MINI AUTOMATIC GUIDED VEHICLE USING PERIPHERAL INTERFACE CONTROLLER

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ABSTRACT

Automatic Guided Vehicles (AGVs) system has been in existence since 1953. It begins with the vehicles to follow the imbedding a wire in the factory floor. Today the technology continues to evolve. The wire in the floor is still available for the proper application. However, many systems today are being designed without the floor wire[5]. This paper is concern about the development a prototype of AGVs called Mini Automatic Guided Vehicle (Mini AGV) with a sophisticated technique in tracking the path on the floor. It involved software development for the system to give a view on how the real operation of AGVs in the industry. All these system will be controlled by the Peripheral Interface Controller (PIC) microcontroller.

1.0 INTRODUCTION

Automatic Guided Vehicles (AGVs) is an automation vehicle used in numerous industrial application and process for moving the products around automatically. Industrial AGVs have been designed to follow the wires embedded in the floor and transmitting a signal, which the vehicle is programmed to follow. Different wires transmit different frequencies, so AGVs can be programmed to branch off from the main route and follow wires to selected destinations. This paper is concern about development of AGV prototype with new technique for guiding the vehicle. The basic theory of this Mini AGV is base on autonomous robot called line following robot. Line following robot is an autonomous robot with capability to follow a line marked along the floor. Same concept with the line following robot, this automation system is designed to follow the track along the floor from one point to another point.

2.0 SYSTEM ARCHITECTURE

The structure of Mini Automatic Guided Vehicle (Mini AGV) system includes hardware and software development. This section will describe the design methodology in detail about hardware and software development.

2.1 Hardware Development

Hardware development can be divided into two parts which is vehicle part and control room part. Vehicle of the Mini AGV has an ability to track the line or path and sense any obstacle in front of the vehicle. The paths have been designed to be white line on a black surface. Figure 1 shows the track model for Mini AGV and the tasks to be executed by the vehicle are shown in the flow chart Figure 2.

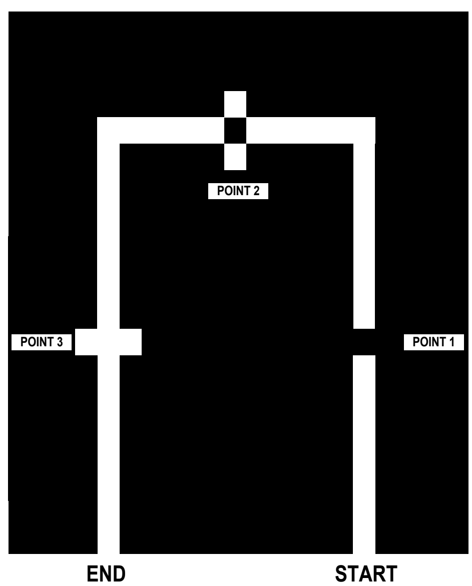

Figure 1: Mini AGV Track Model.

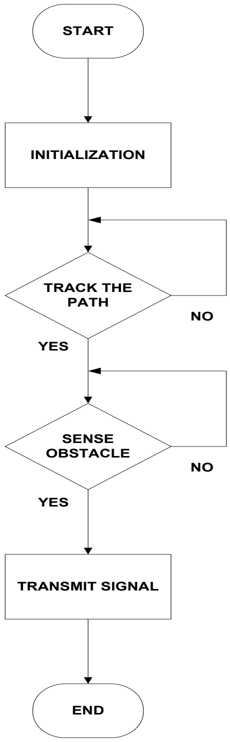

Figure 2: Flow chart of task sequence

Figure 3 shows the block diagram of the Mini AGV system which is describes the vehicle part of the system.

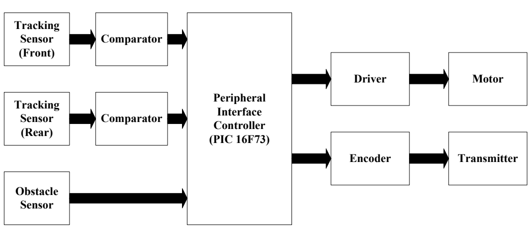

Figure 3: Block diagram of Mini AGV system vehicle.

This vehicle is consisting of three main parts that is sensors, controller and actuators. There are two types of sensors used in for the vehicle which is tracking sensors and obstacle sensor. Figure 4 shows the schematic of a single sensor used for tracking the paths.

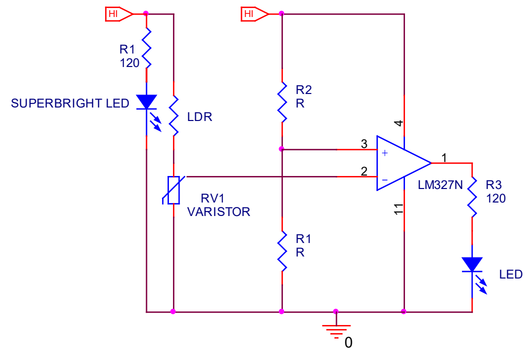

Figure 4: Schematic diagram of single sensor

From Figure 4 above, super bright LED and light dependent resistor (LDR) is act as a sensor for tracking the path. When the super bright LED transmits the light to path surface, it will reflect the light to the LDR. The potential from LDR is used as an input for the comparator. Comparator circuit used to compare the potential difference between potential divider and LDR potential. A good sensor circuit should give maximum change in potential at point 2 for no light and bright light conditions. These outputs from the comparator will be connected directly to the input of microcontroller. For the obstacle sensor, SHARP sensor model GP2D150A used in this vehicle. This digital sensor has capability to detect in a range of 3 to 30cm. The specialty of this sensor is low cost and no external circuit is needed. Since this sensor is digital type, the output can be directly to the microcontrollers.

Second main part of the vehicle is controller. The function of the controller is as a "brain" for the vehicle. In this paper, microcontroller Peripheral Interface Controller (PIC16F73) was used as a controller for the Mini AGV vehicle. PIC 16F73 consist of 22 input output (I/O) port, operating frequency of 20MHz, 4Kx14 words of program memory and 192x8 bytes of RAM [2]. Furthermore the interrupt capabilities, I/O pins, PWM module, capture and compare modules, timer modules and Universal Asynchronous Receiver Transmitter (USART) make this type of PIC is the suitable for the application. Figure 5 shows the basic connection of PIC 16F73.

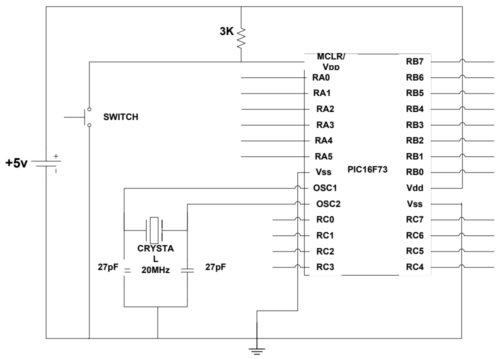

Figure 5: Schematic diagram of PIC 16F73

Mini AGV vehicle actuator should produce much torque at low RPM and consume as little energy as possible. So, TAMIYA Worm Gear Box High Efficiency is used for this application. This gearbox is using TAMIYA RE-260 DC motor with two selections of gear ratios, 216:1 and 336:1. Since the application need a low RPM and high torque, the gear ratio of 336.1 used because at this ratio, the gearbox can produce a low RPM as low as 30 RPM with a torque of 2072 gcm [8]. These high gear ratios make this gearbox appropriate for small walking robots, lifting mechanisms, and other applications where high torque is desired.

Driver motor circuit used to drive the DC motor of the gearbox. To perform this task, H-bridge circuit is used to control the DC motor. The function of H-bridge is as switching the movement of the motor, either forward mode or reverse mode. The switches are turned ON in pairs, either high left and lower right , or lower left and high right but it will never both switches on a same side of the bridge. If both switches on one side of the bridge are turned on it creates a short circuit between the supplies. The operation of H-bridge can be simplified in Table 1.

Table 1: The operation of H-Bridge circuit

High Side Left	High Side Right	Low Side Left	Low Side Right	Description
ON	OFF	OFF	ON	Forward Running
OFF	ON	ON	OFF	Reverse Running
ON	ON	OFF	OFF	Braking
OFF	OFF	ON	ON	Braking

Mini AGV has an ability to transmit the signal to the control room when the obstacle sensor detected an object in front of the vehicle and when it reaches at the check point. It can be perform by using Radio Frequency Amplitude Shift Keying Hybrid Modules (RF ASK Hybrid Modules) transmitter. This module has a frequency of 315, 418 and 433.92 MHz.

In the Mini AGV control room, there are components used such as Radio Frequency Amplitude Shift Keying Hybrid Modules (RF ASK Hybrid Modules) receiver, Liquid Crystal Display (LCD) and buzzer. The main function of the control room is as an indicator for the vehicles. When the vehicle transmitted the signal to the control room, the receiver will receive the signal and the LCD will display the position of the vehicle, either in check point 1 areas, check point 2 areas or check point 3 areas. If the vehicle detects an obstacle in front of it, the LED is ON and the buzzer will alert. The LCD will show the warning sign to technician in control room. This control room is using PIC16F84A microcontroller as their controller. Figure 6 shows the block diagram for the Mini AGV control room.

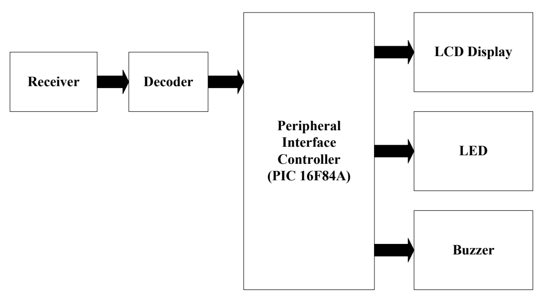

Figure 6: Block diagram of Mini AGV control room.

2.2 Software Development

The programs of the vehicle and control room have been written in the Just Another Language (JAL) program. JAL program is a High Level Language for Microchip PIC microcontroller. The program sequence of this controller is shown as in Figure 7.

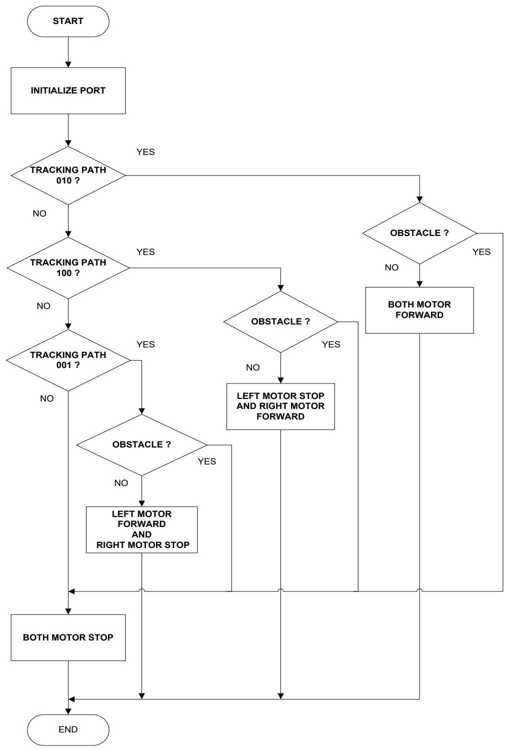

Figure 7: Main flow chart of the software program.

Figure 7 shows the main flow chart of the Mini AGV system. It indicates the main operation of the system. The system starts with initialize the data that have been set. If the line tracking sensors sense the path *"black, white, black"* and the output of the obstacle sensor are low, both of the motor move in forward mode. If the line tracking sensors sense the path *"white, black, black"* with no obstacle detected, the vehicle will turn left and if the line tracking sensors sense the path *"black, black, white"* with no obstacle detected, the vehicle will turn right. The Both motors will be stop in any condition if the obstacle sensor senses an object in front of the vehicle.

Mini AGV vehicle has an ability to transmit the signal if they reach at a check point area and when it detects an obstacle. The check point area can be differentiating with using different design on the floor. Figure 8 shows the process of the transmitting the signal.

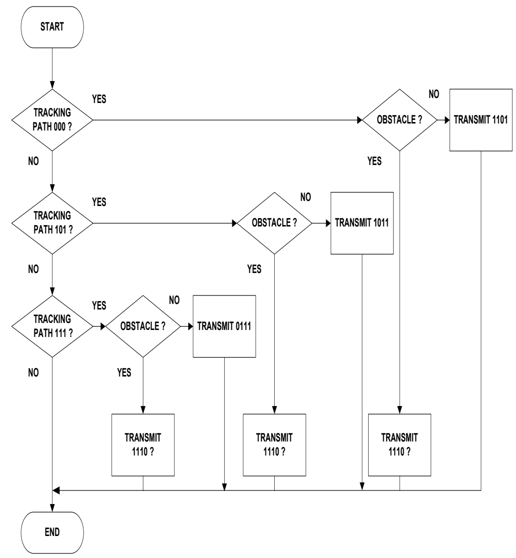

Figure 8: Flow chart for transmitting the signal.

If line tracking sensor sense *"black, black, black"* with no obstacle detects, the transmitter will transmit data 1101. If line tracking sensor sense *"white, black, white"* with no obstacle detects, the transmitter will transmit data 1011 and if line tracking sensor sense *"white, white, white"* with no obstacle detects, the transmitter will transmit data 0111.

The function of control room is to receive the signal transmit by the vehicle and show the current position of the vehicle. In addition, it also functioning to give an alert while the vehicle detects any object that blocking it from moving. Figure 9 shows the process in the control room of Mini AGV.

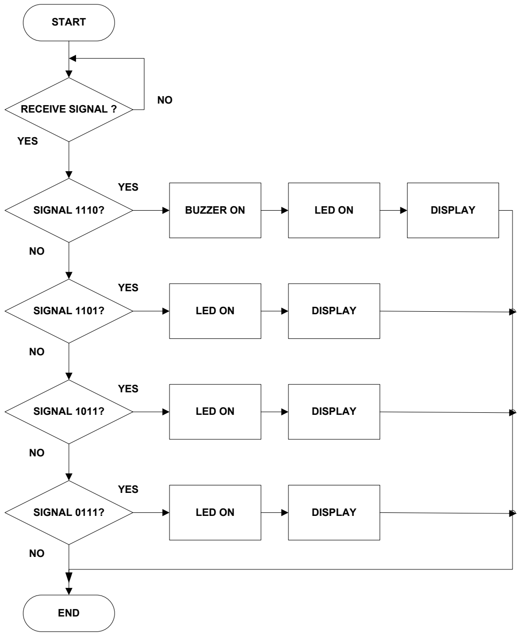

Figure 9: Flow chart for the control room of Mini AGV

3.0 RESULT AND DISCUSSION

3.1 Tracking Sensor

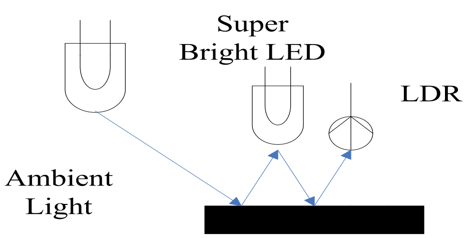

Figure 10: The operation of tracking sensor

Figure 10 shows the operation of the tracking sensors used for the vehicle. These sensors are developing using reflection theory. When the super bright LED transmits the light to the surface, it will reflect to the LDR. If the LED is transmit to the white surface, there is an output at the LDR but if the LED is transmit to the black surface, there is no output produce by LDR. From the testing that has done, it shows that the light of the sensors is affecting each other. This is because the range between the sensors are close, about 14mm each others. To avoid the light from affecting each other, a black cardboard is placed between the sensors so that the ambient light can be blocked.

3.2 Comparator Circuit

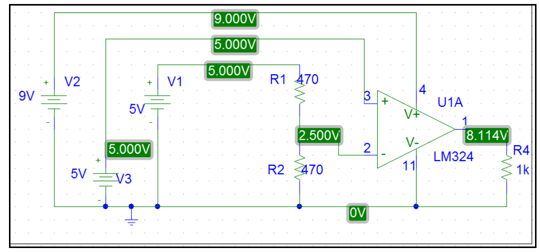

Figure 11: Simulation of comparator circuit

This simulation is considered when the sensor is track a white surface. From the simulation using P-Spice, the output from the comparator is about 8.11V but in actual circuit, the output voltage is only 6.62V. This is because in the actual circuit, there are voltage drop at the components used in the comparator circuit. An output value of 6.62V is not suitable to be an input for the PIC because the maximum input limit for the PIC is 5V. So, a voltage divider is developed to divide the output to be in half of the value. At this value, the output of the comparator is suitable to be an input for the microcontroller. The main function of the comparator is to produce an output either logic 0 or logic 1.The comparator will produce logic 0 at 0V when the sensor is track a black surface but when the sensor is track a white surface, it will produce logic 1 where the output voltage is about 3.3V.

3.3 SHARP Sensor GP2D150A

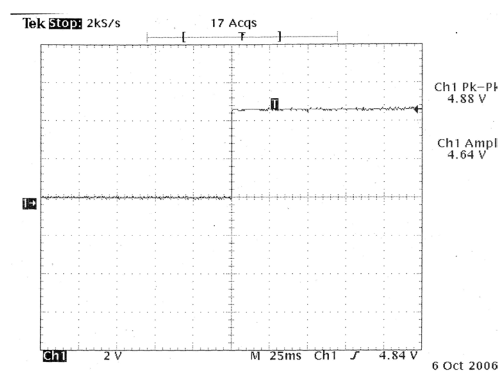

Figure 12: SHARP Sensor GP2D150A Output

Figure 12 shows the output of the sensor when it detects an object between their ranges. Since this sensor is produce digital output, it show that a step output while it sense the object. From the figure above, when the condition is low, there is no output voltage but after it detected an object, it produces output voltage of 4.68V.

3.4 Driver Motor Circuit Output

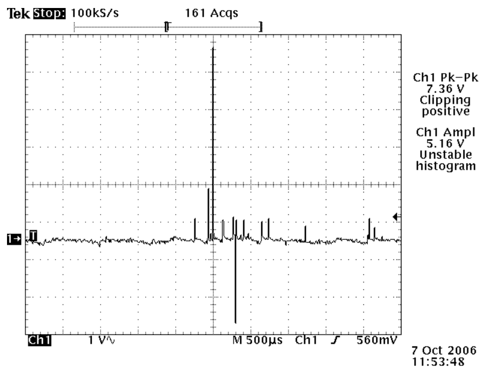

Figure 13: Driver motor circuit output

Figure 13 shows the output from the driver motor circuit (H-bridge circuit). It produces output of 5.16V with the supply of 6V. This is because a few volt of supply are lost on the transistor of the H-bridge so that supply of 6V delivers about 5.16V to the motor. This amount of voltage gives a reasonable amount of power for the motor.

3.5 PIC 16F73 Output

From the result of troubleshooting that has been done, it is found that when the output from PIC is directly connected to the driver motor circuit, the driver motor circuit cannot produce output to the motor. After several time reset the PIC, it show that the output signal from PIC has been cancel out by the motor. This is because of erratic voltage surge from the motor. To cope this problem, an optoisolator used to protect the microcontroller from damage besides it can prevent the erratic voltage surge from the motor.

4.0 CONCLUSION

AGV's is one of the most important automation used the industrial application and process. The development of Mini AGV is to study the mechanism and the operation of the real time AGV's. Furthermore, this can be use as a new idea to develop another automation application in the future.

Through Mini AGV, the objective to study about automation is success. Starting from the sensor development and their operation until the movement of motor, this will give a view about the functions, the applications and the advantages of automation as well as robotic for humans' life.

Peripheral Interface Controller (PIC) is one of the intelligent controllers usually used in robotic and automation applications. It can reprogram depending on the applications. This flexibility makes this controller more efficient and reliable for the users.

5.0 FUTURE DEVELOPMENT

In the future, these systems need to be improving because there are still have weaknesses in the development. One of them is a tracking sensor. Since the current sensors used have weaknesses because of ambient effect, it can be replaced by the OMRON line tracking sensors. With this OMRON sensor, the path or line can be detected accurately besides it as more reliable to use.

An accurate programmer such as Fuzzy Logic can be used to replace JAL language because with Fuzzy Logic, the controller is more intelligent compared using JAL language. With Fuzzy Logic, the error of the system can be reduces.

Since this system is small prototype, it can be upgraded to be real system with replace the motor with power window motor and appropriate design of vehicle. With the real design, the vehicle is able to bring a heavy load same as AGV used in the industry.

Control room of Mini AGV can be improving with using another RF ASK module. With this improvement, the vehicle can be controlled manually by remote control from control room.

6.0 ACKNOWLEDGEMENT

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7.0 REFERENCES

[1] Zan Bin Ridwan, *Robot Dance "Hell Guy" Structure Design*, Universiti Teknologi MARA, October 2004

[2] Datasheet of PIC16F73 and PIC16F84A, www.microchip.com

[3] Datasheet of Sharp GP2D150A, www.rsmalaysia.com

[4] W.Bolton, *Mechatronics, Electronic Control Systems in Mechanical and Electrical Engineering,* Pearson Education Limited, 2003

[5] History of Automatic Guided Vehicle System, www. agvsystems.com

[6] Priyanka Patil, *Line Following Robot*,Department of Information Tecknology. K.J. Somaiya College of Engineering,Mumbai, India

[7] Robert Boylestad and Louis Nashelsky, *Electronic Devices and Circuit Theory*, Prectice-Hall Int. Inc., 1999

[8] Datasheet of TAMIYA Worm Gear Box High Efficiency.

[9] JAL Manual, www.voti.nl/jal