)

SEMICONDUCTORS

IC1	NE555N	1	(QH66W)
IC2	4017BE	1	(QX09K)
IC3	4013BE	1	(QX07H)
D1	Green LED	1	(WL28F)
D2	Red LED	1	(WL27E)
D3	Orange LED	1	(WL29G)
D4	1N4148	1	(QL80B)

MISCELLANEOUS

S1	Miniature Reed Switch	1	(FX70M)
	Magnet	1	(FX72P)
	8-Pin DIL Socket	1	(BL17T)
	14-Pin DIL Socket	1	(BL18U)
	16-Pin DIL Socket	1	(BL19V)

GO/NO GO THYRISTOR TESTER

RESISTORS: All 0·6W 1% Metal Film

R1	2M2	1	(M2M2)
R2,R3	3k3	2	(M3K3)
R4	820Ω	1	(M820R)

CAPACITORS

C1	100nF Polyester	1	(BX76H)
C2	1µF 100V Electrolytic	1	(FB12N)

SEMICONDUCTORS

LD1	5mm Red	1	(WL27E)
IC1	CMOS 4001	1	(QX01B)
IC2	CMOS 4017	1	(QX09K)
TR1	BC107	1	(QB31J)

MISCELLANEOUS

S1	Push to Make Switch	1	(FH59P)
B1	PP3 9V Battery	1	(FK58N)
	Battery Clip	1	(HF28F)
	14-Pin DIL Socket	1	(BL18U)
	16-Pin DIL Socket	1	(BL19V)
	Red Crocodile Clip	1	(FM37S)
	Black Crocodile Clip	1	(FK34M)
	Yellow Crocodile Clip	1	(FK35Q)

SOIL MOISTURE TESTER

RESISTORS: All 0·6W 1% Metal Film

R1,R2,R5	10k	3	(M10K)
R3	68k	1	(M68K)
R4	330k	1	(M330K)
RV1	10k Linear	1	(JM71N)

CAPACITORS

C1	1µF 100V Electrolytic	1	(FB12N)
C2	100nF Polyester	1	(CX21X)
C3	100µF 10V Electrolytic	1	(FB48C)

SEMICONDUCTORS

IC1	TL082	1	(RA71N)

MISCELLANEOUS

S1	Push to Make Switch	1	(FH59P)
B1	PP3 9V Battery	1	(FK58N)
	Battery Clip	1	(HF28F)
LS1	64Ω 0·1W	1	(YT27E)
	8-Pin DIL Socket	1	(BL17T)
	6BA 3 1in. Bolt	2	(BF07H)
	6BA Solder Tags	2	(BF29G)
	6BA Nuts	4	(BF18U)

The circuits and information presented here must be considered as a basis for your own experimentation. No warranty is given for suitability in particular applications, reliability or circuit operation. Maplin cannot support, in any way, the information presented here. However, where possible, we will endeavour to check that information presented is correct, and that circuits will function as stated.

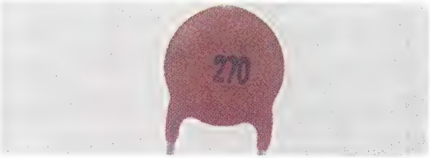
Mini-circuits text by Robert Penfold and J. K. Redpath.

Sealed Nickel Cadmium Batteries

Nickel cadmium (NiCd) cells will replace dry batteries in most medium and high current applications. They are very economical in applications where dry batteries constantly need replacing. They must be recharged using special constant current chargers but, even if the cost of the charger is added to the cost of the batteries, they still show a considerable saving over dry batteries after just a few changes. NiCd cells are not suitable for use in very low-power applications such as clocks, or any similar application where a dry cell would only need replacing infrequently.

All the batteries in the range should have a minimum life of at least 500 full charge/discharge cycles. Providing that the charge rate never exceeds the maximum current stated and the discharge rate never exceeds twice the current, the life should be around 3,000 full charge/discharge cycles. Cells may be charged at any current up to the maximum stated, but will take progressively longer to charge at lower currents. No harm will result if the cells are charged for longer periods.

Metallised Ceramic Plate Capacitors



A miniature ceramic capacitor with a cementcoated case. Values up to and including 220pF are suitable for temperature compensation in tuned circuits where low losses, close tolerance and high stability are required. Values from 270pF to 4700pF are for use in coupling and decoupling applications, where a non-linear change of capacitance with temperature is permissible. Values 10,000pF and 22,000pF are suitable for use in coupling and decoupling applications, where capacitance stability is not critical.

Specification

Tolerance:	
1·8pF to 4.7pF:	±0·25pF
5.6pF to 330pF:	±5%
390pF to 4700pF:	±10%
10,000pF and 22,000pF:	-20% +80%
Working voltage:	
1·8pF to 4700pF:	100V DC
10,000pF and 22,000pF:	63V DC
Insulation resistance:	>1000MΩ
Temperature coefficient:	
1·8pF to 220pF:	Zero
270pF to 390pF:	+350 to -1000ppm/°C
470pF to 4700pF:	medium K (±10%)
10,000pF to 20,000pF:	high K (+22% -82%)
Power factor:	
1·8pF to 390pF:	$<10x10^{-4}$
470pF to 4700pF:	$<25x10^{-3}$
10,000pF:	$<50x10^{-2}$
22,000pF:	$<25x10^{-2}$
Dimensions	
Thickness of body:	2·25mm max.
Lead spacing:	5mm
Lead length:	25mm

High Voltage Metallised Polyester Film

Conis

A range of high voltage,metallised polyester film capacitors that are suitable for a wide range of applications including supply decoupling, filter, integrator and audio circuits etc. These low-cost, non-inductive, self-healing capacitors conform to IEC 384-1/384-2.

Specification

Tolerance:	±10%
Dissipation factor:	$\tan\partial \le 100 \times 10^{-4}$/1kHz
Insulation resistance	
≤0.33µF:	10^4MΩ
>0.33µF:	10^3MΩ