Kit 3. LED DICE WITH SLOWDOWN

The Kit uses 7 light emitting diodes (LED's) to simulate the rolling of a dice after the Roll button is pushed. It has a slowdown feature so you can see the 'rolling' of the dice slowing down and then stop. This is more satisfying than the usual LED dice circuit which just stops after the button is released.

The kit is constructed on a single-sided printed circuit board (PCB). Protel Autotrax was used to design the board.

ASSEMBLY INSTRUCTIONS
Assembly is straight forward and components may be added to the PCB in any order. Add the battery snap to the inside of the box. The cathode of the LED is the short lead which is also the side which has the flat on it. Make sure you get them around the correct way. Match to the flat marked on the PCB overlay. Do not mix up the transistors.

CIRCUIT DESCRIPTION
There are three parts to the circuit. These sections can be seen from the circuit diagram.

1. Pressing 'Roll' switch. When the switch is turned on T1 is turned off (its base is pulled high by the 3M3) and the 555 oscillator is not oscillating. Pressing the ROLL switch immediately charges the 470nF capacitor, T1 is turned ON and the 555 starts to oscillate. The 470nF gradually discharges via the 10M and 3M3 and turns T1 off. Since values & capacitor leakage are not critical a small monoblock capacitor can be used.

2. 555 IC oscillator. The 555 is connected as an oscillator. The frequency of oscillation is generally independent of the potential difference across the pins. However, as T1 turns off the frequency becomes dependent on the voltage.

3. The 14017 decade counter. Look at the data sheet – see website below. The counter CPo is advanced by a LOW to HIGH transition from pin 3 of the 555 to pin 14. We are using the first six outputs from the 14017 labelled Oo to O5. The next output O6 from pin 5 is conected to the Reset pin 15. The table below lists the output sequence, which pin it appears at, what dice number is shown and which LED's are illuminated.

The last column allows us to interpret the resistor and LED connections. First note that LED's 2 and 6 are always on except when a value of 1 comes up. So a HIGH on pin 1 turns off LED's 2 and 6 and turns on LED 4 which shows the value 1. When none of the pins have a HIGH (that is when pin 10 is HIGH but is not connected anywhere) then only LED's 2 & 6 (dice value 2) are on.

If you have followed to here OK then the function of the resistors will start to be clear. They have a dual function. Firstly, they function as voltage dividers for the various combinations of LED's which may be turned on at any time. Secondly, they are for limiting the current to the bases of the various transistors.

WHAT TO DO IF IT DOES NOT WORK
Poor soldering is the most likely reason that the circuit does not work. Check all solder joints carefully under a good light. Next check that all components are in their correct position on the PCB. Thirdly, follow the track with a voltmeter to check the potential differences at various parts of the circuit particularly across the base, collector and emitter of the two transistors.

A check list of other items: are the transistors and IC's in the correct way. Is the battery flat. if an LED does not light up then check that it is in the correct way.

WHAT TO LEARN FROM THIS KIT
1. The 555 timer. The universal timer IC is the 555. It is about the most popular and versatile IC's ever produced. It is an ingenious combination of analog and digital circuitry. It operates from supply rail voltages of between 4.5V and 15V. We use the 555 here as an oscillator. Whole books have been written about this chip and the many ways it may be connected.

2. The 14017 5-stage Johnson Decade Counter. Only 6 of its ten outputs are used in this Kit. Follow through the data sheet with the circuit description given above and you will quickly see how the chip works. In Kit 6 all 10 outputs are used.

3. General circuit analysis. Reducing a problem (turning the dice LED's on in a sequence) to the minimum number of components requires the initial judgement that such an analysis is possible and then the work to do the actual analysis. In practice a lot of the analysis is done by trial and error; you build the circuit and connect the resistors together until it works. Then you sit down to justify and document why it works!

COMPONENTS

Resistors (carbon, 0.25W, 5%):	
220R (red, red, brown)	3
270R (red, violet, brown)	1
10K (brown, black, orange)	8
100K (brown, black, yellow)	1
10M (brown, black, blue)	1
3M3 (orange, orange, green)	2
Capacitors:	
470n monoblock	1
100n monoblock	1
Electrolytic capacitor 100uF/16V	1
1N4148 diode	1
1N4004 diode D1	
LED 5mm	7
555 IC	1
14017 IC	1
BC547	3
BC557	2
Hat Keyswitch	1
9V battery snap	1
8 pin IC socket	1
16 pin IC socket	1
Kit 3 PCB	1
Box #1 & 4 screws (optional)	1
SPDT PCB-mounted switch	1

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14017 Output high sequence	14017 pin number	Dice Number	LED's on (See circuit diagram for reference)
1	3	4	1 2 6 7
2	2	3	2 4 6
3	4	6	1 2 3 5 6 7
4	7	5	1 2 4 6 7
5	10	2	2 6
6	1	1	4
7	reset 5 to 15		

For the data sheet and an excellent introduction to the 14017 chip see

http://www.doctronics.co.uk/4017.htm

Google LM555 will bring up tens of websites on it.