Robobug: An Autonomous Mobile Robot using Microcontroller

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ABSTRACT

Some of the created robots had been rebuilt again to improve their ability and new research been made to get new ideas of creating higher technology robots. In this paper, writers described the development of mobile robot called RoboBug (Robot Bug) with three-legged that works automatically using 16F84 PIC microcontroller. The implementation of this project is separated into three main sections; they are mechanical, electrical and programming section. Six servo motors had been used with each leg consists of two servo motors and two infrared sensors act like feelers were used to avoid obstacle. The walking gait used a crawling concept with four basic movements; forward, backward, left and right. The results indicate that the robot has good stability of its body structure, good in avoiding obstacle and good in motion system. It is said to be the first step of developing a robot that really acts like a bug.

Keywords: *Mobile robot, PIC microcontroller, RoboBug, three legged robot*

Introduction

At the present time, through the new age of advance and high technology, many robots have been created. Some of the created robots had been rebuilt again to improve their ability and new research been made to get new ideas of creating higher technology robots. Robot is a machine that can do some task that a human can do and that works automatically or is controlled by a computer.

Mobile robots may further categorized into wheeled, tracked or legged robot. Legged robots are grouped into different categories based on the number of legs a robot had. The robots are called biped, quadruped, hexapod for robots with two, four and six legs respectively. Biped and quadruped are the most common today. Nevertheless, there are one-legged, three-legged, six-legged and eight-legged robots as well. The number of legs affects the stability and weight of the robot which must be taken into considerations when designing a legged robot.

To designed and constructed a robot depends on the task and the manipulation of the robot. Every built robot always has a weaknesses and problems. A step by step improvement and modification to the robot can cover some of the weaknesses and solve the problems. But in better way, it can be prevent by recognized all the possible of weaknesses and problems that may be occurred before construct a legged robot.

In this paper, we have developed a mobile robot called RoboBug (Robot Bug) with three-legged that works automatically using 16F84 PIC microcontroller. The implementation of this project was separated into three main sections; they are electrical, mechanical and programming section.

Electrical Section

The electrical section development involves the servo motor circuit, power supply circuit, and sensor interface circuit. The most important in the project development is the movement of the robot using servo motor. Servo motors are widely used in building robots. The nature of servo motor are wide selection of torque, low weight, cartridge type casing, precise positioning of the servo and robust.

Figure 1 shows the circuit connection for servo motors. Servo motor 1 and servo motor 2 are connected to RB0 and RB1 which control the movement of the left leg. RB0 is for upper left leg and RB1 is for lower left leg. The upper right leg is controlling servo motor 3 and the lower right leg controlled by servo motor 4. RB2 and RB3 are connected to both servos. The robot's front leg controlled by servo motor 5 and servo motor 6. All the movement of the motor are control by the microcontroller. PIC16F84A will send the signal to make the servo rotate forward and backward within angle.

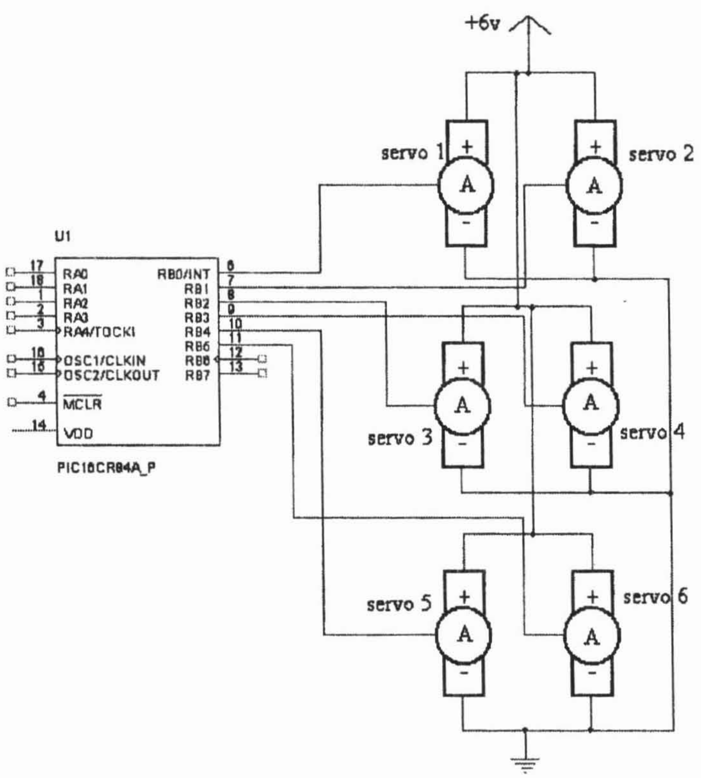


Figure 1: Servo Motor Circuit

Microcontroller as shown in Figure 2 is a brain of a digital device that operates in a close loop control process. PIC 16F84A has been select as microcontroller of this project. It has I/O port to take in interrupt or data and send out signal to control relay or just simply a motor or that type of mechanisms. In this project PIC16F84 will be used to control the robot movement. The PIC16F84 has two ports; each can be individually program as input or output. Port A is a 5bits/lines (mostly use as input), and port B is 8 bits/lines (normally use as output). The two ports are each consists of multiple lines that can be use for parallel data transfer. The PIC16F84 has two separate blocks of memory; program memory and file registers memory (Iovine, 2000).

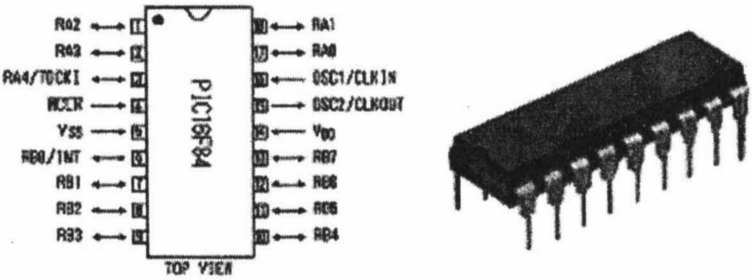


Figure 2: PIC16F84A Microcontroller

The sensor for RoboBug is infrared sensor to detect an obstacle as shown in Figure 3. Every infrared sensor is divided into two elements. First element is infrared transmitter. Transmitter type LED (IR-LED) can radiate the infrared light in about 880nm wave and need 270Ω resistance with +5V power supply. The second element is infrared phototransistor or infrared receiver. Phototransistor is special transistor because the phototransistor resistance is flexible depend on the amount of light that had been received. Transmitter radiates the infrared light to the wall or obstacle and then the light are reflected and bounce back to the receiver. After that, it sends the information to the microcontroller brain for the next action. Variable like texture, surface, colour, and reflection will affect the reliability. The infrared sensor is suitable to detect the distance from the obstacles (Sierra, 2002). It will acts like feelers for this robot.

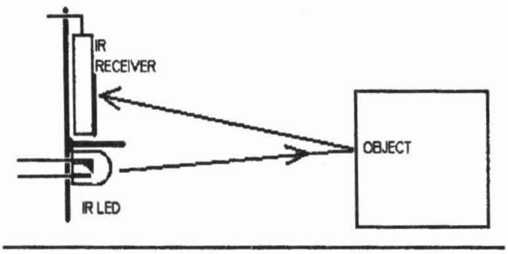


Figure 3: Infrared Sensors (Feelers)

Mechanical Section

The mechanical design was a critical phase in the development of project. Without an accurate and details design, there are possibilities that the expected movement can not be reached by the robot. Main criteria were framework balancing which placed for servo motor, infrared sensors and microcontroller circuit that shows in figure 4. Base of the framework must be really tough and strong to support the load. A few main factors to be met for the framework requirements listed in Table 1; there are weight, cost and process in designing. Plastic or polyvinyl chlorides (PVC) are suitable material for base of framework and zinc for housing of the robot.

Table 1: Designing Framework Criteria

Designing factors	Specification
Weight	The main body is should not too heavy. Because to make sure the legs capable to support the load of the system
Size	The size is not too big and appropriate with the size of the motor.
Shape	The shape of main body and legs appropriate with the weight and the size.
Material	The material must be easy to find and design.

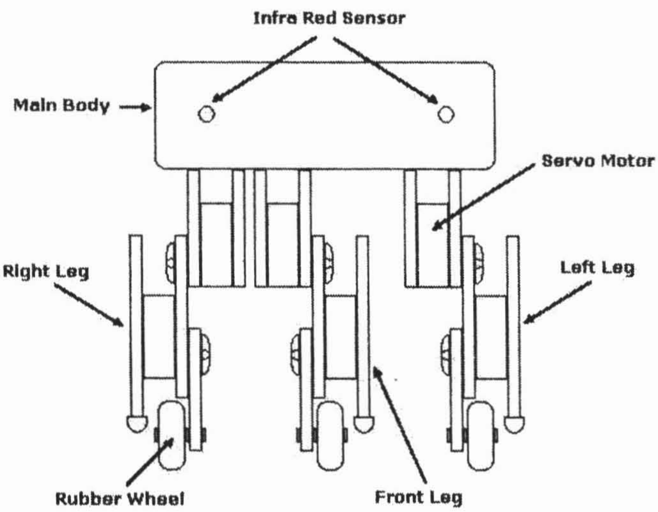


Figure 4: Front View Mechanical Structure of RoboBug

This robot was categorized as small robot due to its small size which is 22cm wide, 26cm long and 18 cm height in stable condition. Without batteries its weight is 1.6kg. Basic structure of RoboBug was built using U-shape aluminums as legs, a piece of acrylic plastics as the main body. Apart from that, screws used to hold each part and rubber eraser and toy's wheel are used to construct the legs. Figure 5 shows the size of the main body and the leg of RoboBug. Figure 6, 7 and 8 shows the leg, feelers and main body of RoboBug respectively.

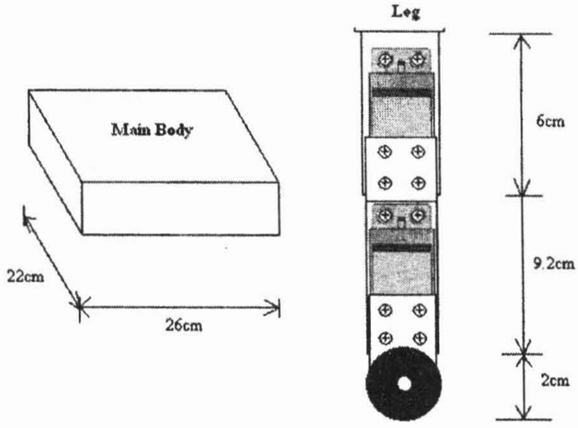


Figure 5: Main Body and Leg Size

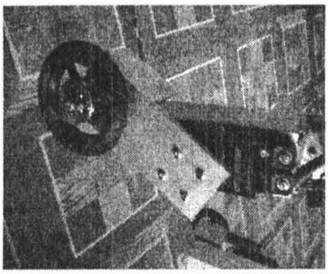


Figure 6: Bug leg

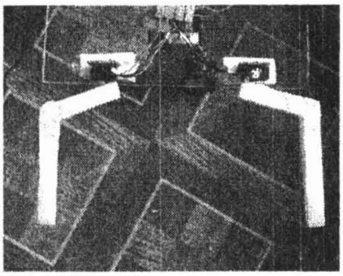


Figure 7: Bug feelers

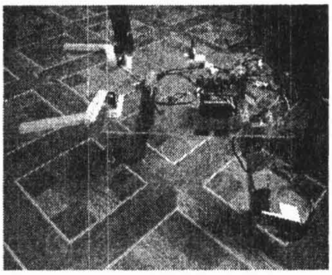


Figure 8: Main body

Programming Section

Robot programming is the process of writing the instruction to control the robot movement. It is necessary to determine the robot behavior before writing the program. There are two parts in programming the controller: writing and download. In this project, a software that been used to write the program is MPLAB version 7.2 using PIC Basic Pro Language. Programming PIC microcontrollers using a BASIC language is a simple and the easiest languages to learn. The Desktop Programmer as figure 9 below is used to download the program into PIC micro controller using IC-Prog 1.05D software.

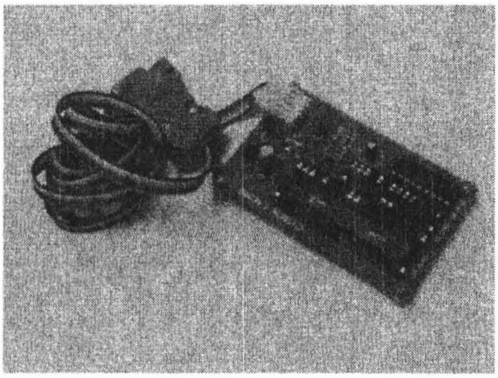
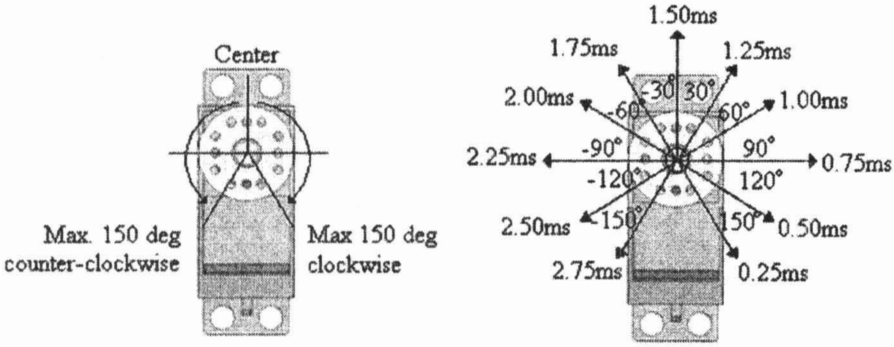


Figure 9: Desktop Programmer

Results and Discussion

Analysis has been made for controlling the angle of servo motor. By generating a certain pulse value to the signal can drive servo's gear to clockwise (CW) or anti-clockwise (CCW) rotations from its neutral point. The GWS S03T STD type servo motor can be rotate to maximum of 150 degrees angle clockwise and anti clockwise. Figure 10 and Table 2 shows the analysis of pulse signal value and angle rotation of servo motor.



(a) (b)

Figure 10: (a) CCW and CW Max Rotations, (b) Angles and its Pulse Signals

Table 2: The Pulses and Servo angle for Servo Motor

Pulse Signal (millisecond)	Servo Angle (degree)	Rotation
0.25	150°	CW
0.50	120°	CW
0.75	90°	CW
1.00	60°	CW
1.25	30°	CW
1.50	0°	Center Point
1.75	-30°	CCW
2.00	-60°	CCW
2.25	-90°	CCW
2.50	-120°	CCW
2.75	-150°	CCW

The pulse values that can be generated to the signal are between 0.25ms to 2.75ms. It necessary to center the gear before rotates it so we can see the next rotation clearly. The center point (neutral point) is 1.5ms (milliseconds). If more than 2.75ms signal or less than 0.25 signal pulses generated will force the gear to rotate beyond the limit and cause damages to the servo. Figure 11 show the pulse width modulation waveform of 2.0ms that had been measured using the oscilloscope.

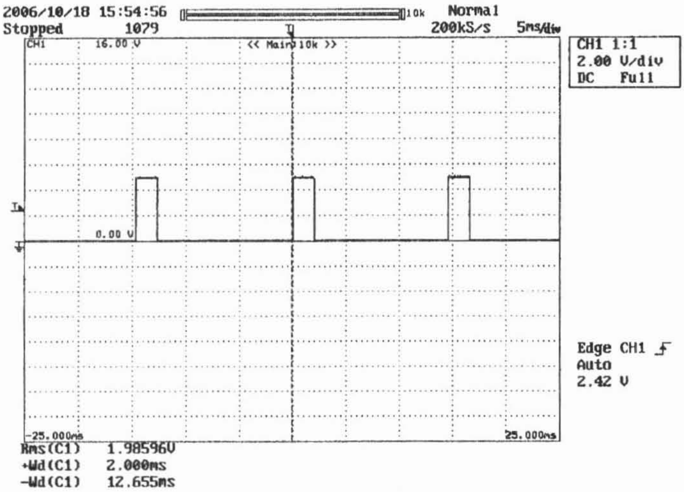


Figure 11: Waveform of 2.0ms Pulse Signal

The legs of the robot are the main part to move the robot. As each legs consist of two servo motors, all the servo motor have been label with servo motor 1 until servo motor 6. Servo motor 1 and 2 controlled the left leg, while servo motor 3 and 4 controlled the right leg. The front leg was controlled by servo motor 5 and 6. Each signal of the servo connected to port B (output) of PIC16F84A.

All the three legs of the robot were designed differently. So, each of every leg moved forward and backward with different pulse value because of the different positions of servo motors. The robot legs can be divided to two parts; upper and lower legs. Figure 12 (a), (b) and (c) below simply give analysis of the movement of each leg. It also shows the servo rotation to either counter-clock-wise or clockwise rotation that moved the legs forward or backward.

Each of every servo motor plays their role at most movement. The walking gait for the robot basically used a crawling concept. Therefore the used of wheel and rubber at each leg are very useful for the walking gait concept. The legs can stand either use rubber or wheel as the foot. The leg which stands with the rubber will function as a puller or pusher that dragging other legs forward and backward that stand on wheel. To achieve the full automation for the robot movement, there are 4 basic movements; crawl forward, crawl backward, turn left and turn right.

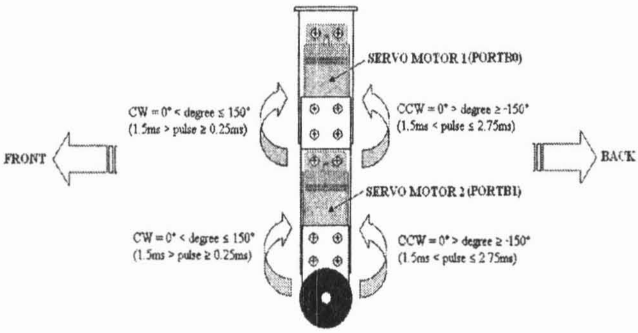


Figure 12(a): Left Leg Movement

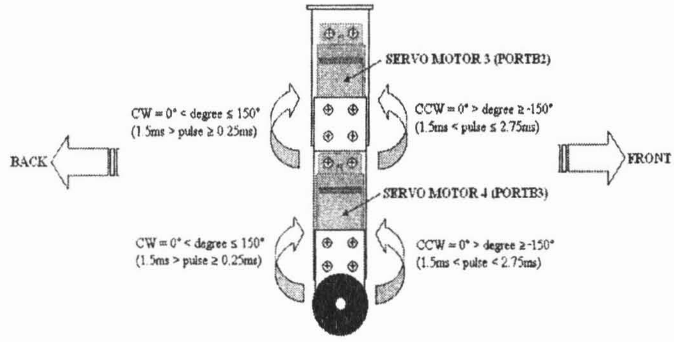


Figure 12(b): Right Leg Movement

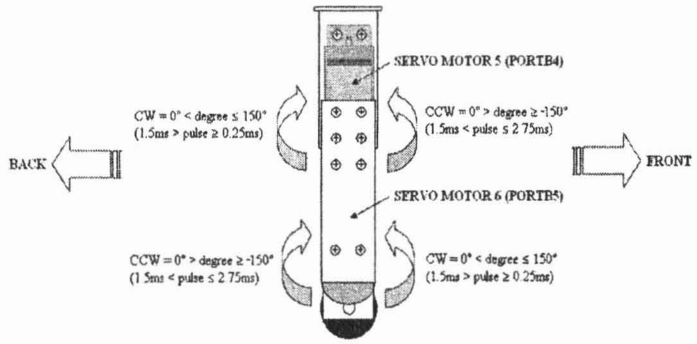


Figure 12 (c): Front Leg Movement

Conclusion

The development of mobile robot called RoboBug (Robot Bug) with three-legged that works automatically using 16F84 PIC microcontroller has been developed. Its ability to move using a crawling concept with four basic movements; forward, backward, left and right.on a flat plane and the intelligent to avoid obstacles using infrared sensors which acting like feelers shows the successful in constructing the robot. The results show that the robot has good stability of its body structure, good in avoiding obstacle and good in motion system. Future development will look onto the behavioural of a bug transform to a robot.

References

Al Salameh, Abd. Al Salam Sheikh. (2000). Design and Construction of Robot Leg for Walking and Climbing on Animal Locomotion Characteristics. M.Sc. Thesis. Universiti Teknologi Malaysia.

Bates, M. (2000). *The PIC 16F84A Microntroller*. London: Arnold.

Dogan Ibrahim. (2001). *PIC Basic Programming and Projects*. Great Britain: Newnes.

Iovine, J. (2000). *PIC Microcontroller Project Book*. First Edition. Washington, D.C: The McGraw-Hill Companies.

Mariam, M. G. and Cheok, Y. S. (2007, December 3). *Development of manually guided robot* *with minimum 5kg of load*. Paper presented at the 2007 2nd Regional Conference on Engineering Education. pp.92-97.

McComb, G. (2000). *The Robot Builder's Bonanza*. Second Edition. New York: Mc Graw Hill.

Microengineering Labs Inc. (2004). *PicBasic Pro Compiler*. MPLAB.

Sierra Pacific Inc. (2002). *Infrared Theory*. USA.

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