Simple LED Timer

A low cost, easy-build unit that can be adapted to many simple timing applications.

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This project is essentially a variation on the chaser circuit, in which a series of LEDs are made to come on in sequence. This display format has been adapted to provide an indicating function which is used to show an elapsed preset time period. An audible output is triggered when the las LED is illuminated and the circuit is latched so that the alarm continues to sound until the circuit is turned off.

Although the component values have been chosen to suit a timing period of about four minutes, the circuit can be easily adapted so that the period is altered to suit other applications. The author uses his model as an audio/visual egg timer.

The design is intended to operate from a standard 9 volt battery. The circuit shown includes a buzzer but this can be replaced with any of the audible output circuits featured in this series, although it may be necessary to alter the transistor to one of a higher power to ensure that correct operation occurs.

How It Works

The circuit really contains three standard circuit building blocks, some of which we have already met in this series.

The first standard circuit block is the 555 timer astable circuit which is used, in this case, to provide a series of pulses which are used to clock the rest of the circuit through. The standard layout of the 555 timer astable is shown in Fig. 1a and this configuration produces an output waveform as shown in Fig. 1b.

The duration and interval between pulses produced by this circuit are determined by the values of R_A, R_B and C as shown by the two formulas given in Fib. 1b. By altering the values of the components in accordance with the given formulas the timer can be adapted to suit other applications.

The second building block is a standard "chaser" circuit using a 4017 Johnson Counter IC. This very useful IC provides a sequential series of outputs, which are used to drive the indicator LEDs, which change every time a clock pulse is received from the astable circuit.

The IC is provided with a "clock enable" input which is connected to the last output so that when this output is energized the clock is "locked". This provides a latching function which is used to keep the last building block (the alarm) operating until the circuit is switched off.

The final building block is a simple, single transistor current amplifier which is used to provide the current needed to drive the output buzzer, which requires more current than could be provided by the Johnson counter.

Circuit Description

The complete circuit diagram for the Simple LED Timer is shown in Fig. 2. The clock pulse required to advance the chaser circuit is provided by IC1, R1, R2, VR1, and C1. This is virtually the same as that shown in Fig. 1a with the combination of preset VR1 plus resistor R2 taking the place of R_B. The addition of VR1 to the fixed resistor enables the time between the clock pulses to be adjusted, for instance, if used as an egg timer it can be calibrated to give exactly the correct time period which is in fact spread over the nine pulses required for the sequence.

Because IC2 is a CMOS device, the bipolar 555 timer can *not* be used in this project and IC1 *must* be the CMOS version, i.e. ICM7555 or TLC555C. There is however, some gain in the fact that the CMOS timer does not require the connection of a capacitor between the 0V power supply rail and pin 5.

The chaser function for the display is provided by IC2, which is a 4017 Johnson Counter. This IC has two inputs which can be configured in different ways so as to provide a number of different functions.

In this circuit the output from the IC1 is connected to pin 14 (one of the clock inputs) of IC2, and pin 13 (used in this case as a clock enable input) is connected to output O_9 (pin 11) of IC2. While O_9 is at the logic 0 (0 volts) level, pin 13 is also held at logic 0.

In this condition the outputs O_0 to O_9 of the 4017 each go to the logic 1 (battery voltage) state in turn, changing every time that the clock pulse at pin 14 changes from the logic 0 state to the logic 1 state (the change going from loci 1 to logic 0 state is ignored) for as long as pin 13 is in the logic 0 state. This continues until O_9 (pin 11) is energized going to the logic 1 state. Because this output is connected to pin 13, which acts as a clock enable input this is also forced to the logic 1 state, causing IC2 to latch in its existing state, keeping pin 11 in the energized state and causing all further pulses at pin 14 to be ignored.

Capacitor C1 and resistor R3 form a very simple pulse circuit which makes the Master Reset input (pin 15) go momentarily to the logic 1 state. This cause the 4017 to be reset so that output O_0 (pin 3) is energized, as

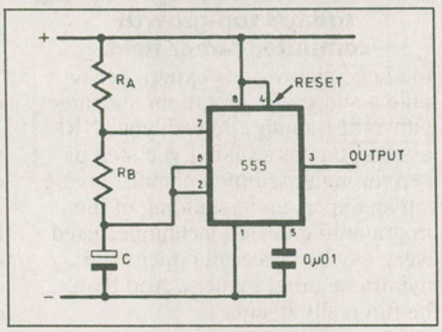


Fig. 1a. Using the 555 timer in the astable mode.

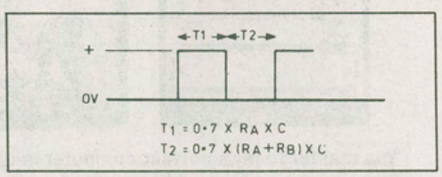


Fig. 1b. 555 timer astable timing diagram.

soon as the timer is turned on.

Display

The ten outputs from the 4017 are each connected to an indicator LED (D1 to D10) through a 330 ohm dropping resistor (R4 to R13). The LEDs work in the same way as ordinary diodes, by allowing a current to flow through in one direction, but not in the other. When a current flows through the LED it glows.

It is important that the LED is not subjected to excessive current and the dropping resistors are included to restrict the current flowing through the LED to a safe level. The LEDs are made to illuminate in turn as each of the outputs of IC2 goes to the logic 1 state.

Current Amplifier

Output O_9 from IC2 is also connected via resistor R14 to the base of TR1. This transistor is used as a simple current amplifier to energize the audible warning device, WD1. When a current is allowed to flow through the base/emitter junction of TR1 it causes a larger current to be drawn through WD1 and the collector/emitter circuit of TR1, causing the buzzer to sound.

Capacitor C3 is a tantalum capacitor which is used to provide smoothing (decoupling) of the power supply rails in all CMOS circuits. This component is necessary to ensure correct operation of the circuit.

Construction

The timer project is easily made up using two stripboards as shown in the photographs and in Fig. 3 and Fig. 4. You

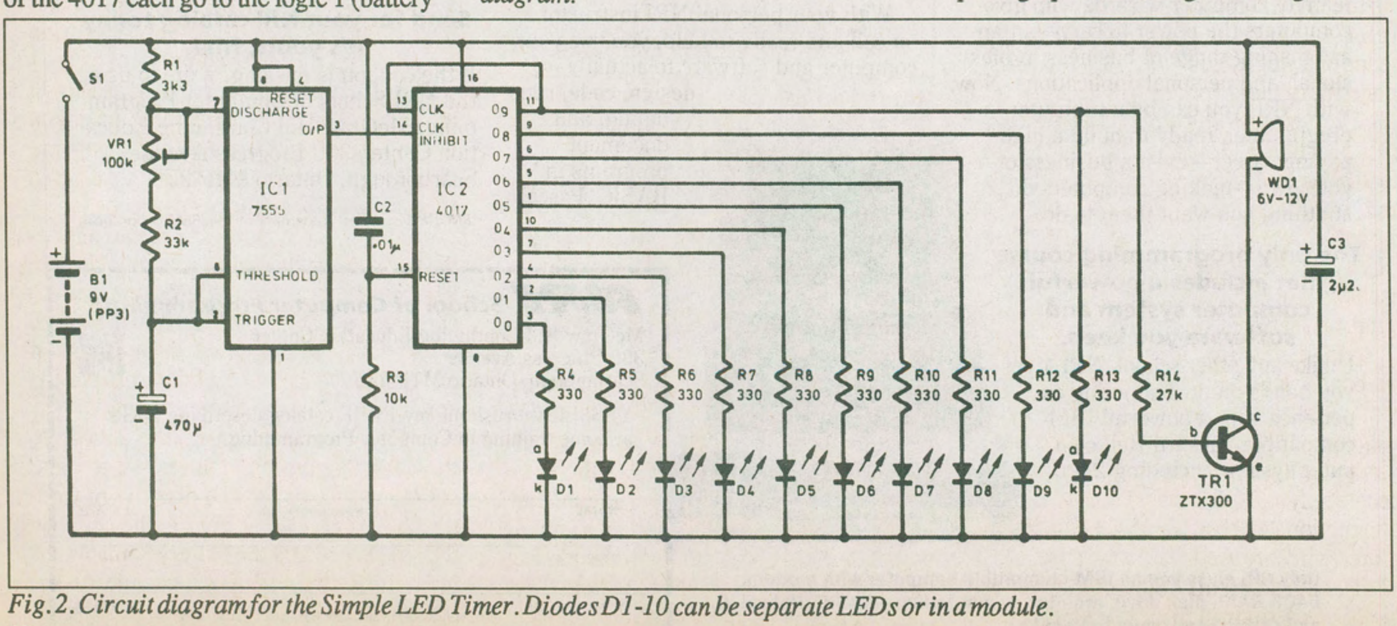


Fig. 2. Circuit diagram for the Simple LED Timer. Diodes D1-10 can be separate LEDs or in a module.

will probably find it helpful to look at those while you make up the circuit.

The first task is to cut two pieces of stripboard to the correct size. You will need one piece, used for the main circuit board, which is 16 strips deep and 29 holes wide and another, used for the display, which is 16 strips deep by 14 holes wide. The sizes allow for drilling 4mm mounting holes in the positions shown, before starting to construct the circuit.

Similarly, before any components are mounted on the stripboards, you will need to break the copper tracks, as shown in Fig. 3 and Fig. 4. It is important that these track breaks are made completely so that not even the merest sliver of copper remains to bridge any tracks.

Although it does not make any difference to the operation of the circuit which order you make up the two boards or which order you insert the components into the boards you will probably find it best to make up and test the display board first and then go on to the main circuit board. The making up of both boards is easier to do if the components are inserted and soldered in ascending order of size.

Display Board

The display board is the simpler of the two boards to make up. The prototype of this project used a ten-way LED module as the display but there is no reason why you should not make use of ten single LEDs instead if you prefer. The first stage of making up this board is to connect the wire links shown Fig.3.

There are a number of wire links required to make the common 0V connection to the LED cathodes (k) and you may prefer to make these connections by means of a single bare wire soldered to the underside of the stripboard.

The next stage is to insert the DIP socket used for the LED display, followed by the display itself. If discrete LEDs are being used, insert them into their correct places and solder them in place. These LEDs are polarity sensitive so it is important to ensure that they are connected the correct way round, or else they won't work.

Also at this stage the wires linking the two boards together can be attached to the display board. Although the board has been designed so that ribbon cable can be used stranded, single-core wire can also be used successfully. If single wires are used then construction will be made easier if different colored wires are used for this purpose.

Testing and fault finding of the timer should be carried out prior to inserting the boards in a suitable case.

Display Board Testing

It is advisable to test the display board separately *before connecting it to the main driver board.* This is simply done by connecting the negative of the battery to the *common* connection on the board and touching *each* of the wires connected to the anodes (a) of the LEDs, via the associated dropping resistors to the positive connections of the battery in turn.

Each LED should light up as the connection is made. If none of the LEDs light up then the most likely causes are either that the 10-way LED module (if you are using one) is inserted into its holder the wrong way round or that there is a faulty connection in the common wire connecting all the cathodes (k) to the battery negative.

The first fault can be cured by rotating the module through 180 degrees. The second fault will have to be traced by testing the continuity (using the meter's "ohms" range) between the battery end of the common wire and its connections on the board.

If some of the LEDs light but not all then it will be first necessary to check whether there is a pattern as to which diodes light and which do not. If there is a point in the sequence up to which they light and then the rest do not then it is likely that there is a break in the links joining the commoned cathodes together. This can be traced as described above.

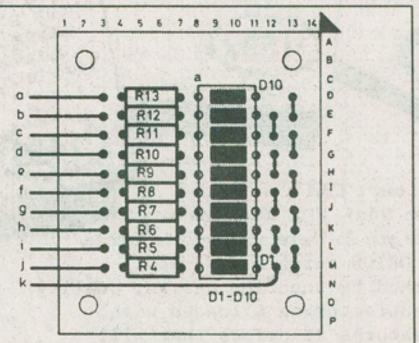
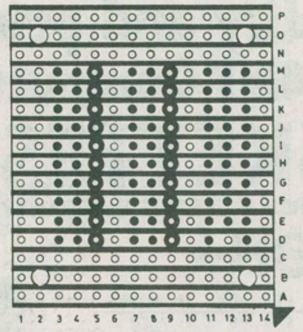


Fig. 3. Display board component layout and track cuts.



If there is no pattern as to which LEDs light and which do not then it is most likely that there are individual faults in each of the circuits leading to the anodes of the LEDs via the associated series resistor. The complete circuit, from the wire leading to the main board, through the series resistor and the connection to the anodes should be thoroughly checked with a meter to ensure complete continuity of the circuit. If neither of these checks reveals any explanation as to why a correctly installed LED does not light then it must be assumed that it is faulty and should be replaced.

Main Board

After the display board has been made and checked it is now time to construct the main board, starting by inserting the wire links as shown in Fig. 4.

The next task is to put the resistors in their correct places by first bending the wires of the resistor at right angles to the body of the component, so that they will fit through the holes, as shown in Fig. 4. Also fit preset VR1 into the correct position and solder it into place.

The next item to be inserted into position is the IC holder. Although it is possible to solder the IC directly into place using a socket will both make the construction simpler and make for easier replacement if a fault should occur. It is important that you take care to make sure that the notch on the IC holder is facing towards the bottom of the stripboard as this will help you when inserting the ICs into place.

Next come the capacitors. C2 is a non-polarized capacitor so it does not matter which way round it is inserted by C1 and C3 are electrolytic capacitors so it is important that they (the -ve connection usually marked on the component case — see photographs) are connected as shown in Fig. 3. Similarly care must be taken when mounting the transistor to ensure that its orientation corresponds with that shown in Fig. 3 and the photographs.

The final component to be mounted is the buzzer or other audible warning device. This device if often polarity sensitive so care must be taken, if the device is marked with polarities on the case or by means of red and black colored wires, to make the connections with the correct polarity.

The wires connecting the battery to the circuit board can then be tinned and soldered into place. The black wire from the battery connector goes to the point on the stripboard and the battery connector's red wire will need to go to one of the switch terminals. Another wire is connected between the other switch terminal and the B1+V connection on the stripboard. The tested display board can now be connected to the main board taking care to ensure that the connections match exactly those shown in the board layouts.

The final step is to insert the ICs into their holders, making sure that the notch or indentation on the IC corresponds with the notch on the IC holder. Some ICs do not have a notch in one end but have a slight, circular dent near pin one.

Main Board Testing

Before connecting the battery and testing the circuit you should carefully examine the stripboard to make sure that all of the components are inserted into the correct places, are the correct way round and that there are no blobs of solder shorting out the tracks. Once the board has been checked then the battery should be connected and you should be able to see the LEDs turning on in turn and be able to set the rate of this by adjusting VR1.

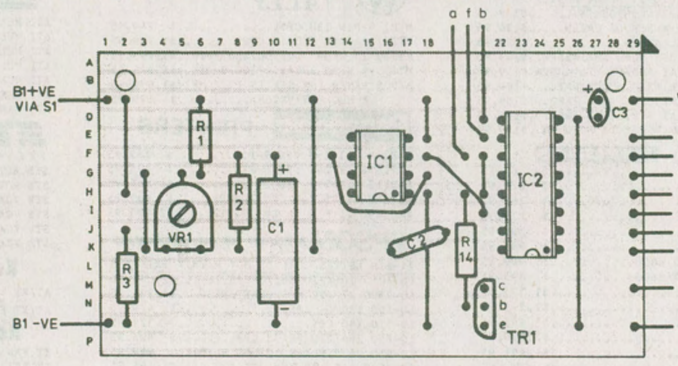
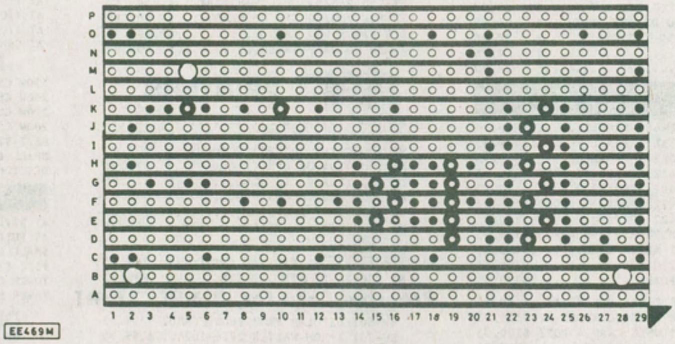


Fig. 4. Main stripboard component layout and details of track cuts.



If the circuit does not operate correctly it will be necessary to check for faults. You will probably find that you will need the aid of a multimeter to perform this stage of the process.

Clock Generator

Check that the clock generator circuit, comprising R1, VR1, R2, C1 and IC1, is operating correctly. The best method of doing this is to use a voltmeter to measure the output voltage at pin 3 of IC1. If the clock circuit is operating correctly then the meter needle should be seen to register a slow pulse at approximately 30 second intervals.

If this does not happen then the next stage is to perform some basic voltage checks. You should be able to measure the battery voltage between an 0 volt connection and both pins 8 and 4 of IC1 as well as between the Battery+ connection to the board and pin 1. If these voltages are not present this will indicate faulty wiring up of the stripboard.

If this does not produce a satisfactory solution then the output voltage at pin 3 of IC1 should be checked. If this is locked permanently at a fixed voltage then you should remove the IC from its socket and check the voltage at pin 3 connection again. If the voltage persists with IC1 removed then the fault does not lie with IC1 but possibly with the wiring associated with the IC and the output to IC2 or its associated wiring.

The next step is to replace the IC and check the voltages at pins 2, 6 and 7. The voltage at pin 7 should be fluctuating slowly around a value which is roughly between 1/3rd and 2/3rds of the battery voltage. The voltages ate pins 2 and 6 should be identical (because these two pins are connected together by a wire link) and these should also be fluctuating but at a voltage slightly less than that found at pin 7.

If both of these voltages are not present then the most likely cause is that the circuit from the + voltage rail, through VR1, R1 and R2 is not correctly made. This is best checked by measuring the voltage present between 0 volts and each of the points in the component chain through VR1, R1, R2 and C1 and investigating at the junction where no voltage is measured.

If no voltage is present between 0 volts and pin 7 but no voltage, or only a very small voltage, is measured between the 0 volts rail and pins 2 or 6 of IC1 then you should check that the resistance between pins 7 and 6 of IC1 is roughly equal that of resistor R2. If this is correct then check the resistance of capacitor C1 with the resistance range of your meter.

If the resistance is very low (less than about 500 ohms) then you should replace C1. If there is no voltage measurable between pins 6 and 2 of IC1 then this could be caused by a short circuit between the connections of C1 or by a short circuit within C1 or its connections to the stripboard.

If voltage is present at pins 2 and 6 of IC1 but it does not fluctuate then the likely causes are that C1 is not correctly connected, is faulty or that IC1 is faulty. To check C1 you should touch connect another capacitor of similar value across the connections to see if this cures the fault. If this does not cure the fault check that the connection between the positive connection of C1 and pins 2 and 6 of IC1 is correctly made.

Counter

If voltage switching is taking place at the output of IC1 then the IC is working correctly and the fault is most likely to lie in the area of IC2 and its associated components. The first stage is to check that the power supply is correctly connected to pins 8 and 16. In case this voltage cannot be measured then you should check the connections to pin 8 and 16 and ensure that the wire links have been correctly made.

The next stage is to check that the clock pulses from pin 3 of IC1 are being correctly received at pin 14 of IC2. As these pulses are somewhat slow you may find it helpful to replace capacitor C1 with a lower value capacitor at this stage.

If the clock pulses are being correctly received at pin 14 of IC2 then it is necessary to check that pin 15, the master reset input, is at logic 0. If a logic 1 state exists at this point the circuit will be locked with output 0o permanently in the high state. If a logic 1 state is found at pin 13 then you should check very carefully for solder bridges between pins 15 and 16 of IC2.

If the clock pulses are being received at pin 14 and pin 15 in the logic 0 state, then the counter should advance by one for every clock pulse received, provided that pin 13 (the count enable input) is in the logic 0 state. Because this pin is connected to pin 11 of IC2 then the counter should advance until pin 11 is forced to the logic 1 state.

Now check the logic state of pin 3, which should be at logic 0 (0 volts). If the logic state at pin 13 is logic 1 or an indeterminate logic state then the connections between pins 13 and 11 (which is a wire link) should be carefully checked.

If this connection is correct, with no accidental connection between either of these pins and the battery supply line, then the states of the output pins of IC2 should be checked. You should find that only one of the outputs (pins 1, 2, 3, 4, 5, 6, 7, 9, 10 and 11) should be in the logic 1 state and all other outputs should be in the logic 0 state.

Immediately the device is switched on pin 3 should be at the logic 1 state. If this is not the case then the problem may possibly be that the master reset input (pin 15) is not receiving a quick reset pulse from the circuitry made up of capacitor C2 and resistor R3. The connection between the battery supply rails and these two components as well as that between the junction of R3 and C2 and pin 15 of IC2 should be checked.

If more than one of the outputs is in the logic 1 state then one must suspect that IC1 is faulty and must be replaced. Assuming that the LED display board has been checked and connected up to the main board beforehand then the states of these outputs may be monitored by observing the illumination of the LEDs on the display board to the main board. If more than one LED lights at the same time then the connections between the ribbon cable joining the display to the main stripboard should be carefully checked to ensure that there are no solder bridges between adjacent tracks.

Alarm

The final part of the project to check is the alarm. This is very simple since it comprises a resistor, a transistor and an audible warning device. If the audible warning device does not sound when the last LED is illuminated then the circuitry associated with TR1 should be checked.

An initial test is to short out the emitter and collector of TR1, with a small piece of wire, and see whether the audible warning device sounds. If this produces no effect then WD1 should be inspected to ensure that it has not been connected with the wrong polarity. If the polarity is correct, the connections from the positive power supply rail to WD1 and from the warning device to the collector of TR1 and from the emitter of TR1 to the strip carrying the battery negative connection should be checked.

PARTS LIST

Resistors

R1	3k3
R2	33k
R3	10k
R4 to R13	330
R14	27k

All 0.25W 5% carbon.

Potentiometer

VR1	100k min. preset, horiz.

Capacitors

C1	470u elec. 10V
C2	0u01 mylar 16V
C3	2u2 tantalum 10V

Semiconductors

D1-D10	10-way bar LED array (or 10 single LEDs)
TR1	ZTX300, 2N3904 NPN
IC1	CMOS 7555 timer
IC2	4017 10-stage Johnson counter

Miscellaneous

S1	SPST switch
WD	6V-12V solid state buzzer
B1	9V battery

Stripboards, 17 strips X 29 holes (main board) and 16 strips X 14 holes (display); 16-pin IC socket; 8-pin IC socket; plastic case; self-adhesive stand-offs; battery connector; connecting wire; solder, etc.

If the audible warning device is working correctly then the operation of the transistor can be checked by making a temporary link, with IC2 removed from its socket, between pins 16 and 11 of IC2. This should produce a battery voltage measurable between the end of resistor R14 furthest away from the base of TR1 and 0 volts. If this does not occur then the connection between pin 11 and the IC end of R14 should be investigated.

With a battery voltage present at the junction of resistor R14 and pin 11 of IC2, a voltage of approximately 0.7V should be measurable between the base and the emitter of transistor TR1. If no voltage is measurable here then the resistance of R14 should be measured to endure that it is actually acting as a resistor and not an open circuit. If this does not produce a resistance reading, close to the value specified for R14 and TR1 is connected the correct way round, then TR1 must be suspected of being faulty and should be replaced.

Case

This project has been designed to fit inside a case. The first stage of preparation of the case is to cut, carefully, a hole in the case lid, the correct size to accommodate the LED display. This should be carefully measured, taking into account the need to allow for stand-offs into which the mounting holes on the stripboard containing the display will fit. For this reason the positioning of the display should be done with some care. It is also necessary to drill a hole in the case lid to accommodate switch S1. Once the necessary holes have been drilled in the case lid it can then be lettered and the lettering protected with several layers of clear, spray on varnish.

Self adhesive stand-offs should be mounted on the component side of the display board and the board offered up to the inside of the case lid. When the display is correctly seated in the hole cut for it then the pads may be pressed firmly into place to hold the board in the correct position.

Self adhesive stand-offs can also be fitted to the main board (with the pads on the track side this time). The main board can be offered into place and the self adhesive pads pressed firmly onto the bottom of the case to hold the stripboard into the correct position. The battery can now be replaced in the battery clips, the circuit tested and preset VR1 adjusted to give the correct timing period before finally screwing down the case lid.

In Use

The timer is very simple to use. All that is necessary to do is to operate switch S1, at which point D1 will come on. The remaining LEDs will then come on in order, at approximately half minute intervals, until D10 is illuminated at the time that you have preset by adjusting VR1. When D10 comes on the audible warning device will sound and will continue to sound until S1 is switched off. ■