Top Tenners

STEEPLECHASE GAME

OWEN BISHOP Project 2

This short collection of projects, some useful, some instructive and some amusing, can be made for around the ten pounds mark. The estimated cost does not include an enclosure, for many of them work just as well as an open board.

All of the projects are built on stripboard, and have been designed to fit on to boards of standard dimensions. All of the projects are battery-powered, so are safe to build. In a few cases in which, by its nature, the project is to be run for long periods, power may be provided by an inexpensive mains adaptor. Again, the cost of such a unit is not included because most spares boxes contain a few of these, possibly pensioned off from obsolete electronic gadgets.

AT FIRST glance, this is a very simple game. There is a row of seven l.e.d.s across the top edge of the circuit board, all of them red except for the one on the right, which is green. A timer drives a counter that turns on the l.e.d.s one at a time, starting from the left, in order.

The travelling display represents a horse approaching a jump, which is the green l.e.d. If the player presses the white button (switch S1) at the exact moment when the green l.e.d. is lit, this counts as perfect timing and a "clear jump" is scored. There is an eighth l.e.d. close to the white button to indicate when this happens. However, there is no time to gloat over a successful jump because the horse is already pounding toward the next fence.

The travelling display repeats regularly, with only short pauses between.

Now comes the catch! Although this is a digital game, which one might expect to run as regularly as clockwork (a digital clock, we suppose), there is an element of uncertainty that taxes the skill of the player. Like most horses, the steeplechaser may accelerate or hang back as it approaches and takes the jump. The player must take this into account if the horse is not to jump too soon or too late, and fall at the fence.

This game can be played by one person just for fun, but also makes a game for two or more opponents. You can make your own rules about this but, as a suggestion, a player may attempt ten jumps in succession, and count the number of clear jumps scored. The turn then passes to the next contestant until all have played.

The winner is the player with the highest score out of ten. A tie results in a jump off. Players take jumps alternately and drop out if they do not achieve a clear jump.

HOW IT WORKS

Referring to the Steeplechase Game circuit diagram in Fig.1, IC2 is a decade counter that has 1-of-10 outputs. This differs from an ordinary binary divider/counter because only one output is high at a time. The counter is incremented as the input from the timer IC1 rises from logic low (0V) to logic high (+6V). The output that is currently high goes low and the next output in order goes high.

There are seven l.e.d.s driven by the counter so they each go high in turn, producing the travelling display referred to earlier. There is a gap of three counts between "runs" because there are no l.e.d.s for stages 7, 8 and 9.

The aim of the player is to press the pushbutton switch (S1) while the seventh l.e.d. is lit, but more about that later.

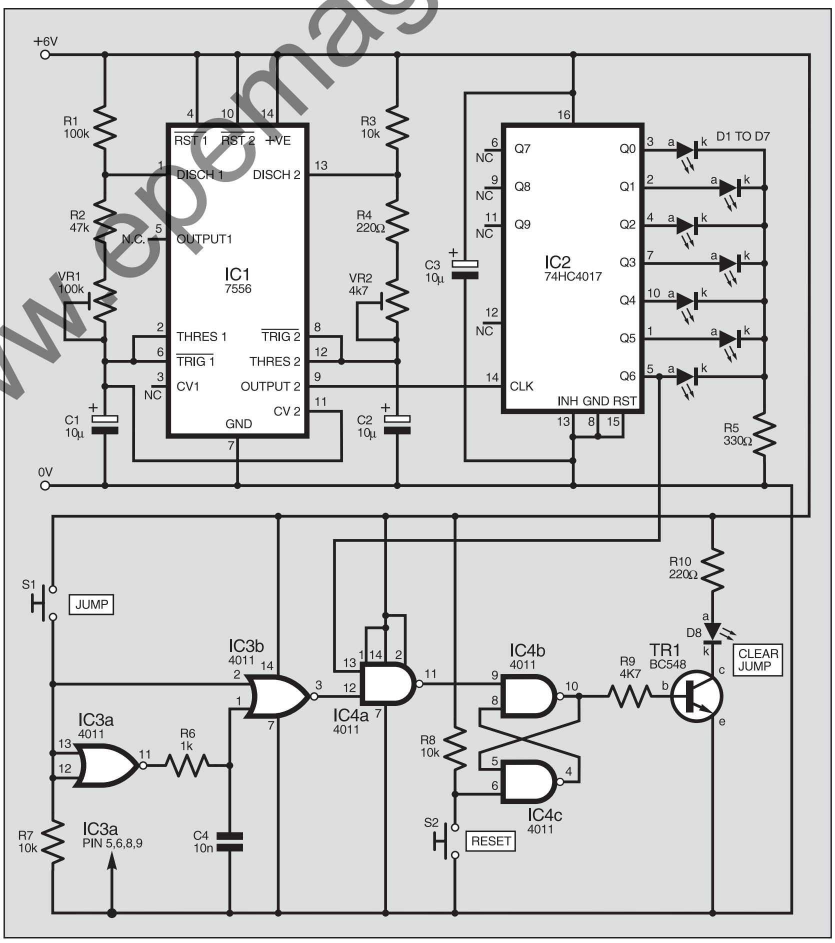


Fig.1. Complete circuit diagram for the Steeplechase Game.

The counter could be driven by a single 7555 timer integrated circuit (i.c.) but this circuit uses the 7556 dual timer instead, shown as IC1. The counter is driven by the timer on the right of IC1, call it Timer 2.

From the values allotted to the components (R3, R4, VR2 and C2), we can calculate that the clock runs at a frequency of between 7Hz and 14Hz, depending on the setting of preset VR2. This allows the players to adjust the skill level of the game.

These frequencies are modified by the action of the other timer in IC1 (Timer 1). The values of R1, R2, VR1 and C1 show that the frequency of this clock can range between 0·74Hz and 0·37Hz.

CONTROLLING TIME

To understand how one timer can influence another we need to look more closely at the connections. In Fig.1 there is a connection between the positive plate of capacitor C1 and pin 11 of IC1. Pin 11 is the control voltage (CV) input of Timer 2.

In the more familiar single 7555 timer, the control voltage input is at pin 5, and we normally ignore it. Either we connect a low-value capacitor between it and the 0V line, or we simply leave it unconnected. In this circuit, it is doing something useful just for a change.

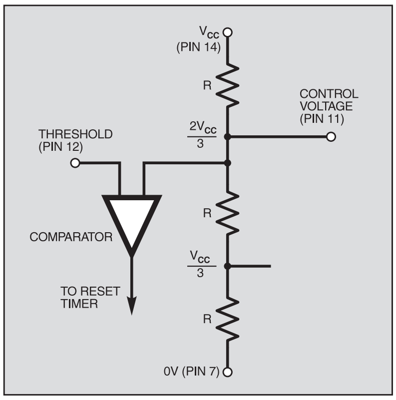


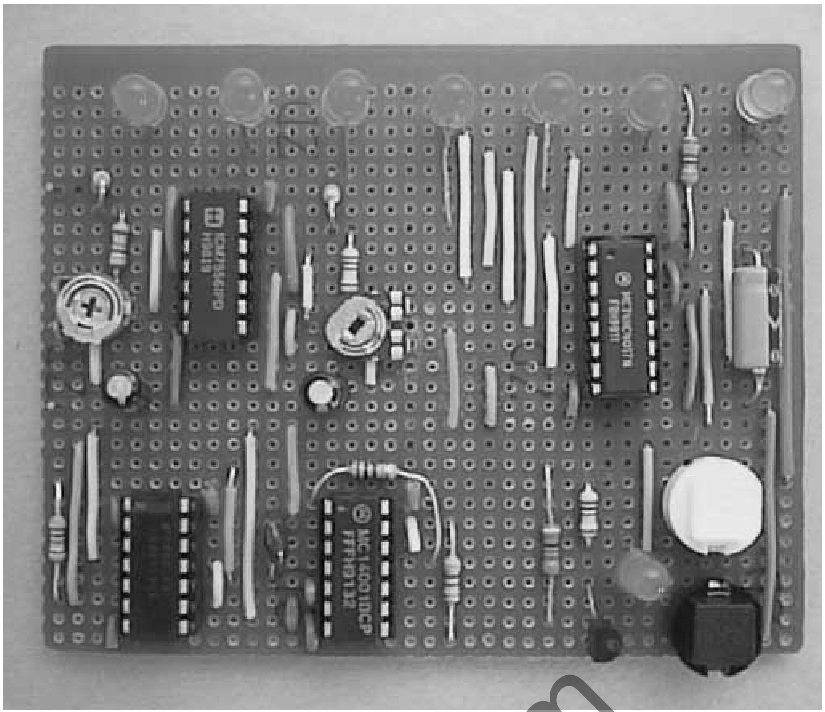
Fig.2. Part of the internal circuit of the timer.

Part of the internal circuit of the 7556 timer is shown in Fig.2. This is the part that is concerned with detecting when the voltage across the timing capacitor has reached two-thirds of the supply voltage (Vcc, or +VE). The resistor chain has three equal value resistors and, since they are all manufactured on the same chip, these are very closely matched. This explains why the timer i.c. has such good accuracy.

A comparator detects when the threshold voltage (the voltage across the capacitor) has risen to be exactly equal to two-thirds of the supply. At this point, the comparator changes state and resets the timer. Its output goes low.

The circuit in Fig.2 shows why it is unnecessary to connect anything to the control voltage input when using the timer in the normal way. In the absence of any connection, that point on the resistor chain sits at two-thirds of Vcc.

However, if an external voltage is connected to the resistor chain through the control voltage input, it is possible to pull the voltage at that point higher or lower than two-thirds of supply. The comparator will then reset the timer when the capacitor charge reaches a voltage other than two-thirds of the supply voltage. It resets earlier or later than usual.



Steeplechase prototype circuit board.

If the timer is running as an astable, as in this circuit, the effect is to alter its frequency.

In this circuit, the source of the control voltage is the voltage across the capacitor of Timer 1. This is a sawtooth waveform, frequency around 0·6Hz, ramping up from one-third of the 6V supply (2V) to two-thirds of the supply (4V) as the capacitor charges, and falling sharply back to one-third of the supply in each cycle as the capacitor is discharged.

This is a good example of frequency modulation. The counter is being driven by a square-wave oscillator at around 10Hz, which is frequency modulated by a 0·6Hz sawtooth. The depth of modulation is fairly high, producing a noticeable effect on the frequency applied to the counter. In terms of the horse, its rate of approach to the fence is tantalizingly erratic. It is not actually unpredictable, but a player needs to get the feel of the timing to be successful in jumping the fence.

JUMP CIRCUIT

The "clear jump" l.e.d. (D8) is switched by transistor TR1, which is fed from the output of a set-reset flip-flop. This is built from two NAND gates, IC4b and IC4c, and is triggered by a low input pulse at pin 9, supplied by NAND gate IC4a. It is reset by a low pulse to the other input, pin 6, produced by pressing Reset switch S2.

The flip-flop can be set only if both inputs of IC4a are high at exactly the same time, one supplied by counter IC2 from output Q6, the other generated by the player through IC3b. With the clock running at (say) 10Hz, each output of IC2 is high for 0·05s. The player has to produce a trigger pulse to occur within that period when only output Q6 is high.

COMPONENTS

See SHOP TALK page

Resistors

R1	100k
R2	47k
R3, R7, R8	10k (3 off)
R4, R10	220Ω (2 off)
R5	330Ω
R6	1k
R9	4k7

All 0·25W 5% carbon film or better.

Potentiometers

VR1	100k min. preset, horiz.
VR2	4k7 min. preset, horiz.

Capacitors

C1, C2	10µ radial elect. 10V (2 off)
C3	10µ axial elect. 10V
C4	10n polyester

Semiconductors

D1 to D6, D8	5mm l.e.d., red (7 off)
D7	5mm l.e.d., green
IC1	7556 CMOS dual timer
IC2	74HC4017 CMOS decade counter
IC3	4001 CMOS quad 2-input NOR gate
IC4	4011 CMOS quad 2-input NAND gate
TR1	BC548 *npn* transistor

Miscellaneous

S1, S2	min. push-to-make switch (2 off, black, white)

Stripboard, 29 strips x 39 holes; 6V battery and connector clip; 1mm terminal pins (2 off); 14-pin d.i.l. socket (3 off), 16-pin d.i.l. socket; connecting wire; solder, etc.

Approx. Cost Guidance Only **£10**

The trigger pulse is generated by the two NOR gates IC3a and IC3b, connected to produce a high output pulse on a falling edge occurring at input pin 2. In other words, the pulse is generated when the player *releases* pushbutton switch S1. Note that it is not possible for the player to cheat by pressing and holding the switch while the horse canters up to the fence.

The pulse is generated when the switch is first released. It lasts a little less than one time constant, or $10\mu s$, as determined by the time constant set by R6 and C4. If the switch is released an instant too soon, the pulse is finished before the Q6 output from IC2 goes high. Thus, it is essential to release the switch within the 0·05s that the output is high.

The circuit should be powered by a 6V battery (do not use any other supply voltage).

CONSTRUCTION

The Steeplechase Game is constructed on a piece of stripboard, 39 holes wide by 29 holes (strips) down. The layout details are shown in Fig.3. Dual-in-line (d.i.l.) sockets should be used for all i.c.s. Note that some resistors are mounted vertically.

There are a lot of wire links on the board, preferably use sleeving on them to prevent accidental short circuits between them. Note that two links have one end beneath VR1 and VR2. Ensure that the i.c.s., l.e.d.s and electrolytic capacitors are inserted the correct way round. Also ensure that all the required track cuts are made in the correct positions.

Begin construction with IC3 and IC4. Note that only two of the four gates of IC3 are used, and only three of the four gates of IC4. In the layout shown, the inputs to unused gates are connected to 0V or +6V. When assembling this part of the circuit, solder in the lead connecting IC4 to IC2. This is the wire link from N21 to S21 in Fig.3. Solder the end at S21 but leave the other end free.

To test this section of the circuit, connect the free end of the link to 0V. Pressing S1 should have no effect, l.e.d. D8 remaining unlit. Then connect the wire link to +6V. Now, pressing S1 should cause D8 to light, and then pressing S2 turns it off.

If this part does not work correctly, check all the connecting wires and also check that the copper strips have been cut at the correct points.

Next install the socket for IC2, l.e.d.s D1 to D7 and resistor R5, but do not put IC2 in its socket yet. Check the wiring by connecting the terminal pin at F1 to +6V. Take a flying lead connected to 0V and touch it against the individual pin sockets in the socket for IC2. The l.e.d.s should come on one at a time as the appropriate pin is grounded (see Fig.1 to check which l.e.d. should light.)

Finally, assemble the timing circuits based on IC1. Again, check very carefully that you have cut the copper strips at the correct points. Insert IC1 and IC2.

When the circuit is complete, test the effects of altering the setting of VR1 and VR2. The overall speed of the horse is controlled by VR2. The amount by which its speed varies is controlled by VR1.

May the best horse win!

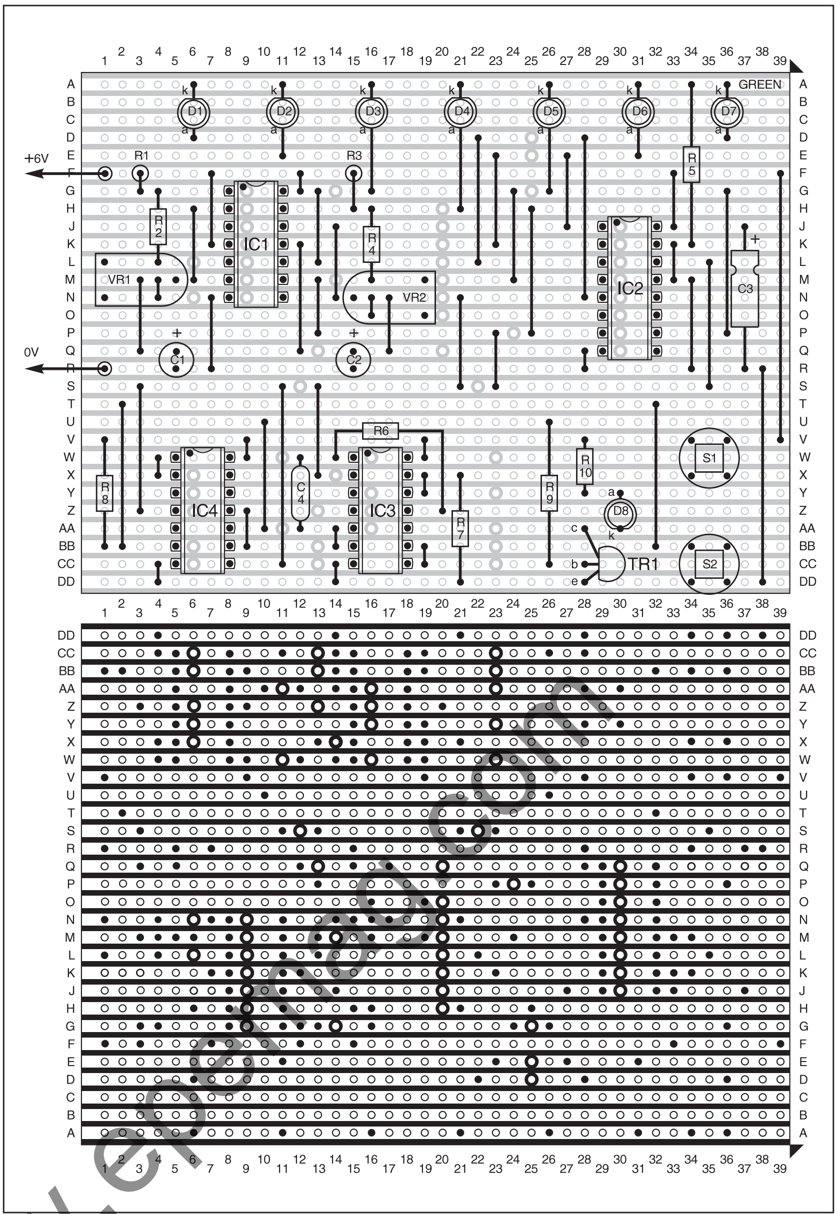


Fig.3. Steeplechase Game stripboard component layout and details of breaks required in the underside copper tracks. Note the wire links under the two presets (VR1, VR2).