Autonomous Lawnmower Using Peripheral Interface Microcontroller (PIC)

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Abstract - This project is about an autonomous lawnmower using a peripheral interface controller. This project is using PIC16f873 to program the task regarding to the movement of the lawnmower. The autonomous lawnmower is programmed to automatically moving, which it takes two seconds after switch on. The Autonomous lawnmower will mow a field of grass. A borderline will be a layout on the surface of the field to ensure the movement of the autonomous lawnmower. The field of grass is considering having no obstacle. All hardware and software has been tested as separate modules followed by integration.

Keywords-Autonomous lawnmower, peripheral interface microcontroller, PIC16f873

1.0 INTRODUCTION

Every year, a lot of cost is spent in commercial lawn upkeep. Golf courses, local parks and other expensive grass areas require hundreds of man-hours to maintain. As well, those who have yard in their houses are concern on the cost of cutting the grass.

For that reason, the goal of this project is to design an autonomous lawnmower that works safely and efficiently mows an area typical of a homeowner's yard. The previous versions of autonomous lawnmower that has been designed relied on the principle of randomness to mow an area. Therefore, the autonomous lawnmower had no realization where they had mowed or did not mow. The premise was as follows: given a long period of time, eventually the vast majority of the mowing area would be cut. Obviously this process would take considerably longer than if a human had mowed the same area, but the point is the human did not have to perform the task.

The main effort of this project is to design an autonomous lawnmower that mows similar in fashion to how a human would mow. The design

of autonomous lawnmower was divided into 3 testing; each one is designed to deal with a particular requirement of the overall system.

1.1 PIC16f873

PIC16f873 is chosen because it has advantages over other types of microcontroller. It has 28 input/output line which is divided into 3 ports; A, B and C. The algorithm used only has 35 single word instructions to learn. It has low power consumption; less than 0.6mA for typical used. Furthermore, it has 5 input channels for a 10-bit Analog-to-Digital Module. This is the main factor to use PIC16f873 as the sensor used is in analog signal.

1.2 MPLAB

MPLAB® IDE is a software program that runs on personal computer to provide a development environment for any embedded system design. It is typically a design making use of the power of a small microcontroller, like the Microchip PICmicro® and dsPIC® digital signal controllers [6]. These chips have a microcontroller unit and some input/output line on the same chip to make a small control module requiring few other external devices.

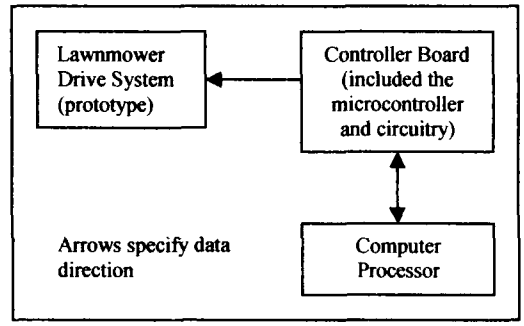

Figure 1: Overall System Model

2.0 SCOPE OF WORK

The project involves five (5) distinct stages as follows:

1. Study on specifications of Peripheral Interface Microcontroller, PIC16f873.
2. Software development which is implementation of assembly language to PIC16f873
3. Hardware development for controlling the Autonomous Lawnmower
   - To implement the circuit for the Reflective Opto-switch Sensor and the Stepper Motor Driver.
4. Integration of hardware and software development
   - To load program to PIC16f873
5. System testing for usability and accessibility.

3.0 METHODOLOGY

To ensure that this project is going well and achieve the objective, the methodology used is to divide the testing procedure into 3 sections. There are software testing, hardware testing and integration testing.

3.1 Software Testing

In an effort to maneuver the lawnmower, software is required to control all aspects of the lawnmower including the sensors and motors. The PIC16f873 contains 8K x 14 words of FLASH Program Memory, 368 x 8 bytes of Data Memory (RAM), 256 x 8 bytes of EEPROM Data Memory which proved to be a sufficient amount of space for programming requirements. Fortunately, the speed of the lawnmower is relatively slow; about 10km/h. Therefore, the efficiency of the software is not a critical issue.

For this reason, the assembly language is used in writing the software program and the MPLAB is used to compile the algorithm into executable files that can be downloaded directly to the PIC16f873 from a personal computer. The software is the final stage in the development of the lawnmower. It is responsible for controlling the Stepper motors and repeatedly polling the Reflective Opto-sensor Switch to utilize the A/D conversion system.

3.2 Hardware Testing

Beside the software testing, this project needs to identify the right circuit to guarantee that the designation of autonomous lawnmower is achieving the objectives. The circuit is tested to ensure that it is function.

3.2.1 Stepper Motor.

In this project, two stepper motors are used to control the movement of autonomous lawnmower. The stepper motors are for the left and right wheel. The movement of stepper motor is depending and controlling by the Reflective Opto-switch sensor. The stepper motors used are 6 wires unipolar; consists of a motor with four coils, wired as pairs with a common center connection. To operate the motor, the common wire is connected to the supply voltage, and the other four wires are connected to ground through transistors, so the transistors control whether current flows or not [2]. A microcontroller or stepper motor controller is used to activate the transistors in the right order.

3.2.2 Reflective Opto-swich Sensor.

In order to control the movement of the autonomous lawnmower, it requires a line to follow. Since the autonomous lawnmower is moving on the surface of a field, the used of this sensor is usefull. The field for the prototype will be in a black colour while the line border will be n a white colour. The reflective opto-switch sensor consists of infrared diode and infrared transistor. When the surface is white, infrared light from the diode will reflect very efficiently and turning on the transistor. A black surface tends to absorb infrared light and very little is reflected, keeping the phototransistor turned off [1].

3.3 Integration Testing

Integration testing is the final testing for this project. This integration testing is to ensure that the prototype is work correctly, accurately and efficiencely. The integration testing is the combination of the software testing and circuit testing. The prototype will be testing on the test map; known as the field of the prototype.

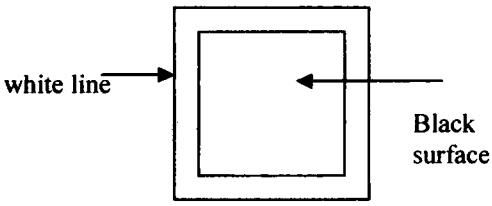

Figure 2: Test Map

4.0 RESULTS

4.1 Software Testing

For the beginning, the algorithm is written for switching on the LED. Then, the algorithm is assembled to program the reflective opto-switch sensor and stepper motor. The programming for both has no error and successfully can be loaded. Hence, both programming has been combining and altering and having no errors.

4.2 Hardware Testing

The driver circuit for the stepper motors is function very well. The circuit used a transistor; TIP132 because of it has a very high power. The transistor is replaced the used of relay since the relay needs a supply of 12V and has a complex connection.

For the reflective opto-switch sensor, the circuit is also fully functioning. The LED as indicator is used to ensure either the sensor is in high state or in low state. LED will turn on or high when the sensor is positioned on the white surface while turning off or low when it is on a black surface.

4.3 Integration Testing

The sensors used have a major function as regards to move the prototype of autonomous lawnmower. Combining together with the PIC16f873, the sensor worked perfectly. The reflective sensor is in analog signal form and is converted into digital by the PIC16f873.

For the stepper motor, it stepped to the forward and backward direction regarding to the programming from the PIC16f873. The speeding of the rotation is depending on the time given.

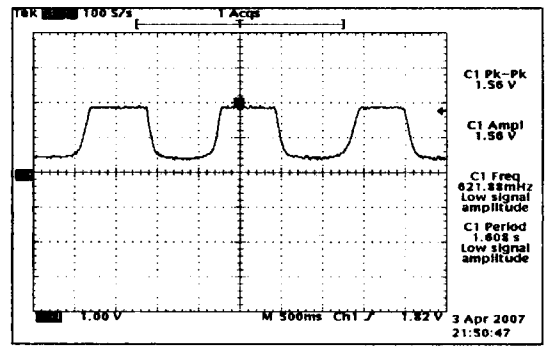

Figure 3: The output of the reflective opto-sensor switch without connected to the PIC16f873

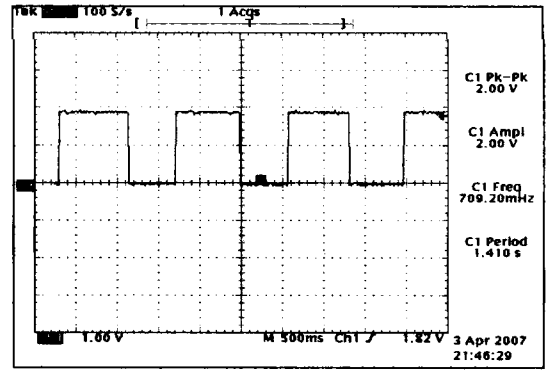

Figure 4: The output of the reflective opto-sensor switch with connected to the PIC16f873

The figure 3 is for the output of the reflective opto-sensor switch without connected to the PIC16f873 while figure 4 is for the output of the reflective opto-sensor switch with connected to the PIC16f873.

5.0 DISCUSSION

To ensure the sensor work correctly, the sensor is injected a supply of 5V to switch it on. The operational amplifier, LM358 is used as the voltage stabilizer to provide a constant voltage to the sensor. The sensor has a voltage rating between 5V to 18V. Besides, using the operational amplifier make easier for the sensor to have an output and connected to the PIC16f873.

A LED is used as signal indicator. The LED will turn on when the sensor is facing on the white surface about 3.5cm from it. The LED will turn off when the sensor is on the black surface.

Thus, the sensor is achieved to the theoretical aspect. The light of infrared has a higher reflection on a white surface while it has a very low of reflection on a black surface. The black surface tends to absorb infrared light.

For a stepper motor, the movement of the motor is depends on the wires connected to it. Each 2 wires has different rotation, therefore it makes the programming simple. By changing the delay, the speed of stepper motor will change. When the delay is 500ms, it stepped slower and not smoothly while when the delay is 50ms it stepped smoothly.

For integration testing, the combination between software and all the hardware is having a problem regarding to the program written. Otherwise, the stepper motor cannot be rotate due to the weight of wheel used and the battery of 12V.

6.0 CONCLUSION

As the conclusion, the objective of this project is not fully achieved. This is occurred because the prototype are encountered a problem regarding to the algorithm written. Even though, all the circuits are function perfectly if they are only connected to the PIC16f873 by itself.

Therefore, it may be conclude that the prototype needs the attention to integrate the hardware and software into a system that demonstrates the ability to maneuver using all sensors and motors.

7.0 FUTURE DEVELOPMENT

In the first version, an Autonomous Lawnmower will mow the field of grass in home yard. An Autonomous Lawnmower will lesson the human efforts. But it is only can mow the yard within the system which it is considering the field is having no obstacle.

For the future development, the system can be upgraded to have the ability of the autonomous lawnmower to navigate around avoiding any obstacles and detecting the edge of the green surface correctly.

All of these need a very good sensor to ensure that the movement of the autonomous lawnmower is accurate. Moreover, it may have a wide application to maneuver a large yard than home yard such as golf courses, local parks and stadium. This application can save human workforce and also reduced the cost.

8.0 REFERENCE

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