Tutorial

Electronic Dice Project

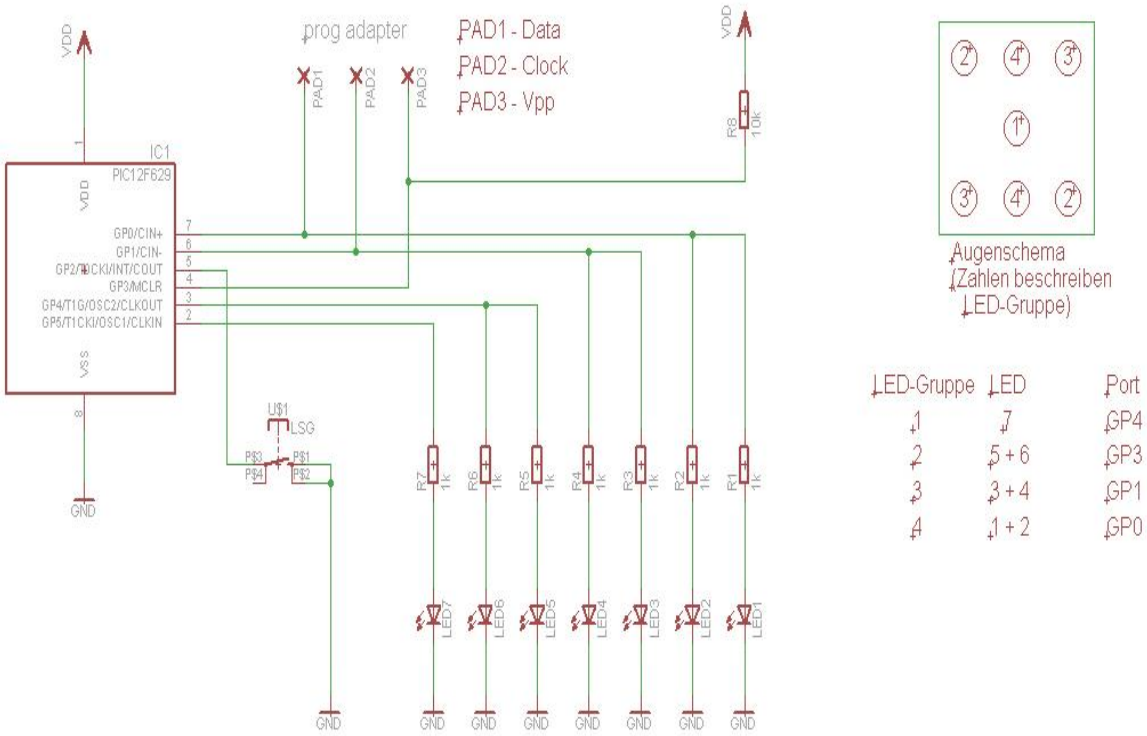
Thomas Hitzner, January 2017

Introduction

You must have played with a dice at some time, for example when playing Ludo or Monopoly. Dice have existed for a very long time. The first known six-sided dice were found in Iraq and were made in 2750 B.C. They were made of terracotta, with small holes for the spots.

This project involves building your own electronic dice. This assignment involves soldering various components to a given circuit board. Looking at the circuit diagram, you can see how and where to attach the various items. You will also need a switch.

Circuit diagram



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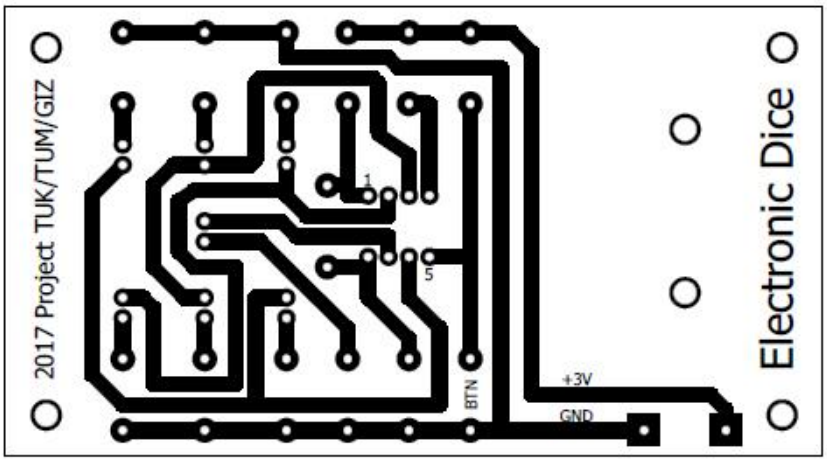
PCB Board and Layout

A PCB (printed circuit board) is a plastic board which has conductive wires on the back. The tracks make the connections between the components of a circuit. This makes it possible to connect a large number of components quickly and easily in a small space.



Original size: 100mm x 55mm

Soldering

The different components will be mounted at the front of the circuit board and soldered at the back. This means you have to bend the wires of the components in such a way that they fit through the holes. Do them one by one, starting with the smallest component. Solder each wire to the back of the circuit board and cut off the excess wire.

1. **Surface Preparation:**

   A clean surface is very important if you want a strong, low resistance solder joint. All surfaces to be soldered should be cleaned well.

2. **Component Placement**

   It is best to start with the smallest and flattest components and then works up to the larger components after the small parts are done. Bend the leads as necessary and insert the component through the proper holes on the board. To hold the part in place while you are soldering, you may want to bend the leads on the bottom of the board at a 45 degree angle.

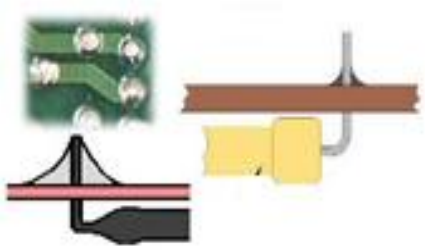
3. Apply Heat and solder

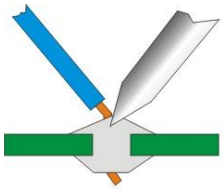
It normally takes a second or two to get the joint hot enough to solder. Once the component lead and solder pad has heated up, you are ready to apply solder. Touch the tip of the strand of solder to the component lead and solder pad, but not the tip of the iron. If everything is hot enough, the solder should flow freely around the lead and pad.

4. Inspect The Joint and Cleanup

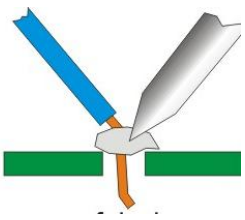
Once the joint is made you should inspect it. Check for cold joints, shorts with adjacent pads or poor flow. If the joint checks out, move on to the next.

Good Examples





Wrong Examples, bad soldering



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Components list

Component	Description
R1 – R7	270R 0.25W or 0.1W CF RESISTOR (you have to calculate new value, if LEDs with more current or voltage are used)
R8, R9	1.8 K 0.25W or 0.1W Resistor
C1	100nF CERAMIC DISC CAPACITOR RC
LED1 - 7	LED 3mm or 5mm RED, WHITE, GREEN, 3V or 2V, 10mA or 2mA (You can use almost any type of LEDs of any color with this circuit.)
J1	PCB DC POWER SOCKET for 2 AAA batteries
Socket for IC1	8 PIN IC PIN SOCKET
IC1	PIC12F675 -I/P MICROCONTROLLER (The PIC16F628A will need programming, see chapter firmware, for the kit the PIC is programmed.)
PCB Board	PCB board, designed by TUK/TUM, 100mm x 55mm
Button	Push button, for example 6.5mm diameter, normally OFF
Metric screws and nuts	2 x M3 6mm for mounting DC power socket
Power supply	2 x 1.5V AAA batteries
Sheet metal screw	4 x 2.9mm to fix the PCB board into the box

Assembling

1. **2 short (0 ohm) connections for + and – to the IC**

   Use the wire from 2 other resistors and use them as a 0 ohm resistor. Solder these 2 short wires to connect plus and minus for the IC. These connections are in the same line like all the other resistors.

2. **Series resistors for LEDs**

   Resistors are used to reduce the voltage in a circuit. For the electronic dice we use two different kinds of resistor. There are two resistors for the push button and reset and seven resistors to reduce the current through the LEDs.

   Solder now the 7 series resistors for the LEDs. The value of the resistors is not critical. The values of our resistors are calculated to use 3V and 10mA LEDs. If you will use other LEDs, for example with more or less current or voltage, so you have to calculate the value of these serial resistors again. For the Kit we use 220 ohm resistors, color code red – red – brown

3. **Resistors for push button and RESET**

   Solder the 2 resistors for the push button and the RESET input of the IC. The value of the resistors is not critical.

4. **IC socket**

   Solder the 8 PIN socket for IC1.

   ICs are very sensitive to static and can break as a result. When mounting the ICs we therefore use IC sockets. These IC sockets will be soldered at the spot indicated on your circuit board.

   Note the notch in one end of the socket. On this side, the first PIN on the left side is PIN number 1. This PIN should connect to the pad, marked with the 1.

5. **DC connector**

   Fix and solder the 2 pin DC connector for 2 AAA batteries.

6. **Capacitor**

   Solder the capacitor C1. If you're assembling from the kit; the value of C3 is 100 nF. The ceramic capacitors value is not critical, only should be more than 47 nF.

7. **LEDs**

   At the end solder the 7 LEDs. LEDs (light emitting diodes) are small electronic lamps. The electric current can flow through an LED in only one direction and for this reason it is important to be very careful how you connect the LEDs.

   Be alert, though. Some components (for example this 7 the LEDs) must be mounted in a specific way. Check carefully the positive and the negative side before soldering

these items. It is very important to mount them the correct way because otherwise your circuit will not work.

You will see that one leg is shorter than the other. The short leg is the cathode (negative side, minus). So, you can recognize the negative side by the shortest leg of the LED.

8. Switch

Install the switch and connect the leads with 2 short wires to the PCB board. Fix the PCB Board with a bit of glue to the plastic box.

9. Insert PIC

A PIC contains a large number of circuits on a very small board. They can be programmed to perform various tasks. When making the electronic dice we use a type of chip with 8 legs. There are 2 legs to connect the voltage to the IC; the other 6 are for inputs and outputs. For example the push button is an input to the IC. The 7 LEDS are the output from the IC.

With everything is assembled and having tested the 3 volt supply, disconnect power from the board. Then insert the PIC microcontroller into the socket. Be sure to fit it the correct way round.

Final test

Is your own electronic dice is ready, press the button, some of the LEDs will light up. The LEDs are basically the spots on the dice. The number of LEDs that light up is unpredictable. Your own electronic dice is working. You can use it instead of an ordinary one.

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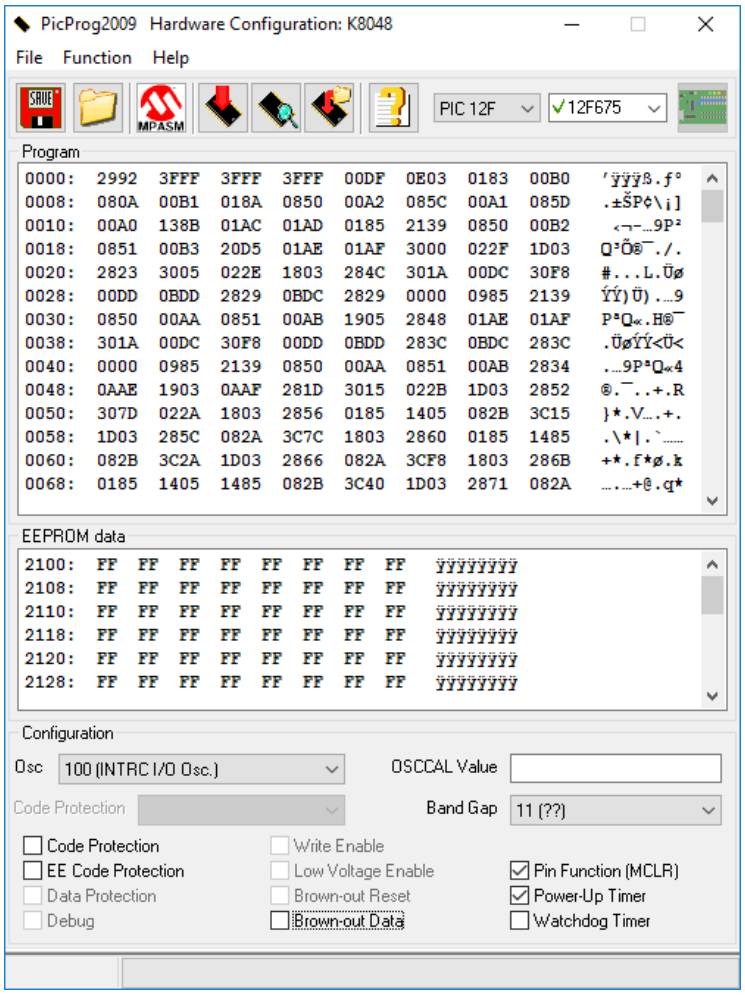
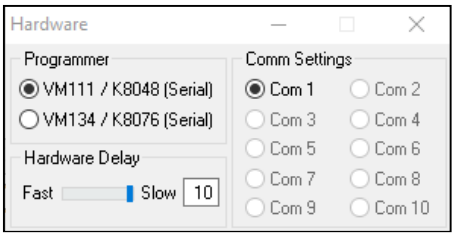
Programming and Firmware

To Flash the PIC a prepared HEX File is available. See file in folder Software: “2017-01-10 Electronic Dice with 12F675 by Th. Hitzner.HEX”. The program PiCProg2009 is used to flash the PIC. Fuses settings are important. These settings should be the same like as the following picture (INT RC I/O OSC, no Brown out Data, Power-Up Timer and PIN function (MCLR)).



A test board VM111/K8048 is recommended to use. The Hardware delay should set to slow.



Examples for C Source code for „electronic dice 12F675“

The complete source code is available: “2017-01-11 C Sourcecode for 12F675 electronic dice.DOC”. Following important information for programming own applications.

Setting the Inputs and outputs:

```
sbit LED1 at GP0_bit;       // define Port for LED 1 (1 LED in the Middle)
sbit LED2 at GP1_bit;       // define Port for LED 2 (2 LEDs, right bottom and left top)
sbit LED3 at GP5_bit;       // define Port for LED 3 (2 LEDs, right top and left bottom)
sbit LED4 at GP4_bit;       // define Port for LED 4 (2 LEDs, in the middle left and right)
sbit Start_Key at GP2_bit;  // define Port for a Button, used for Interrupt to start the main
```

Routine for INTERRUPT

- Routine is starting if Button is pressed
- waiting till button released
- calculation of the numbers 1 to 6 randomly and setting the LEDs

Routine to init the Ports

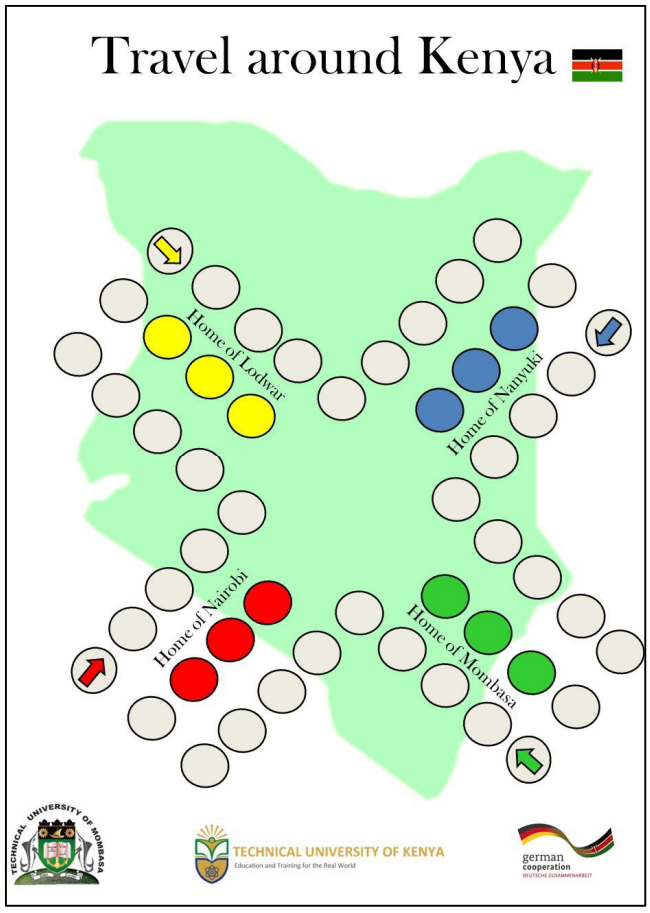
```
TRISIO = 0b00001100;          // Setting Inputs and Outputs
ANSEL = 0b00000000;           // All ports are digital ports
CMCON = 0b00000111;           // Comparator is off
OPTION_REG = 0b0100000;       // Bit 6 = set interrupt low to high flag
INTCON.INTF=0;                // Set INT Flag for GP2 to 0
INTCON.INTE = 1;              // Enable External interrupt on GP2
INTCON.GIE = 1;               // Enable Interrupts globally
```

Main Routine

Here is the main program, but mostly only counting the time till PIC will go to sleep. The real work is in the interrupt routine and works if button is pressed down.

Example of the board for the game Ludo

The board is a square with a pattern on it in the shape of a cross. At each corner, separate to the main circuit are colored circles where the pieces are placed to begin. The starting square, the starting circle, the home triangle and all the home column squares are colored to match the corresponding pieces.



Rules for the game Ludo

How to play

- Each player chooses one of the 4 colors (green, yellow, red or blue) and places the pieces of that color in the corresponding starting circle.
- Players take turns in a clockwise order; highest throw of the die starts.
- Each throw, the player decides which piece to move. A piece simply moves in a clockwise direction around the track given by the number thrown. If no piece can legally move according to the number thrown, play passes to the next player.
- A throw of 6 gives another turn.
- A player must throw a 6 to move a piece from the starting circle onto the first square on the track. The piece moves 6 squares around the circuit beginning with the appropriately colored start square. The player then has another turn.
- If a piece lands on a piece of a different color, the piece jumped upon is returned to its starting circle.

Winning

- When a piece has circumnavigated the board, it proceeds up the home column. A piece can only be moved onto the home triangle by an exact throw.
- The first person to move all pieces into the home triangle wins.