PingPongBall Launch System

Team 68-Qihao Wang, Jiayi Wu, Ruofan Hu
ECE445 Project Proposal-Spring 2020
TA: Chi Zhang

Introduction

1.1 Objective:

Ping-pong is one of the most popular games in the world. Based on the data from the International Table Tennis Federation, there are 37620 professional players in various organizations (ITTF, 2019). For Ping-pong players, an efficient daily practice is essential for people who want to improve their skill. Swing is one of the most fundamental and important training items. To practice the swing, it is necessary to find a partner. In addition, According to the author of the website [1]“newgy”, finding a proper training partner is one of the most efficient methods to improve our skills and if we have to work alone, the training robot is also an alternative. However, it will take Ping-Pong players extra resources, such as money and time, to find a suitable partner.

To save these resources, we want to design a Ping-Pong Ball practice machine, which can launch the ball automatically. The practice machine adjusts the direction, speed and frequency of the ball. Other than these basic functions, we also want to minimize the amount of time and energy waste on setting up the machine. We will add the remote-control feature to the machine. This feature will allow users to adjust the direction, speed and frequency of the ball anytime during the practice. Moreover, the machine will also have designed launch models for the players. For example, the machine can launch the ball from low frequency to high frequency.

1.2 Background:

Most of the existing Ping Pong Ball launcher machines are stationary and can only be controlled manually. If a player wants to change the ball direction, frequency or speed, he or she needs to stop the training process and manually set the machine to a different direction. Obviously, the existing Ping Pong Ball launcher is not efficient, since it will waste energy and time to adjust the machine. The second drawback of the launcher machines is that it cannot adjust the ball direction, frequency or speed dynamically during the practice. In our Ping Pong Ball launch machine, the players will hold a remote controller and change the launch direction and launch speed by pressing the button. Therefore, with the ability to remotely change the different speed and direction, the

player can simulate how to stroke the ball in different positions and different angles dynamically. Since we can control the launch system conveniently, we do not need to waste time to manipulate the machine and our efficiency improves significantly when we practice alone.

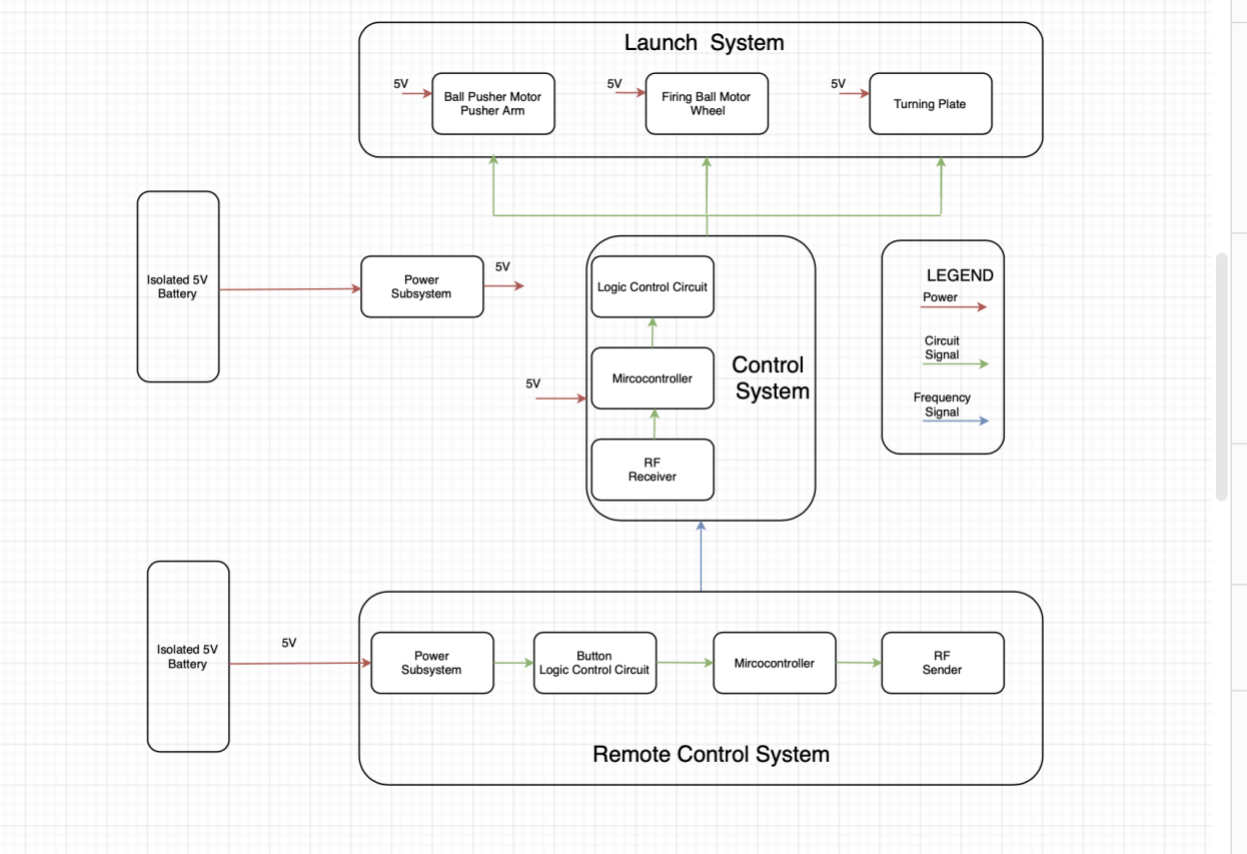
1.3 High-Level Requirement

- The Ping-Pong Ball launch system can launch the ball with different directions, speeds and frequencies.
- The Ping-Pong Ball launch system will have pre-designed training model
- Remote controllers can change the direction, speeds and frequencies.

Design

2.1Block Diagram

Notice: Please read the block descriptions for the launch system, since it is hard to clarify all details in the block diagram.



2.2.1 Launch System - Ball Pusher Motor & Pusher Arm

The ball pusher will push the ball to the firing ball subsystem. The fundamental component will be a motor and a mechanic arm. The motor will move the mechanic arm backward and frontward and the ball will be pushed forward when the arm hits it.

Requirement	Verification
1.The ball should be launched with frequency of average 10 balls pers min or 20 balls per min or 30 balls per min. 2.The motor should be able run on different speed average 10 RPM (revolutions per minutes) or 20 RPM or 30 RPM	A. 5 minus experience, keep shooting the ball and we take the average of number of balls fired over 5 min
3.The motor should take 5 - 10 seconds to change the speed.	B. The speed difference between the slowest 10 balls per min and 30 ball per min is obvious. Therefore, we can just measure the time that it takes to see the difference.

2.2.2 Launch System - Firing Ball Motor & Wheel

The firing ball subsystem will accelerate the ping-pong ball. The fundamental component will be a motor and wheel. The spinning wheel will speed up the ping-pong ball and fire it. Similar to the ball pusher system, we will have a circuit to change the speed of the motor.

Requirement	Verification
1.The Firing Ball Motor & Wheel should be able to speed up the ball to 5m/s to 15m/s.	

2.2.3 Launch System - Turning Plate

The turning subsystem will move the direction of the ball. The fundamental component will be a motor and a plate. The launch system will be attached to the plate. When the motor rotates the plate, the direction of the ball will be changed

Requirement	Verification
1.The Turning plate should be able to turn the launch system with a range -85 degrees(left) to +85 degrees(right) (0 degree means facing front)	A. physical measurement of angle with protractor

2.2.4 Control System

The control system will receive the signal from the remote controller and produce the control signal to change the power of the motor.

Requirement	Verification
1.The microcontroller should be able to take 4 bit input and generate 4 bit corresponding output as control signal. 2.Logic Control Circuit will be able to control the power of motor range from	A. Measure the voltage of motor with a voltmeter, and ensuring the motor run on different voltage and with the corresponding spinning speed B.We will observe the output of microcontroller. We can know whether or not it constantly has 4 bit meaningful information

2.2.5 Remote Control System - Button Logic Control Circuit

The button logic circuit will generate different signals for different buttons to the RF sender component. Remote Control System will run on a separate power supply. Basically, we will put a small battery packet on it, so that the Remote-Control System can be portable.

Requirement	Verification
1.Button Logic Control Circuit generates 5 different signals to control the RF sender. 1). Power ON/OFF 2). Increase Frequency 3). Decrease Frequency 4). Turn Left 5). Turn Right	A. We can see the output of the Button Logic Control Circuit. It should consist every time we press the button

2.2.6 Remote Control System - RF sender & Control System - RF receiver

Requirement	Verification
1.RF sender should be able to send 4 bit information 2.RF sender should be able to send with distance 3 - 5 m 3.The error rate of transition should lower than 10% 4.RF receiver should decode the information with a error rate lower than 10%	A. We will observe the output of decoder on the RF receiver. We can know whether or not it constantly has 4 bit meaningful information B. We will observe the output of the decoder of the RF receiver, which is located 3m or 5m away from the receiver. And we can check if read clearly meaningful information C. We will continuously transit 1000 bits. And we calculate the error rate using the formula Bit Error Rate = Total Number of Bit in Error / Total Number of Bit Transition

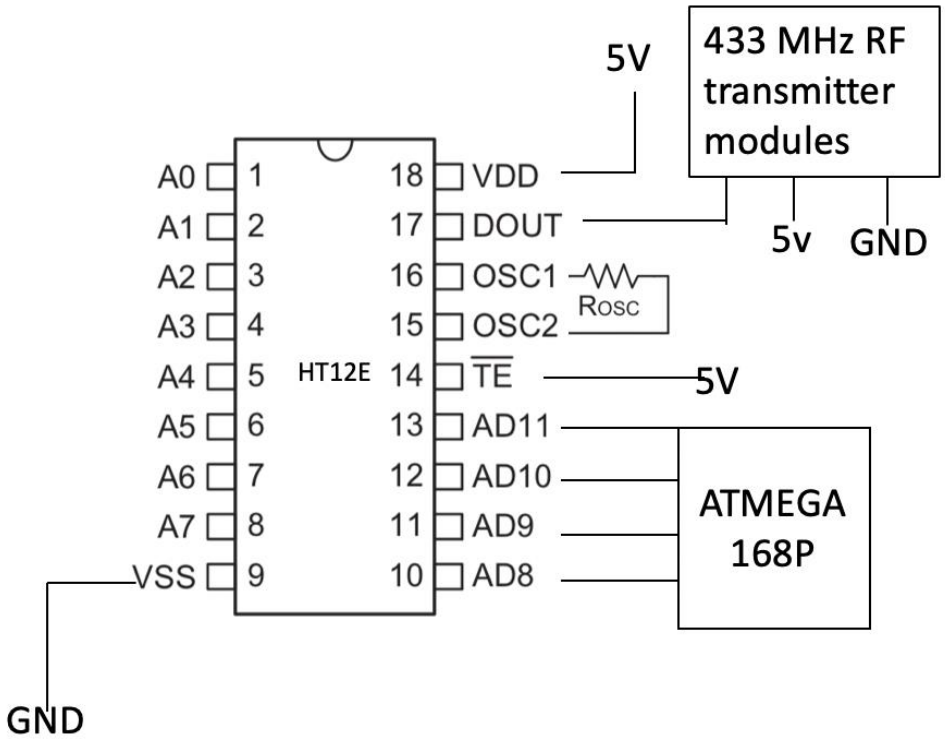
2.2.7 Power System

The power system will provide power to all the other systems.

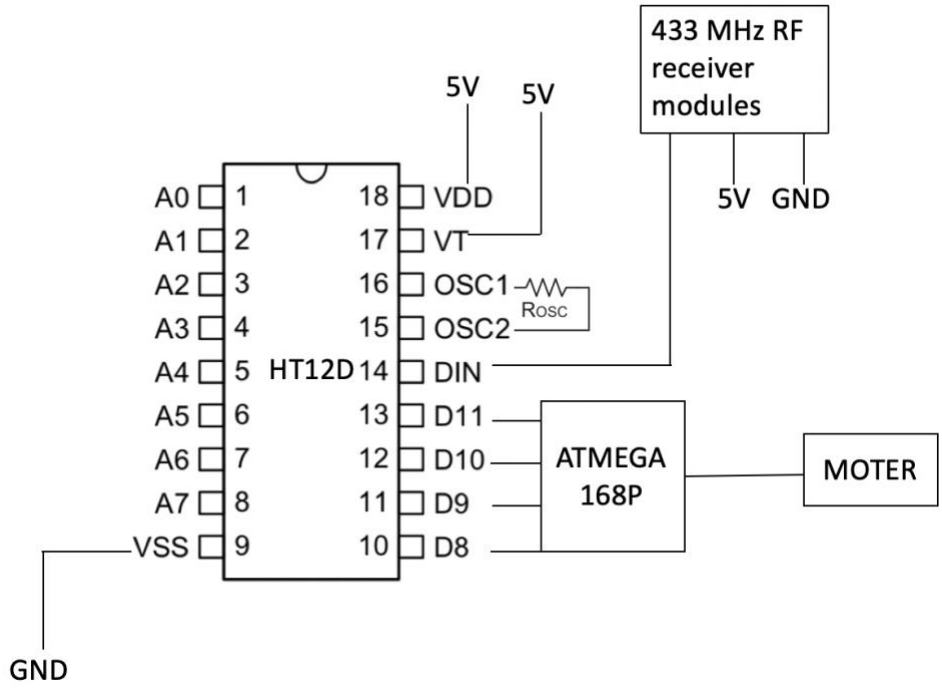
Requirement	Verification
1.Output voltage between 4.00V-7.00V	A. Measure the open-circuit voltage with a voltmeter, ensuring that it is below 7.00V

2.6 schematics

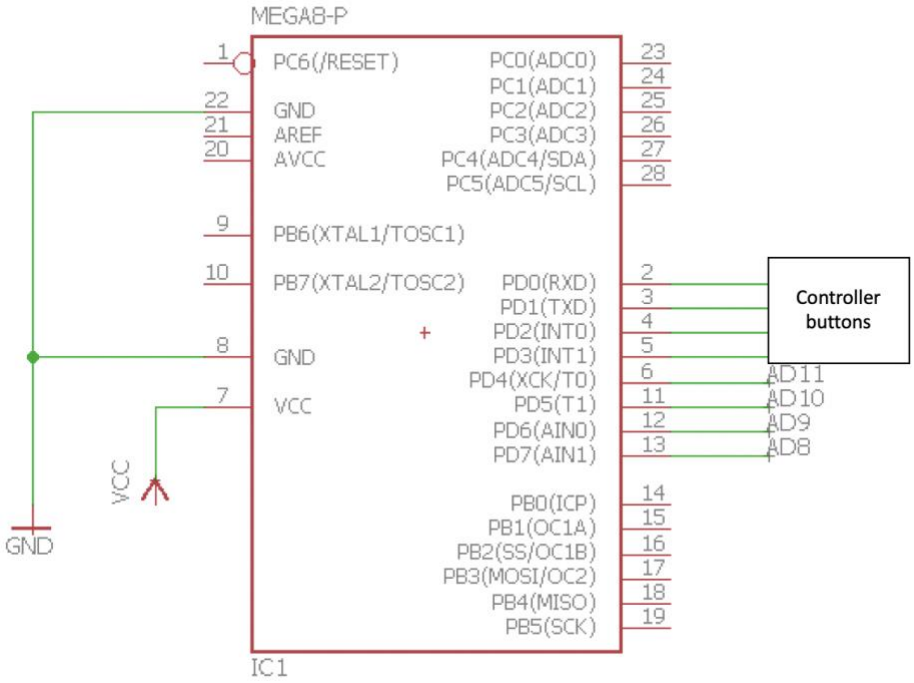
RF Transmitter Circuit:



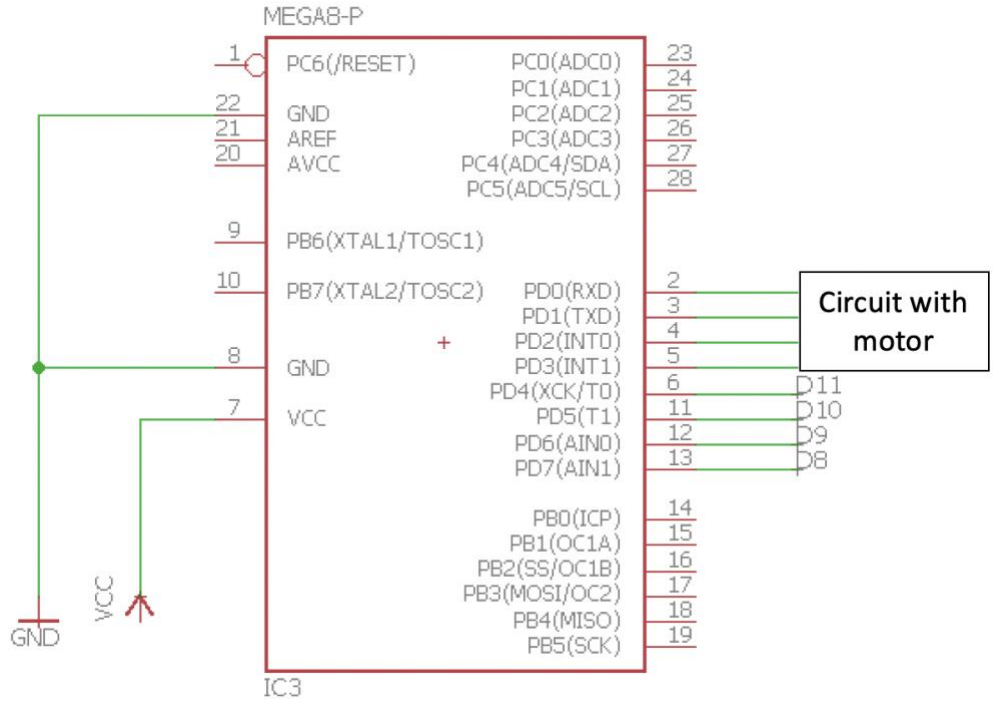
RF Receiver Circuit:



Circuit for microcontroller in RF transmitter circuit



Circuit for microcontroller in RF receiver circuit



Calculation

Motor requirement is an important calculation when designing the launching device. Based on the weight of a ping pong ball, the friction force, the total force and torque on the motor; We determined a specific motor that best fits our system

Information given:

Maximum distance: D = 3m

Angle Θ = 10 degrees

Wheel diameters d = 3.8cm

Ping-Pong ball weight Wb= 2.7g

Calculations:
Initial launch speed

V0 = D*g/sin(2 Θ)^ (1/2) = 3*9.81/sin(2*10)^1/2 = 3.8m/s

Initial motor speed

R0 = 95.49 RPM

Force of wheel

Fwheel = 0.3175*60 = 19.05N

Friction Force

Coefficient of Friction u= 0.3

f = u*Fwheel = 0.3*19.05 = 5.715N

Total force

Ft = Fwheel+f = 24.765N

Torque on Motor

T = Ft*d = 24.765*0.038 = 0.94107 N*M

Weight of the wheel

W= 0.34kg

E = W*(V1^2 -V0^2)/2g

V1 = V0 + sqrt(T*2g)/W = 3.8+sqrt(0.94*2*9.81)/0.34 = 16.43m/s

So R1 = 412.88 RPM

The last velocity listed is the initial required revolutions per minute to launch the ping pong ball

Angular Velocity

V1rads = R1*2 π/60 = 44.179rad/s

a = 0.736rad/s^2

Torque on motor

T = a * I where I is Rotational Inertia

T = a * mr^2 = 0.736*0.34*3.8^2=3.613N*M = 2.6648 ft-lb

So

HP = Torque * RPM = 2.6648*412.88/5252= 0.209hp

This is the minimum horsepower required for the motor to launch the ping pong ball 3m

Ethics and Safety

There are several safety concerns involved in our system. The user of our device will be involved with the operation through a remote control system and the ping pong balls that our system launches. So, it is crucial that we ensure the safety of both the user and our system.

The first potential hazard is our launching system. It is possible that high speed ping pong ball could injure our user and others around. In this case we need to limit the launch speed of the ping pong ball when we build our pushing motor so that it won't hurt our users or any others.

Moreover, according to the [2] IEEE code of ethics term No. 1 , we must hold paramount the safety, health, and welfare of the public. Our system will be using some rechargeable or lithium battery for power source of launching and controlling system. Thus we must prevent batteries from being exposed to dangerous conditions like overcharging by monitoring the temperature of the battery and warn our users of the potential hazards the batteries can do.

Citations and References

[1] “10 Key Tips to Advance Your Table Tennis Game” https://www.newgy.com/pages/10-tips-to-advance-your-table-tennis-game

[2] “IEEE Code of Ethics.” IEEE. Accessed February 13, 2020. https://www.ieee.org/about/corporate/governance/p7-8.html.