PROJECT

Four-Way Chaser

Using the CMOS version of the 555 timer to produce a simple LED light chaser.

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This project features a simple chaser circuit which can be easily redesigned to give a number of chase patterns for between two and ten output circuits. It is a truly digital project and should provide an interesting introduction to digital electronics for anyone who has been unsure about using such ICs in projects.

The major advantage of digital circuitry over other forms of circuitry is that it operates on only two voltage levels. These are the power supply (referred to as LOGIC 1) and 0 volts (referred to as LOGIC 0).

Circuit Description

The full circuit diagram for the Four-Way Chaser is shown in fig. 1. In effect this circuit consists of two basic building blocks. These are the clock pulse generator, which is made up of preset VR1, resistors R1, R2, capacitor C1 and IC1. this is used to drive the chaser circuit which consists of IC2 and the output LEDs D1 to D4.

The clock uses a standard 555 timer circuit. However, in this project it is important that a CMOS 555 timer (such as the 7555) is used, because the cheaper, bipolar version is not suitable for circuits which also include digital elements. The CMOS ICM 7555 timer does not require the connection of the capacitor between 0 volts and pin 5 that you may have noticed in some circuits using the bipolar device.

To produce the clock pulses, the timer is configured as an astable, so that its output (at pin 3) will be switched off (logic 0 state) and on (logic 1 state) repeatedly. The duration of the ON state is set by the values of the preset VR1, resistor R1 and capacitor C1 and this can be calculated by using the formula:

ON time = 0.7 x (VR1* + R1) x C1

[Time measured in seconds, resistance in ohms and capacitance in Farads.]

The OFF time between each *on* period can also be calculated by using the formula:

OFF time = 0.7 x (VR1* + R1 + R2) x C

The circuit shown incorporates a preset potentiometer wired as a variable resistor, VR1, which is included so that the actual speed of operation of the clock can be adjusted as desired by adjusting the wiper of VR1. Only the part of the resistance which is actually incorporated into the circuit is included in the two timing formulae given above.

Chaser Circuit

The chaser circuit consists, very simply, of a 4017 Johnson Counter which is used to turn on the output LEDs D1 to D4 in sequence. The 4017 has two clock inputs (at pins 13 and 14). These operate with opposite sense inputs and for the purposes of this circuit the clock pulse from pin 3 of IC1 is connected to pin 14 of IC2 with pin 13 of IC2 held at the logic 0 level by being connected to the 0 volts power supply rail.

In this arrangement each pulse from the output of IC1 causes the outputs of IC2 to go to the logic 1 state in sequence. As we only require four LEDs to be driven by this circuit only outputs 0 (pin 3), 1 (pin 2), 2 (pin 4), and 3 (pin 7) are used to drive the LEDs. The fifth output to be energized in sequence (4 — pin 10) is connected to the Master Reset input (pin 15). The effect of this is that whenever output four (pin 10) goes to the logic 1 state this immediately triggers the Master Reset circuit within IC2 which in turn resets the counter to zero with output 0 once more in the logic 1 state.

Each of the outputs 0 to 3 is connected to an LED, via a 330 ohm series resistor (R3-R6). These resistors are necessary to restrict the current flowing through the LED to a safe level to prevent them burning out.

Capacitor C2 is included in the circuit to provide the decoupling necessary to prevent the rapid switching which occurs within the ICs from scrambling the sequence generated by IC2.

Construction

The Four-Way Chaser is easily made up using stripboard. The finished board is shown in the photographs and the component layout in Fig. 2 so you will probably find it helpful to look at those while you make up the circuit.

The first task is to cut a piece of stripboard to the correct size. You will need a piece which is at least 14 strips deep and 46 holes wide. You will need to drill the mounting holes as shown, using a 4mm drill, before starting to construct the circuit.

Before any components are mounted on the stripboard you will need to break the copper tracks as shown in Fig. 2 with a stripboard cutter or a small drill. It is important that these track breaks are made completely so that not even the merest sliver of copper remains to bridge across the track break.

Once the board has been prepared you can start the electronic construction. Although the operation of the circuit is not affected by the order in which you insert the components into the stripboard, you will find it easier to construct the circuit if the components are inserted in ascending order of size.

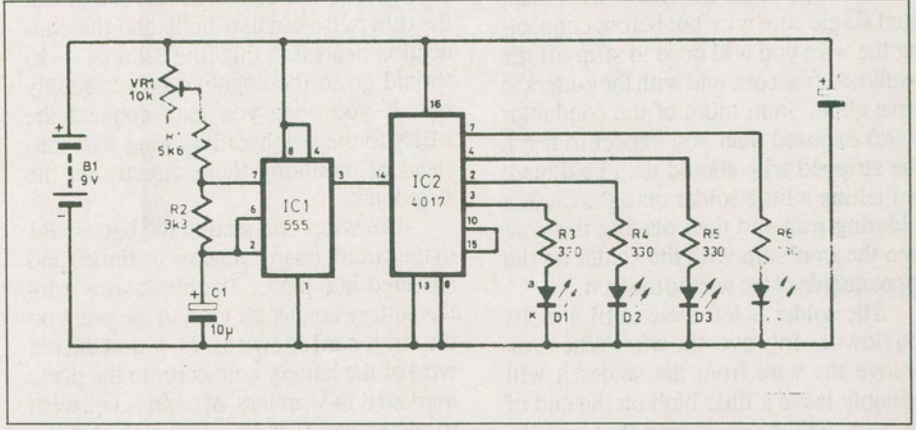


Fig. 1. The circuit diagram of the Four-Way Light Chaser.

PARTS LIST

Resistors
R1 ....5k6
R2 ....3k3
R3-R6 330
All 0.25W 5% carbon

Potentiometer
VR1 10k min. horizontal trim

Capacitors
C1 ....10u elec. 10V
C2 ....2u2 tantalum 10V

Semiconductors
D1-D4 ....LED
IC1 ....ICM7555 CMOS timer
IC2..... 4107 CMOS Johnson counter

Miscellaneous
B1 ....9V battery
S1...... SPST toggle switch (optional)

Stripboard, 0.1in matrix 14 strips x 46 holes; case (optional); l.e.d. clips (optional); battery clips; connecting wire; solder, etc.

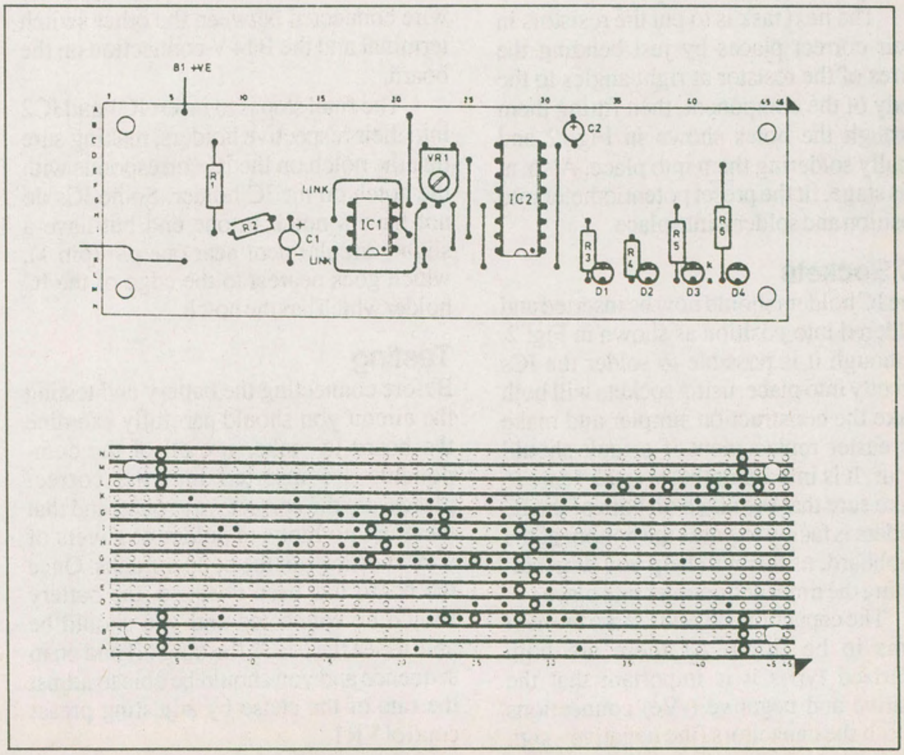


Fig. 2. Stripboard component layout and details of breaks required in the underside copper strips. The ICs should be in sockets.

Link Wires

The first stage in constructing this circuit should be to insert the wire links into place. To do this you should place the stripboard so that the strips of copper on it are underneath the board and run from left to right and not up and down.

Starting at the top left hand corner of the board count across and then down the correct number of holes until you can place one end of the wire link in the position shown in Fig. 2. Turn the board over and solder the wire into place. Cut off any excess wire on the underside of the board with your cutters and turn the board over again for the other end of the link wire.

The wire links are made with insulated single core wire but before connecting the wire you will need to strip off the insulation from one end with the cutters to leave about 3mm more of the conductor (wire) exposed than you expect to need. The stripped wire should then be tinned, by melting a little solder onto the bit of a soldering iron and then placing the wire onto the iron's tip with the solder on the opposite side of the wire to the iron.

The solder is left there until it melts and flows evenly over the wire. When you remove the wire from the solder it will probably leave a little blob on the end of the wire, which you should then cut off. The tinned wire should now fit easily through the hole in the stripboard.

The next task is to put the resistors in their correct places by just bending the wires of the resistor at right angles to the body of the component, then fitting them through the holes shown in Fig. 2 and finally soldering them into place. Also, at this stage, fit the preset potentiometer into position and solder it into place.

IC Sockets

The IC holders should now be inserted and soldered into position as shown in Fig. 2. Although it is possible to solder the ICs directly into place, using sockets 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 both of the IC holders is facing towards the bottom of the stripboard, as this will help you when inserting the timer and counter into place.

The capacitors C1 and C2 are the next items to be fitted. As these are both polarized types it is important that the positive and negative (-Ve) connections of both the capacitors (the negative - sign is usually marked on the component case) are connected to the correct holes marked in Fig. 2 . Failure to mount these components correctly will, at least, cause the risk of the circuit not working.

Both of the capacitors are easy to mount because they have leads which push into the board without needing to be bent. But, because the capacitor's connections are so close together, it is important that you take great care with the process of counting the holes when looking for the correct place to install these components.

The final components to be mounted are the LEDs D1 to D4. These devices are also polarized but the result of not connecting them the correct way round is simply for the circuit not to work. The case of each LED has a small flat on one side of the otherwise circular body and the connection nearest to this (the cathode — k) should go to the negative power supply rail. If you wish you may connect the LEDs to the stripboard by long wires instead of mounting them directly on the stripboard.

The wires connecting the battery B1 to the circuit board can now be tinned and soldered into place. The black wire from the battery connector goes to the point on the stripboard shown as B1-V and the red wire of the battery connector to the place marked B1+V, unless, of course, you wish to add an on/off switch. In which case the battery connector red wire will need to go to one of the switch terminals and another wire connected between the other switch terminal and the B1+V connection on the board.

The final step is to insert IC1 and IC2 into their respective holders, making sure that the notch 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 one pin (pin 1), which goes nearest to the edge of the IC holder which has the notch.

Testing

Before connecting the battery and testing the circuit you should carefully examine the board to make sure all of the components are inserted into the correct places, are the correct way round and that there are no blobs of solder or slivers of wire shorting out the copper tracks. Once the board has been checked, the battery should be connected and you should be able to see the LEDs flashing off and on in sequence and you should be able to adjust the rate of the chase by adjusting preset control VR1.

If the circuit does not operate correctly it will be necessary to check for faults. The first step in fault finding is to check carefully, once more, that all of the components are in the correct places and are the correct way round. In this project the components likely to cause faults if connected the wrong way round are the LEDs, C1, C2 and IC1 and IC2.

The next stage is to check carefully that all of the soldered joints are good joints. This is probably best done by reheating the joint with a soldering iron.

If no mechanical problems of the sort mentioned above are found then it will be necessary to check the circuit through to see whether there is a faulty component or not. You will probably find that you will need to use a multimeter to perform this stage of the process.

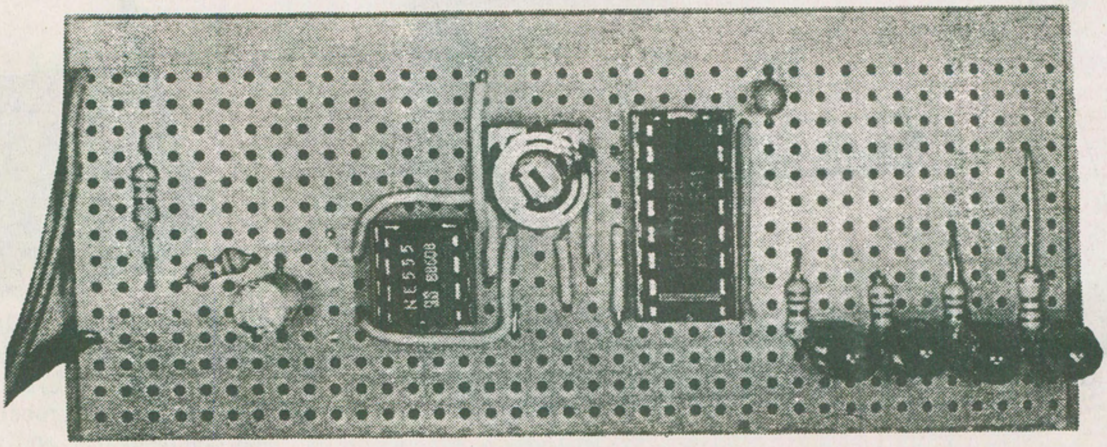
Fault Finding

When fault finding it is important to adopt a logical approach to the problem, the first step being to look at the symptoms presented by the circuit and decide which is the most likely part of the circuit to produce the fault. The circuit description above will help you here.

The logical place to start is by checking that there is an output from the clock circuit. To check this simple place the multimeter so that the positive probe is connected to pin 3 of IC1 and the negative probe of the meter is connected to any 0V connection, such as pin 1 of IC1. If the clock circuit is operating correctly you should see the meter needle swing rapidly back and forth. If this is not happening you should investigate further by testing the voltages present at various points in the circuit.

Firstly you should measure the battery voltage with the battery disconnected from the circuit and then between any 0V connection and both pins eight and four of IC1 as well as between the battery positive connection to the board and pin 1. If there are no voltages present when a good battery is connected to the board this will obviously indicate faulty wiring up of the board.

If the output voltage at pin three is locked permanently at a fixed voltage then you should remove IC1 from its socket and check the voltage at the pin three connection again. If the voltage persists with the IC removed then the fault does not lie with IC1 but most possibly with the wiring associated with the input to IC2. Similarly a permanent 0V at pin three of IC1 might be caused by a short between pins 13 and 14 of IC2 or the 0V connection to pin 13 having been inadvertently connected to pin 14.



Layout of components on the completed prototype board. Note that the timer i.c. is not the required CMOS version.

The next stage is to replace IC1 in its holder and check the voltages between 0V and pin two, pin six and pin seven. The voltage at pin seven should be fluctuating around a value which is roughly 2/3rds of the battery voltage. The voltages at pins two and six 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 seven.

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

If a voltage is present between 0V and pin seven but no voltage, or only a very small voltage, is measured between the 0V rail and pins two or six of IC1, then you should check that the resistance between pins seven and six of IC1 is roughly equal to 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 capacitor C1. If there is no voltage measurable between pins six and two 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 two and six of IC1 but it does not fluctuate then the likely causes are that the capacitor C1 is not correctly connected — which can be checked by reheating the joints of C1 on the stripboard — 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 then you should check that the connection between the positive connection of C1 and pins tow and six of IC1 is correctly made.

Chaser Circuit

If voltage switching is occurring at pin three of IC1 then the clock circuit is working correctly and the fault must lie within the chaser circuit. Again a few voltage checks need to be made to help with the diagnosis of any chaser circuit faults.

Check that the signal from pin three of IC1 is repeated at pin 14 of IC2. There should be no wiring problem here as the connection is made by a direct copper strip.

If the signal is not reaching pin 14 of IC2 then the only real explanation is that there is a poor soldered joint either at the connection of the strip to pin three of IC1 or to pin 14 of IC2.

The next step is to check that the battery voltage is measurable between pins eight and 16 of IC2. If this is not measurable then the connections between the power supply rails and the IC should be investigated.

The battery voltage should be measurable when the positive meter probe is connected to pin 16 and the negative probe is connected to pin 13. If this does not occur the connection between the 0V power supply rail and pin 13 should be investigated.

The final input to be investigated is pin 15. This pin (and pin 10) should be at logic 0 (0V) for virtually the whole of the time. The very brief time for which these two pins are at logic 1, which occurs at the reset point, is so small at to be almost unmeasurable. If the voltage readings at pin 10 and pin 15 are not the same then the connecting link should be checked.

If the above tests reveal nothing untoward the final step is to check the outputs. If all of the other connections to IC1 are correct the outputs 0 to 3 must either be switching from Logic 0 to Logic 1 in sequence or the IC is faulty.

Whenever any of the outputs goes to the logic 1 state its associated LED (D1 to D4) should light. If this does not happen then the connections between the appropriate output pin and LED should be investigated. The most likely cause of this problem is that the LED is inserted into the board with the polarity reversed or that there is at least one dry joint in the series of connections from IC2 outputs, through the dropping resistor and LED to the 0V line.

In Use

The project is simple to use. Once you have checked that it works correctly, you can simple set VR1 to give the correct speed of operation and place the LEDs in the desired position.