Simple Dice using IC 555 and IC 4017

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Abstract—While playing board games, we have been rolling dice. However we were looking at a more appealing way to implement a dice. Hence we came up with a simple dice which is nothing but a random number generator from 1-6 with the help of IC – 555. Every time you press the reset button a new LED glows denoting a number from 1-6. The simple dice works on a 9V again giving it portability and an efficient solution to our need.

I. INTRODUCTION

Using IC 555 and 4017 here, we develop a Simple Dice Circuit. Here, we have used 555 in its Astable mode and 4017 as a decade counter.

II. INTERNAL DESCRIPTION

A. A brief overview of IC555

The 555 Timer IC is an integrated circuit (chip) implementing a variety of timer and multivibrator applications. The IC was designed by Hans R. Camenzind in 1970 and brought to market in 1971 by Signetics (later acquired by Philips).

Depending on the manufacturer, the standard 555 package includes over 20 transistors, 2 diodes and 15 resistors on a silicon chip installed in an 8-pin mini dual-in-line package (DIP-8). Variants available include the 556 (a 14-pin DIP combining two 555s on one chip), and the 558 (a 16-pin DIP combining four slightly modified 555s with DIS & THR connected internally, and TR falling edge sensitive instead of level sensitive).

Ultra-low power versions of the 555 are also available, such as the 7555 and TLC555. The 7555 requires slightly different wiring using fewer external components and less power.

The 555 has been used in the Monostable mode in this application. In this mode, the 555 functions as a “one-shot”. Applications include timers, missing pulse detection, bounce free switches, touch switches, frequency divider, capacitance measurement, pulse-width modulation (PWM) etc.

B. Inside the IC 555

The 555 circuit consists of just a handful of main components: two comparators, a flip-flop, a discharge path, an output stage, and a resistor network. The timing functions of the 555 depend on how the inputs of the comparators are configured and how the discharge path is used.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GND</td>
<td>Ground, low level (0 V)</td>
</tr>
<tr>
<td>2</td>
<td>TRIG</td>
<td>OUT rises, and interval starts, when this input falls below 1/3 $V_{CC}$.</td>
</tr>
<tr>
<td>3</td>
<td>OUT</td>
<td>This output is driven to $V_{CC}$ or GND.</td>
</tr>
<tr>
<td>4</td>
<td>RESET</td>
<td>A timing interval may be interrupted by driving this input to GND.</td>
</tr>
<tr>
<td>5</td>
<td>CTRL</td>
<td>&quot;Control&quot; access to the internal voltage divider (by default, 2/3 $V_{CC}$).</td>
</tr>
<tr>
<td>6</td>
<td>THR</td>
<td>The interval ends when the voltage at THR is greater than at CTRL.</td>
</tr>
<tr>
<td>7</td>
<td>DIS</td>
<td>Open collector output; may discharge a capacitor between intervals.</td>
</tr>
<tr>
<td>8</td>
<td>$V_+$, $V_{CC}$</td>
<td>Positive supply voltage is usually between 3 and 15 V.</td>
</tr>
</tbody>
</table>

Fig 1. IC 555 Internal Structure and Connection Diagram
C. IC 555 Specifications: Absolute Maximum Ratings
- Supply voltage ($V_{CC}$): 4.5 to 15 V
- Supply current ($V_{CC} = +5$ V): 3 to 6 mA
- Supply current ($V_{CC} = +15$ V): 10 to 15 mA
- Output current (maximum): 200 mA
- Maximum Power dissipation: 600 mW
- Power Consumption (minimum operating): 30 mW@5V, 225 mW@15V
- Operating temperature : 0 to 70 °C

D. IC 555 Specifications: Features
- Direct replacement for SE555/NE555
- Timing from microseconds through hours
- Operates in both astable and monostable modes
- Adjustable duty cycle
- Output can source or sink 200 mA
- Output and supply TTL compatible
- Temperature stability better than 0.005% per °C
- Normally on and normally off output
- Available in 8-pin MSOP package

E. A brief overview of IC 4017
The 4017 decade counter has ten outputs which go high in sequence when a source of pulses is connected to the clock input and when suitable logic levels are applied to the reset and enable inputs. The 4017 are 5-stage and 4 stage Johnson counters having 10 and 8 decoded outputs respectively. The 4017 are monolithic integrated circuits, fabricated in standard Al-gate CMOS technology. Are available in 16-lead dual in-line plastic package. Inputs include a CLOCK, a RESET and a CLOCK inhibit signal Schmitt trigger in the CLOCK input circuit provides pulse shaping that allows unlimited clock input pulse rise and fall times. These counters are advanced one count at the positive clock signal transition if the CLOCK INHIBIT signal is low. Counter advancement via the clock line is inhibited when the CLOCK INHIBIT signal is high. A high RESET signal clears the counter to its zero count. Use of the Johnson decade-counter configuration permits high-speed operation, 2-input decimal-decode gating and spike-free decoded outputs. Anti-lock gating is provided thus assuring proper counting sequence. The decoded outputs are normally low and go high only at their respective decoded time slot. It is used in Decade counter/decimal decode display, Binary counter/decoder, Frequency division, Counter control/timers and Divide by N counting.

F. IC 4017 Specifications: Absolute Maximum Ratings
- Supply voltage:
  - G and H types: 0.5 to 20V
  - E and F types: 0.5 to 18V
- Input voltage: 0.5 to $V_{DD}$+0.5 V
- DC Input current (any one input): ±10 mA
- Total power dissipation (any one output): 200 mW
- Dissipation per output transistor: 100 mW for TA = full package-temperature range
- Operating temperature:
  - G and H types: -55 to 125°C
  - E and F types: -40 to 85°C
- Storage temperature: -65 to 150°C

G. IC 4017 Specifications: Features
- Fully static operation
- Medium speed operation -12 MHz (typ) at $V_{DD}$
### III. Schematic

![Schematic Diagram](image)

**A. Schematic Description**

Press the push switch to ‘throw’ the dice: this makes the circuit rapidly cycle through the dice numbers so that an effectively random dice number is displayed by the LEDs when the push switch is released. Drill seven 5mm holes in a dice pattern to mount the LEDs on a panel such as a plastic box lid or sheet of thin plywood. They should be a tight fit but a little glue can be applied from the underside if necessary.

The 555 astable circuit provides clock pulses at about 5kHz for the 4017 counter which has ten outputs (Q0 to Q9). Each output becomes high in turn as the clock pulses are received. Only six counts (Q0-Q5) are needed so Q6 is connected to reset. Appropriate outputs are combined with diodes to supply the LEDs: for example Q1, Q3 and Q5 are combined for LED A.

The dice sequence has been started at 2 so the \(\div 10\) output can be used for LEDs B1 and B2, this saves diodes and simplifies the circuit. Pressing the push switch makes the disable input low so that counting occurs.

![Dice Numbers and corresponding LEDs](image)

- **R1=10K \(\Omega\), R2=10K \(\Omega\), R3=100K \(\Omega\), R4=570\(\Omega\), G1=5V, C1=0.01\(\mu\)F

### V. PCB Making Process

**A. Requirements**
- Laser printer
- Suitable glossy paper
- Copper PCB boards
- An iron
- Etchant
- Protective clothing

**B. Overview**

Print up the PCB traces on suitable paper and transfer the toner to the copper. Etch the board, remove the toner and drill. The PCB is ready.

**C. Printing PCBs**

Use a transparency of good quality. To save time, effort and expenses it’s a good idea to combine multiple images to try and fill the entire 8.5x11 page with PCBs. Remember that these must be printed as mirror images of the final PCB in order to be correct after transferring them to the copper board.

![Placing the PCB mirror image face down on the copper](image)

**E. Transferring the Image**

To proceed you will need a cutout of a single PCB image from the glossy paper, a very clean copper board and a clothes iron. Place the PCB mirror image face down on the copper, ensuring it is correctly positioned. You can use a few pieces of tape to secure the glossy paper to the board but I find that, if you are careful when you begin to iron, the paper sticks and stays in place on its own. Preheat your trusty clothes iron, using the hottest setting it’s got (cotton, linen or above). Iron the entire area of paper, pressing firmly and staying long enough to ensure the toner melts a bit and binds to the copper. Carefully remove the paper. If certain areas seem particularly difficult to peel off, you can try soaking a bit more.
F. Etching the Board

When creating a PCB using a chemical etchant, you want to protect certain areas of copper from the chemical reaction (to form the pads and signal lines) and let the ferric chloride remove all the metal that remains exposed. The next step consists in removing unwanted copper from the board. You can use the classic, ferric chloride or other chemical solutions. You won't need a ton of etchant for a regular sized PCB. Start with a bit, enough to cover the board. You can always add more if the reaction stops. Just how much etchant you need and how long the process takes will depend on many things: the size of the PCB, the amount of copper on the board (both in terms of area and thickness). Somewhat hotter etchant will react faster than a cold solution but we like the ease and control that using room temperature etchant affords us. Regularly stir the solution, every couple of minutes, to ensure the board is in contact with fresh etchant. After a while, you will be able to see that the reaction has begun. The etchant solution will get filled with dark colored particles and the copper will begin to disappear. Removing the PCB from the solution for a few seconds will reveal freshly etched spots. After something like 50-75% of the copper has been removed, gently stir the solution (never use metal) on sway the container and keep an eye on the state of your board. The process seems to accelerate in the final stages; this is only an impression but it can surprise you and lead to over-etching. Leaving the board in the solution too long will cause the etchant to eat at your signal traces from below, potentially causing breaks in your traces.

G. Finishing the PCB

Drill holes as appropriate, place your components and solder.

VI. PCB Layout

VII. Conclusion

The Simple Dice has been successfully implemented using IC 555 and 4017.

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REFERENCES