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APPLYING OF THE EMBEDDED SYSTEM

Wheel of Fortune Project

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Bachelor's thesis

Spring 2014

Degree program in information technology

Oulu University of Applied Science

PREFACE

The aim of this bachelor's thesis was to prove the concept and main solution for the electronic equipment "Wheel of fortune" that is used as a commercial device. In this project, I was responsible for the hardware part designed and implemented. Timo Vainio was supervising, giving me suggestions and guidance during the project work. The thesis was made in period February to May 2014 and my previous supervisor Juha Rätty helped me to order this work. He also helped me quite a lot during the thesis study.

Oulu, 14 May 2014

Cui Zheng

ABSTRACT

Oulu University of Applied Sciences

Degree programmer in Information Technology

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Title of Bachelor's thesis: Applying of The Embedded System

Supervisor: Timo Vainio

Term and year of completion: spring 2014 Number of pages: 27

The aim of this Bachelor thesis was to prove the concept and the main solution for the electronic equipment 'wheel of fortune ' by applying an embedded system, an electric circuit design and a microcontroller technology. The work was commissioned by firm Huvireppu Ay and started in January 2014.

To achieve this aim it needed fully to understand how to build the basic electric circuit inside the equipment. The key feature of the project was to design a clockwise rotating wheel which was used in the project 'wheel of fortune ' as the most important part of this designing scheme.

The design was implemented by using the embedded system technology. Using a microchip connected to the electric circuit controlling the running speed of the 'wheel,' and also can randomly stop the 'wheel' while doing the clockwise rotate. In the project work, two schemes were being used, and they have different principles and use different component, but they all achieve the same goal: The wheel does a clockwise rotate and randomly stops. Option one will use LEDs for the running of the wheel and using the 555 timer IC as a time delay chip, randomly slowing and lighting a group of LED lights that are used as the pointer of the wheel. Option two is using the mechanical solution; connecting the device to a stepper motor and using it as the pointer of the wheel and using the timer delay chip randomly stopping it as the pointer stop during the game time.

Although the solution of this project was made, and the basic electric circuit diagram is complete, this practical design still carries a significant potential for future upgrading .It is still useful to those programmer adjusting and recoding the inner program of the microchip and applying to other similar electric device. To this 'wheel of fortune' electric equipment, more components can be added to perfect the additional function of the device.

Keywords: wheel, embedded,timer IC,LED, stepper motor.

CONTENTS

PREFACE	3
1 INTRODUCTION	6
1.1 Description of the company	6
1.2 Working Description	7
2 THE WORK ENVIRONMENT	9
3 DEFINITION	10
3.1 User's View	10
3.2 Definition of Device	10
4 IMPLEMENTATION	11
5 TESTING	24
6 POSSIBILITIES OF FURTHER DEVELOPMENT	25
7 CONCLUSION	26
8 REFERENCES	27

1 INTRODUCTION

1.1 Description of the Company

The company Huvireppu Ay is the company from which I got the thesis theme. The primary service of the company is building an area for children to play and offering a facility to an amusement park. Also, they have their own staff playing a part as a buffoon.

The company's website is quite funny and childlike. Website: <http://www.nellijaniilo.com/>



1.2 Working Description

My main task given by the company was to offer a solution for making a commercial device to be used as an entertainment facility of children's playground. The height of the device is around 1.5-2 meters, and it contains a microcontroller or an embedded system used as the main function of this electric device.

The general structure of this "wheel of fortune" device is around 2.2 m high, 1.5m Long and 0.6M wide. As we mentioned above it is an electric device used for a commercial purpose. It may also be decorated with some toys or shined LED lights while used in a party or in an amusement park.

Due to outdoor using purpose, it also contains a recharge battery as the power supply.

Here is an example picture of this electric device –"wheel of fortune"

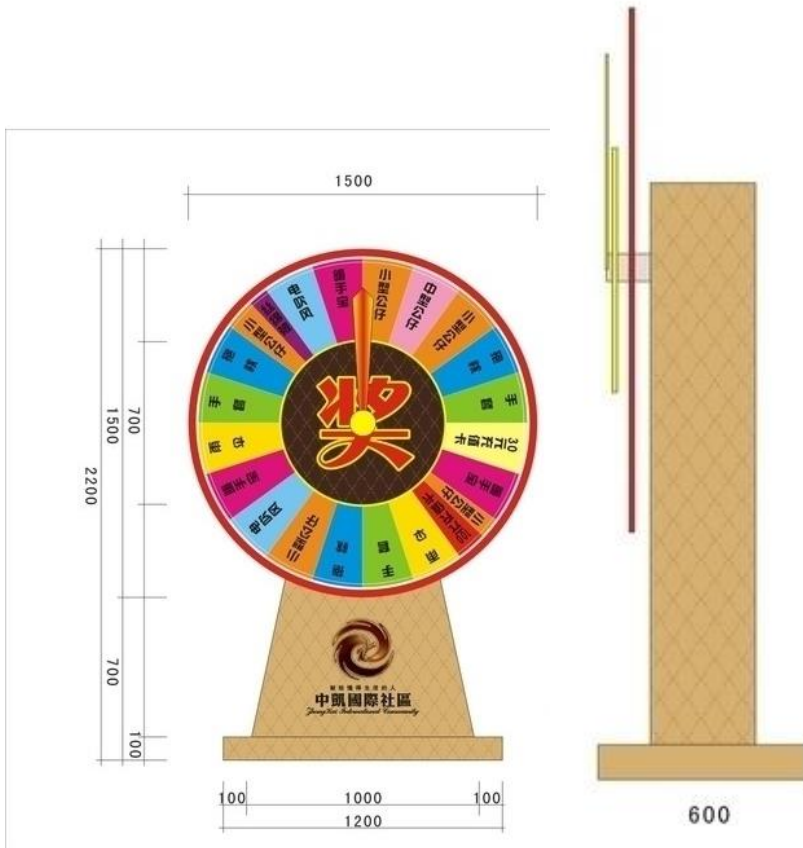


FIGURE 1 Wheel of fortune concept diagram (Nipic, DIY, wheel of fortune)

And in a commercially used situation, it may be decorated like this (picture below) and people may like it.



From the technical point of view, this electric device called “Wheel of fortune” has a hard-core part which is called the “wheel”. When you press the start button, the “wheel” will start turning in a clockwise direction. And it

will randomly stop in one angle of the wheel; children can read from wheel, which prize they have won and get the gifts from the staff.

My main task was to offer a solution how to build a wheel. As the main part of the device, the design and implementation of the “wheel” is quite important. I have three options for the solution of this project and the person in charge of the project will decide which option they will choose for this project.

What I have done here is trying to build an electric circuit connection of the wheel and analyze the advantage and disadvantage of these three options. The knowledge of the thesis contains the electric circuit part and the embedded /microcontroller part. It is also a little bit part of programming language(c#).

I have three solutions for the project and I give details on of how to implement them. An electric circuit diagram and a data sheet are also being listed.

2 THE WORK ENVIRONMENT

The main tasks of the project should contain three people. One person is doing some software relating job and one person is doing the electric circuit part, and the last one will be responsible for the mechanical part.

We should have a group meeting if we have three students participating in the project, and finally we will combine our working results together and get a full description of this project.

Due to the limited time we could not find enough people starting this project together. I will start working on this project first. My job mainly included the electric circuit part and also contained some information about both software and mechanicals material.

My main task was to analyze the solution for the “Wheel of fortune’s wheel”, and my main job was to establish the electric circuit of this device and give the exact electric circuit map as solutions.

The thesis is an analysis achieving the function of the “wheel”. As the hardware part it does not have the exact work environment, I just found the materials relating to this project and listed them in orders. About the tool used in the implementation step, I used a simple simulate, which belongs to Arduino board, loading some simple c# code and also a drawing program.

I tried to understand and study the knowledge parts of software c# code and mechanical related material, hoping I could independently finish my own parts without any communication with other two people who are not participating.

3 DEFINITION

3.1 User's View

From user's point of view, this device is a mechanical and electric box. When our young customers press the starting button, it starts working. The "wheel" of the box will start a clockwise rotation and randomly stop in one degree scale. And our young customers win the prize. From user's point of view, it is not difficult to understand the whole function of this device. It is a commercial device which is used in a children's pleasure ground or in a party.

3.2 Definition of Device

This device called "wheel of fortune" is consisting of a small electric component. Inside we have a power supply, an electric board that contains lots of small components. What we have here is a resistor, a capacitor, a triode, a switch and an electric board used as a connection of the LEDs (option 1). We also have a stepper motor used in option 2 and a microcontroller used in option 3. At last we need a plastic board which has the degree scale marked winning prize that is used as the background of this "wheel" device system.

4 IMPLEMENTATION

At the beginning of the implementation parts, I would like to introduce the most commonly used electric components in this project.

I have three options for this project and I will analyze those options one by one.

The first component which is widely used is NE555 timer IC. This is the chip used as a time delay function. Then we may need 4017IC that is used as a counter. These two components mentioned above are used in the implementation option 1.

Example picture below is using 555timer IC and 4017IC and LEDs as the project's main components.



FIGURE 2 Wheel of Fortune Game Style LED Electronic Project Kit (ebay.co.uk, Wheel of Fortune Game Style LED Electronic Project Kit)

Then we have the option 2. We use a microcontroller connecting directly to the stepper motor. What we need here is an Arduino board.

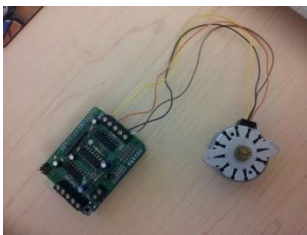


FIGURE 3 Stepper motor with Adafruit Motor, Shield drive circuit for use with Arduino (Wikipedia, stepper motor)

In the option 3 we need the NE 555 Timer IC, D flip flop 7474, 74HCT86 and transistors for this project option. The D flip-flop 7474 is used as a counter that contains two counters inside. The 74HCT86 is a logic gate that

has four XOR gates contains on this chip. The transistors boosting weak electric signals into current power for driving purpose

This option 3 is also designed by using the stepper motor as the main motive power of the “Wheel”. We are using complex electric circuit connecting those components to the driving stepper motor.

1 option one

In this project, the most commonly used component is 555 Timer IC. The 555 timer IC is an integrated circuit (chip) used in a variety of timer, pulse generation, and oscillator application. The 555 can be used to provide time delays, as an oscillator, and as a flip-flop element. (Wikipedia, 555 timer IC)

Here is the picture of the component

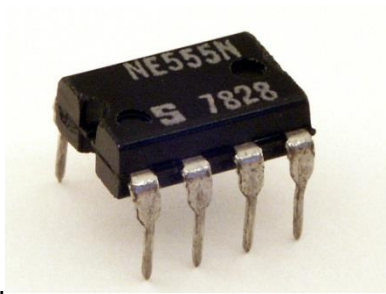


FIGURE 4 Ne555 (Wikipedia, 555Timer IC)

And also the Pin out diagram of the component

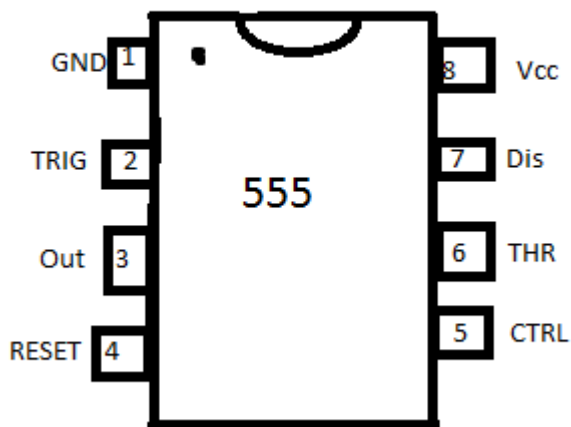


FIGURE 5 The pin out diagram of the component (Paint program drawing)

TABLE 1 the connection of each pin function (Word table)

Pin	Name	Purpose
1	GND	Ground reference voltage, low level(0v)
2	TRIG	The output pin goes high and a timing interval starts when this input fall below 1/2 of CTRL V
3	OUT	This is the output pin
4	RESET	Timing interval may be reset by driving the input to GND
5	CTRL	Provide control access to the internal voltage divider.
6	THR	The timing interval ends when the voltage at THR is greater than at CTRL
7	DIS	DIS open collector output and discharge a capacitor between the intervals.
8	Vcc	positive supply voltage

I have three options for the “wheel of fortune” project.

Option 1

I am considering using the LED light as the interface of the wheel. And I have ten groups of the LED light as a selector. For the purpose of the wheels turning, each group of LED light will become lighted and then off clockwise. I use three different colors of the LEDs making the wheel become more striking. Normally, a wheel is 360 Degrees, but I make each group of the LEDs in the wheel take 36 degrees and use red, yellow and green LEDs in turn.

The scheme of the picture should be like this

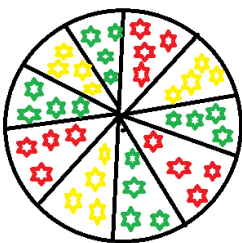


FIGURE 6 simulate the distribution of the LEDs in the “wheel” (Paint program drawing)

And I found the example of the project from the internet. It is a mini wheel of fortune and the whole project was designed in one electric board.



FIGURE 7 Wheel of Fortune Game Style LED Electronic Project Kit (ebay.co.uk, Wheel of Fortune Game Style LED Electronic Project Kit)

Considering about the size of my project, the diameter of the wheel will be around 1-2m, and I will use lots of LEDs in one selector. After building the “LED wheel,” I will use the plastic panel to cover the LEDs and people can read the selectors and images from the plastic panel, regarding the LEDs it is a protection material. Also, the plastic panels reduce the risk for a child player. It decreases the chance that children could contact the electric circuit. Let us consider the diameter of the wheel, It is 1 meter by the diameter, so the perimeter of the wheel circle is $C = \pi d = 3,14 * 1M = 3,14M$ if we divide in 10 selectors, then we can calculate it like this $3,14M / 10 = 0,314M$. So the scheme for one selector is

the perimeteter of 1 selector is 0,314M



The total number of the LEDs in one selector is $5+4+3+2+1=15$

FIGURE 8 simulate the distribution of the LEDs in one selector. (Paint program drawing)

Above it is the situation if we consider the wheel of 1m diameter. So if we need to double the size of the wheel, we just need to double the number of the LEDs. For example, if we need 2m diameter we may need 30LEDs in one selector.

Then let us check the digital circuit of the connections for the simple 10-LEDs wheel .What we need from here is the Registers Capacitors, Triode, switch, IC1555 timer, IC2 -4017, and LEDs.

What we will use here is the IC 4017

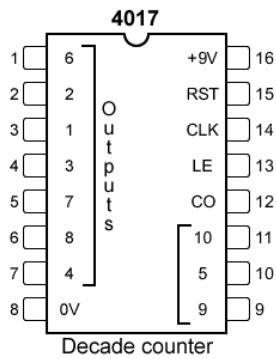


FIGURE 9 4017/4000 series (Wikipedia,4000 series)

The **4017 IC** is a 16-pin CMOS decade counter from the 4000 series. It takes clock pulses from the clock input, and makes one of the ten outputs come on in sequence each time a clock pulse arrives. (Wikipedia, 4000 series)

Here is an electric circuit diagram for the wheel of the fortune.

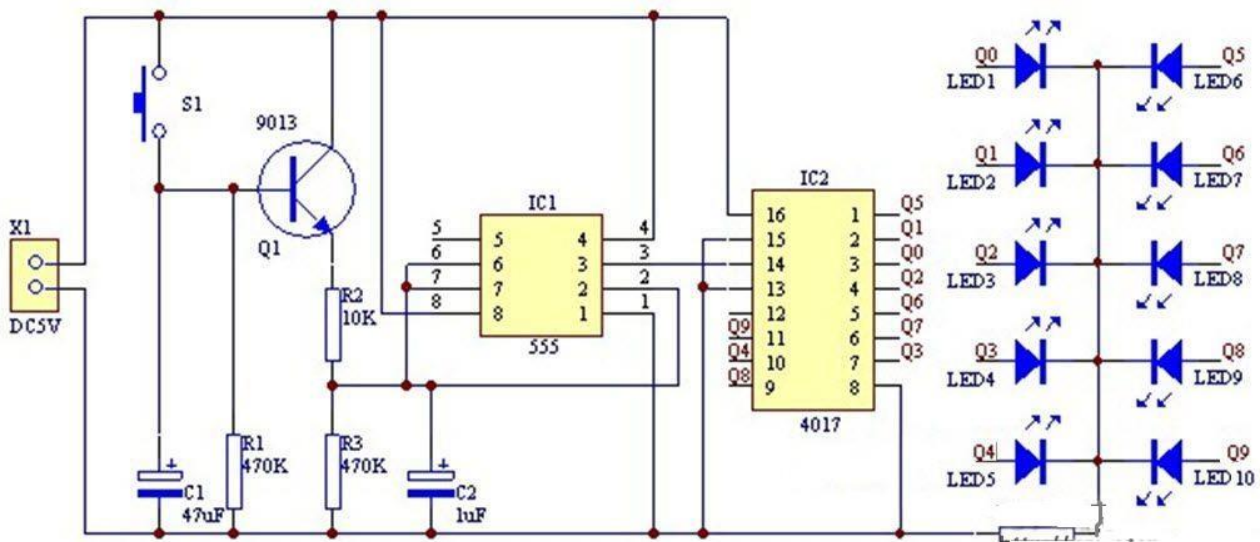


FIGURE 10 Schematic circuit diagram (CNDZZ, DIY signal chip)

According to this electric circuit, C1 is used as a delay of time and C2 is used for controlling the speed. (CNDZZ, DIY signal chip,)

TABLE 2 data sheet of the “wheel of fortune” electric circuit (word table)

Data sheet

Name	Model	Number
Leds1-Leds10	yellow red green	150 or more
R	Resistor	3 or more
C	Capacitor	2 or more
Q	Triode	1 or more
IC 1	IC555timer	1
IC2	IC4017	1
S	Switch	1or 2
PCB	Printed Circuit Board	1
V	Power supply	1

2 option 2

Stepper Motor

A stepper motor is a mechanical solution for this “wheel of fortune” project’s wheel design. A stepper motor (or step motor) is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor’s position can be commanded to move and hold at one of these steps without any feedback sensor (open loop controller), as long as the motor is carefully sized to the application. (Wikipedia, Stepper motor)



FIGURE 11 Stepper motor (Wikipedia, stepper motor)

The Full step Drive map of a stepper motor is

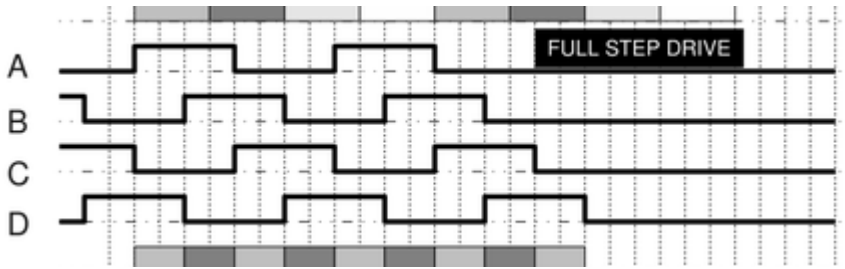


FIGURE 12 4 phase unipolar stepper motor (Wikipedia, stepper motor)

As we can see from the map the Full step drive signal is

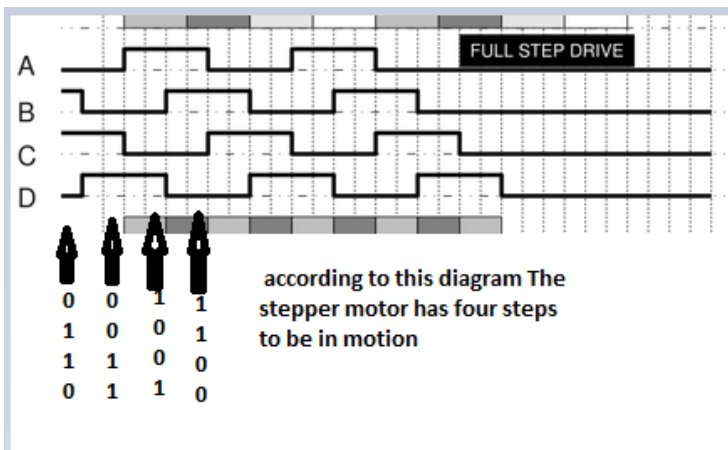


FIGURE 13 Self marked stepper motor working diagram. (Primary diagram- Wikipedia, stepper motor)

So the simplest way coming to my mind to drive the stepper motor is using the Arduino Board. We should connect the stepper motor to a microcontroller, and we can load the code that is used to control the 4 steps of the stepper motor. Then the stepper motor should be able to work like this

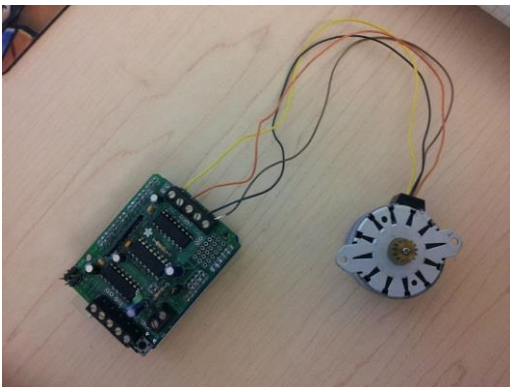


FIGURE 14 Stepper motor with Adafruit Motor, Shield drive circuit for use with Arduino (Wikipedia, stepper motor)

I am able to find some code example to control the stepper motors

```
#include <Stepper.h> //include the function library
#define STEPS 96 //3.75 deg motor (96 steps per rev)
Stepper stepper(STEPS, 4, 5, 6, 7); //create the stepper

void setup()
{
  inti;
  stepper.setSpeed(30); //set speed to 30 rpm
  delay(1000); //pause for effect
  stepper.step(96); //move 360 deg one direction
  delay(1000); //pause for effect
  stepper.step(-96); //move 360 deg in the other direction
  delay(1000); //pause
  stepper.setSpeed(60); //speed up
  for (i=0;i<5;i++) {
  stepper.step(20); //wave the flag
  stepper.step(-20);
  }
}

void loop()
{
}
```

Example Code Notes

1. The example code assumes that the stepper is being controlled by Arduino pins 4, 5, 6 and 7, but you can use any set of four pins.
2. The "#define STEPS 96" line defines the number of steps per rev. A 3.75 deg motor has 96 steps/rev while a 7.2 deg motor has 48 steps/rev.
3. The "Stepper stepper(STEPS, 4, 5, 6, 7)" line is where you enter the four pins used to control the stepper.
4. The "stepper.setSpeed(x)" command sets the motor speed to x rpm.
5. The "stepper.step(x)" command turns the motor x steps at the speed last set in the stepper.setSpeed() command. The motor turns one direction for postive x and the reverse direction for negative x.

(Arduino code, controlling stepper motor)

About the ARDUINO board

Arduino is a single-board microcontroller, intended to make the application of interactive objects or environments more accessible.[1] The hardware consists of an open-source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. Current models feature a USB interface, 6 analog input pins, as well as 14 digital I/O pins which allow attaching various extension boards. (Wikipedia, Arduino)



FIGURE 15 Arduino Board (Wikipedia, Arduino)

3 option 3

Another option controlling the stepper motor is using a clock (555 Timer IC), a counter 74HCT86, a logic gate (XOR gate), and connection to the stepper motor. While we use the 555Timer making the clock pulses and use the counter cover the clock pulses into two binary signals and the logic gate combines the digital signal into the final signal controlling the stepper motor.

The schematic electric circuit is shown below

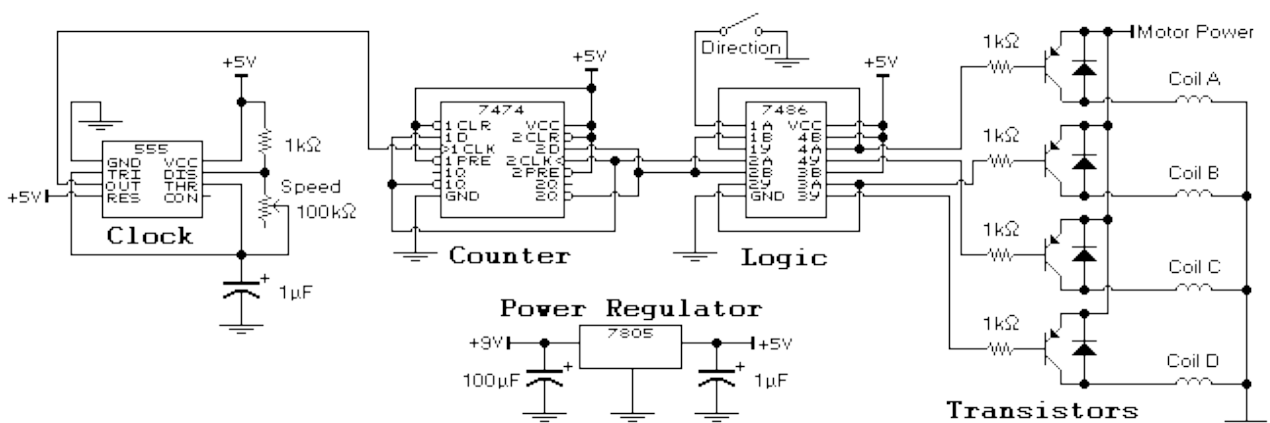


FIGURE 16 Electric control of a stepper motor (Neil Fraser, electric circuit controlling of a stepper motor)

How to connect to a stepper motor?

Those four coils (Coil A/B/C/D) from the transistors are the connection cable to a stepper motor.

What is the purpose of the Clock?

The clock in the above picture is the ubiquitous 555 timer chip. It produces an unending stream of pulses at a rate defined by a variable register, or a speed control. This is the same model chip which we used in option 1 connecting to the LEDs

Then we need a counter

This chip mode is D flip flop 7474, and it has two counters on this chip. Each divides the clock pulses by two. The result is a steady two –binary code: 00,01,10,11 (circuit gallery, D flip-flop 7474)

Here is the pin out for 7474 D flip flop

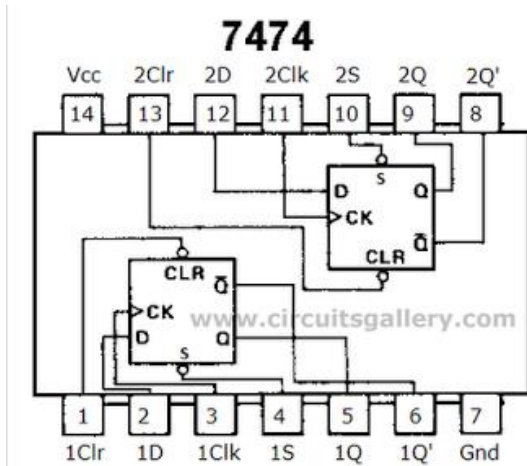
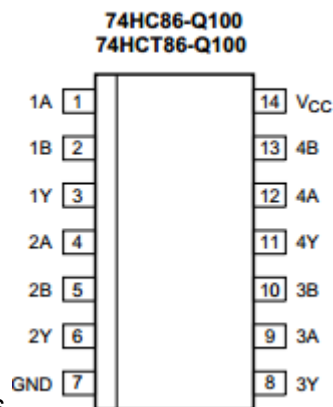


FIGURE 17 Pin out of D flip flop 7474 (circuit gallery, D flip flop7474)

And also we need the Logic gate

The mode for this logic gate is 74HCT86 and the four XOR gates on this chip do several things .The binary code turns into a Gray code, The Gray code is made to count backwards if the direction switch is closed. Finally, the Gray code is expanded into stepping sequences for each coil: 1100, 0110, 0011, 1001.The pinning



for 74HCT86 logic gate is

FIGURE 18 Logic gates 74HCT86 (Futurelc, Logic gate, 74HCT86)

The functional diagram for the logic gate should be like this

In a low voltage power supply I recommend using an NIMH rechargeable battery .It eliminates the pollution problems caused by the heavy metal elements in the environment and the proportion of the Energy density is higher (Wikipedia, nickel–metal hydride battery)

We may need a battery pack and here is the example picture of the battery

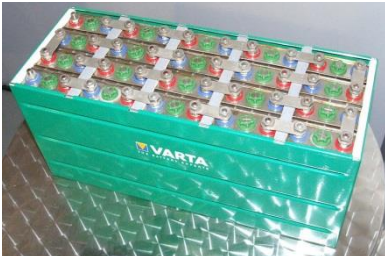


FIGURE 20 Battery pack - nickel–metal hydride battery (Wikipedia, nickel–metal hydride battery)

If we use 9v or 12v DC power supply, we may also still need a transformer

A transformer is an electrical device which transfers energy between two circuits through an electromagnetic induction

Those components are all included in the power supply system of this electric device.

According to the three options above, I listed a table form analyzing the advantages and disadvantages of these three options

TABLE 4 advantages and disadvantages of each option analyzing for the project (word table)

Option Number	Advantage	Disadvantage
1 LEDs “wheel of fortune”	These LEDs are attractive to children and it is a traditional solution for similar project.	We may needs huge number of LEDs and the connection are complex

2 ARDUINO Board controlling	Use few lines of simple code can reach the purpose controlling the stepper motor, and electric circuit connection is also easy to handle	We may needs the knowledge of programming coding those code controlling the stepper motor
3 Electric single stepper motor	This is a mechanical way handling this project and it is easy to understand	The electric circuit is complex and also we needs lots of component in the electric connection

According to the table above, the finest way for me was to use the option 2. In hardware parts, we need a programmable ARDUINO Board and few cables for connecting to the stepper motor. And we also need to program some codes for loading to the ARDUINO Board.

And the hardest way is also concerned to the stepper motors. If we choose the option 3, the electric circuit is very complex and we also need lots of components to be used while we are establishing the connection.

In my option, we are using an innovated method in the first solution of this project. We are using the LEDs instead of the traditional “wheel” and we are lighting those LEDs as the indicator of the “wheel”. This LED using scheme makes this electric device more attractive and has more competitiveness in the commercial way.

So if the device is in a commercially used purpose, the option 1 will be recommended (The LEDs wheel). It is more rare in those “wheel of fortune” device (most of them are related to the stepper motor or some similar kinds of motors), and LEDs make it more blinking especially at night time. And those LEDs decorated with toys are more attractive to children.

5 TESTING

Analyzing the testing program of the “Wheel”, the “wheel circuit”, is the most important part of the “wheel of fortune” device, and this thesis is also presenting three solutions for the implementation. According to the analyzing text, the user should be able to connect to the basic electric circuit of the “wheel” connecting to the whole device. Depending on the analysis above there are three options for the user connecting to the device.

The first option is using the 555 timer chip and integrated circuit chip as the timing delay device for the main idea of an electric circuit, and using the LEDs to replace the mechanized wheel. The LEDs will become light and dark in sequence. It makes the electric “wheel” look like real, the lighting LEDs become the selector of the wheel.

The second option is using the stepper motor as the mechanical way of handling this situation. A microcontroller device (the ARDUINO board) is being used connecting the 4 pins from the stepper motor. Loading the simple C# language code makes the stepper motor work perfect. Using a stepper motor as the selector of the “wheel” makes the device look more mechanized.

The third option is the solution for the stepper motor, using the 555 timer IC making the clock pulse and use a counter that contains two flip flops to cover the pulse signal into a binary signal. At last using a logic gate for the combined signal, generates the final signal for the stepper motor's 4 pins.

Comparing these three options the best way of handling this project is using the LEDs as the whole decoration of the wheel. It makes the device more commercial and more attractive to kids. Compared to the traditional wheel board using the mechanical pointer, this LED board has a more competitive power.

The easiest way to do this project is using the ARDUINO board connecting to a stepper motor as the pointer of the wheel. Using the code as the delay function makes this project quite easy to handle.

The hardest way is using an electric circuit connecting to a stepper motor. First the signal is needed to set up and load the delay function into the device 555 timer, and a counter is needed to cover the signal into two, and then a logic gate is needed to turn the binary code into a gray code. At last the transistors are connecting the four pins to the stepper motor. The step is complex, but this is the traditional way how to handle the stepper motor. So it is hard to distinguish which option is better, this thesis gives the options of how to handle this project and the person in charge of this project will decide which option they will use.

6 POSSIBILITIES OF FURTHER DEVELOPMENT

This project may need three people to participate into. One person is responsible for the software parts such as coding the ARDUINO Board or some microchip achieving the implementation goal. Another person will focus on the mechanical parts including a plastic board, sensor, stepper motors controlling and some push buttons. The third person is doing the job setting up of an electric circuit connection, and combining everything together.

More people are needed to participate into the project and the chance for the future development is quite big. People responsible for coding the software part and loading the code into the component should take part, and also need the electric circuit connecting to the device and someone who is professional in mechanic take part. Also, the power supply is not discussing in this thesis. What kind of the battery will be chosen and is it environmental. These problems will all need to be taking into consideration.

So more people participate into the project, it will offer better solutions in a different field and more communication drafting better solutions for the project.

With this thesis project, there may be useful materials for someone who is willing to continue studying and processing this project. So to be honest it is fun to take part into this project.

7 CONCLUSION

In my thesis, I am offering three solutions for this project “wheel of fortune”. So the basic idea of those solutions is analyzed and also an electric circuit diagram is provided. The component data sheet is listed out and the main purpose of each component is explained. A list table is made to clear the advantage and disadvantage of each solution. The main purpose of the thesis was to analyze the methods of handling the project “wheel of fortune device”.

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