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Robotics Development and Design: Optical and Computer Controls

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ROBOTICS DEVELOPMENT AND DESIGN: OPTICAL AND COMPUTER CONTROLS

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ABSTRACT

In industry today, the use of robotic systems is growing. They can be found in many diverse applications including washing dishes, assembling automobiles and carrying explosives. With such a wide range of applications, robotic systems are a very important division of engineering.

Designing such systems requires an interaction between different disciplines of engineering. In the work world, engineers are required to interrelate with other engineers of differing disciplines and backgrounds. This research was designed to implement this type of partnership and develop a project that required the knowledge of an electrical, a mechanical and a computer science engineer.

Using the Motorola M68HC11 microprocessor, this system is designed as a prototype for a self-contained robot. The robot will have the ability to learn paths and be remote-controlled. With a few modifications this robot would be ready to be adapted to a desired task.

This research investigates the application of this single board processor and the design process required to create a small robot with self-guidance capabilities.

INTRODUCTION

In engineering, the most important aspect of our education is the ability to put text book theory into solid working answers. This research promotes the practice of engineering in three different disciplines of engineering. The topic of robotics was chosen in order to benefit more from the interaction of electrical, mechanical and computer science engineering and the hands-on application of engineering.

The design and creation of a robot is a long process of decisions. The designer must decide on a general purpose that is flexible for the robot so that it will be flexible to many purposes. The purpose chosen then leads to the design of the carriage, drive train, controller, and communication between operator and robot control. This research contains the necessary design processes implemented to complete this project.

USING THE M68HC11EVB MICROCOMPUTER CONTROL BOARD

The center of this research fell on the use of a micro-controller as a central processing unit for the robot and its controls. The M68HC11EVB evaluation board is a flexible controller designed to interface with a personal computer or other controller for input. The board was chosen to act as a total processor on board the robot. The micro-processor was designed to read the inputs from the optical sensors and bump switches, process the information and translate it into a wave drive signal for the stepper motors.

The evaluation board is first connected to a personal computer for external control and monitoring. A cable was made to tie the terminal port of the M68HC11EVB to the com1: communications port of the computer. This cable is the RS-232 type cable similar to a parallel printer cable. The cable was configured to jump the ready line to the ready query line in order to maintain an open input at the computer. The cable was configured as shown below in Figure I.

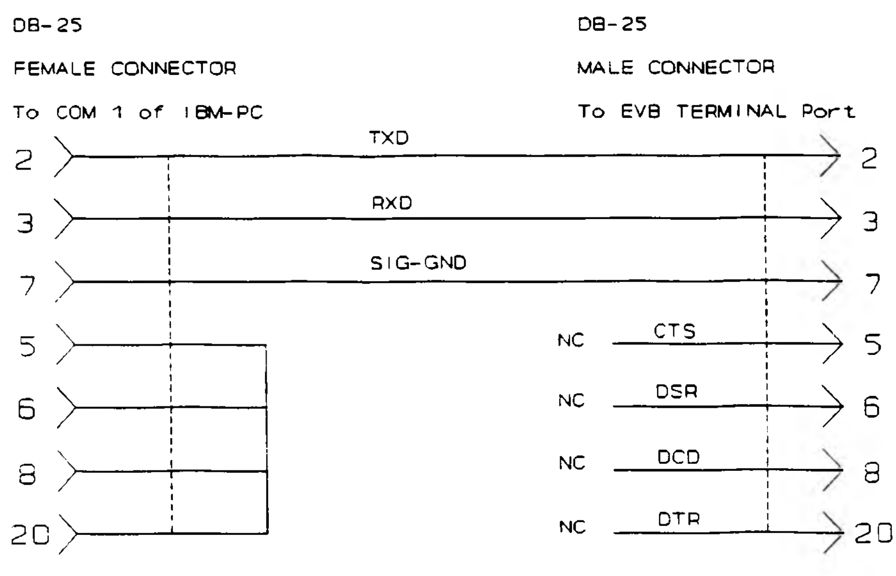

Figure 1: RS-232 Cable Configuration

The connection allows the board to communicate at all times with the computer and therefore the user [1].

Once the evaluation board is connected to the personal computer the input and output ports must be programmed. Ports A-E are each one designed for a specific purpose. The port A pins are configured PA0-PA2 as fixed input pins. Port pins PA3-PA6 are fixed output pins and PA7 is input/output configurable [2]. The Port A pins PA3-PA6 are used in the design as wheel one control output logic. Port B pins PB0-PB7 are configured as fixed output pins [2]. The Port B pins are used as wheel two control output logic. The Port C pins are configured in a complex all input, all output, all input/output handshake or as a time-multiplexed address/data bus port [2]. Port C pins PC0-PC7 are used in the design as full input for optical sensors. This requires the control bit DDRC to be set to 0 to enable them as a full input port. Port D is configured in a similar manner as the Port C pins. To set the Port D pins as a full input port requires that the control bit DDRD is set to 0. The Port D pins are used as interrupt switches triggered by bump switches on the robot. The Port E pins are configured as fixed directional input pins that alternately function as an A-D converter [2]. The Port D pins have no function in the current design of the project. The pins are all TTL compatible for input and for output. A buffer is needed between the output and any circuitry to be driven since the board tends to be loaded down easily.

The micro-processor board also has specific power needs. A self contained power source designed to set next to the personal computer and tethered to the robot by a 30 foot cord was designed and built. The Power source used a simple design as shown in Figure 2.

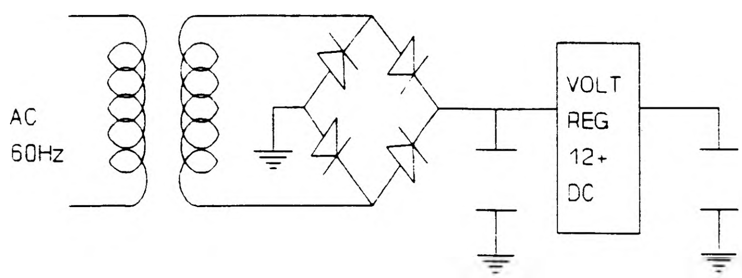

Figure 2: Power Supply Circuit

The capacitors were used to isolate all resonance or ripple out of the power to the computer board. The micro-processor requires 12 volts at .1A, -12 volts at .1A and 5 volts at .5A maximum currents.

The M68HC11EVB evaluation board is programmed using a language called BUFFALO (acronym meaning Bit User Friendly Aid to Logical Operation) [3]. The code is edited in a manageable text editor, such as Turbo C, and then assembled in a cross assembler provided with the board. The cross assembler creates a file filename.s19 which is downloaded using a communications program. The communications program used was KERMIT via the COM1 port [3]. One problem encountered was the board's limited memory. The program was unable to store long enough jump vectors to jump a sufficient number of lines and therefore required address vector jumps which are much more inconvenient. Code instructions can be found in the Reference Manual [2]. The program is not completed and will therefore be appended at a later date.

DESIGNING THE FRAME AND DRIVE SYSTEM

The design of the shape and size of the frame of the robot has a large impact on the other design parameters of the robot. The first step in designing the overall appearance is looking into other work that has already been done and also looking into the purpose of the project. In many catalogs, the use of a round body is utilized to keep the turning radius to a specific distance. The robot needed in this design only needs a predictable turning radius. Others use square designs or rectangles. The robot was designed as a rectangle for ease of placing the sensors and drive motors.

The next big decision to make is the material to use to build the prototype frame. The choice made in this research was aluminum. It is very workable and cheap. The electrical department also had a good supply of it already to purchase. The mechanical engineering department had the tools necessary for the tooling to be done. This made aluminum a good choice. The pieces for the original design were drafted and then cut and assembled. (Figure 3) The design also included a steel rod for the axle and poured and milled aluminum wheels.

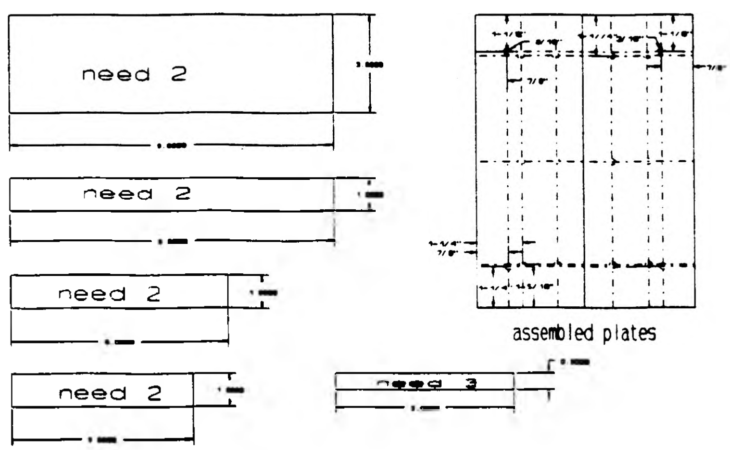

Figure 3: Metal for the Robot Frame

The drive system must be specified to the needs. The robot depends on the robot following commands and carrying them out with little error. There is no feedback of position since the design of a position measure is so difficult in a floor running robot. In order to avoid optical shaft encoder use on the robot, stepper motors were chosen. The motors were chosen on their ability to not slip after stepping and the ability of being strong enough to move the robot. The motors were found in a repossessed parts from old equipment catalog. The strength of 50 oz.in. holding torque was chosen and the steppers were driven as unipolar motors as shown in the EE313 lab manual [4]. This was a cheaper source than any other found. The creation of the mounts for the motor also took some time. The motors needed to stay stationary to ensure tight traction belts and no slippage. Straps were used to tie the motors to an angle with four face bolts to hold the motors.

Using the micro-processor to control the motors requires that there be some kind of switch between the motor power circuit and the TTL output of the board. A buffer is required to keep from loading down the board output power. The motors require five volts and 1 amp of current to energize each coil to be powered up. Unfortunately my first design failed to take into account the drain to source resistance of the VN6000 power MOSFET of approximately 4 ohms. This additional factor increased the voltage source requirements to 9 volts 1 amp per coil per motor. The circuit used to switch the motors is shown
below in Figure 4.

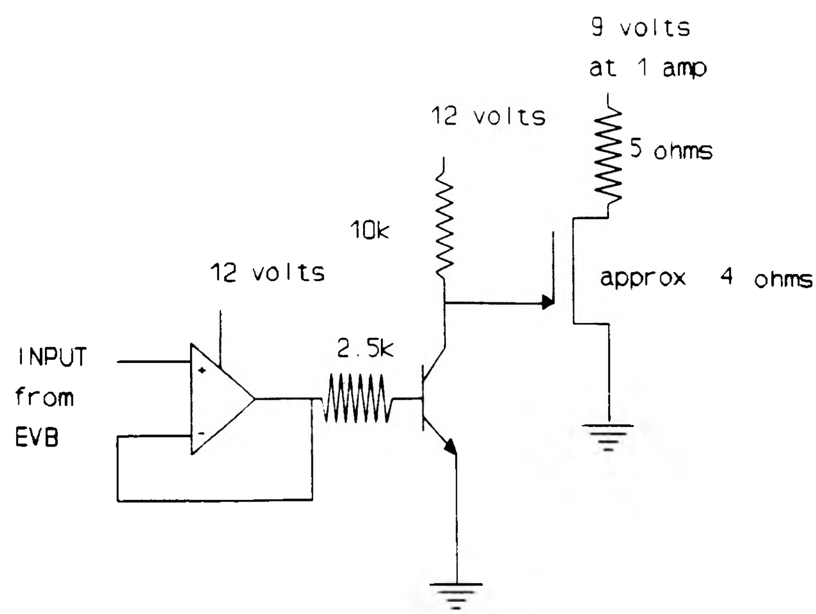

Figure 4: Motor Interfacing Circuit

DESIGNING THE OPTICAL SENSORS

One of the most interesting parts of this research is the optical sensing input devices. There is a wide variety of choices when choosing an optical sensor. The optical sensor type chosen for this project is the Infrared wavelength emitter and detector pair. A photodetector gives to wide a range of sensing and picks up all the light sources in a given room. The infrared sensors allow only the small wavelength around 880 to 975 nanometers to be an influence. Unfortunately the lighting in a room has a high percentage of infrared output [5].

To date, the optical sensors are still under research and design. The optical sensors will bias a bipolar junction transistor to turn on and give a five volt input to the micro-computer. The transistor will act as an amplifier with adjustable gain achieved by means of adjustable resistance in the base and emitter circuit. This will allow the sensitivity of the inputs to be varied for different lighting environments.

BUILDING A MAZE FOR THE ROBOT

The demonstration maze will be constructed as soon as the robot is complete and working. The maze is designed to simulate the use of the robot in an office building where it would possibly be programmed to pick up and deliver mail in the evenings or some other task. The maze will be made of movable walls to simulate any type of corner, room and/or hallway desired. The floor will contain a grid of holes where the walls will bolt down from underneath. Different lengths of wall will be made to be placed anywhere desired. The design is shown below in Figure 5.

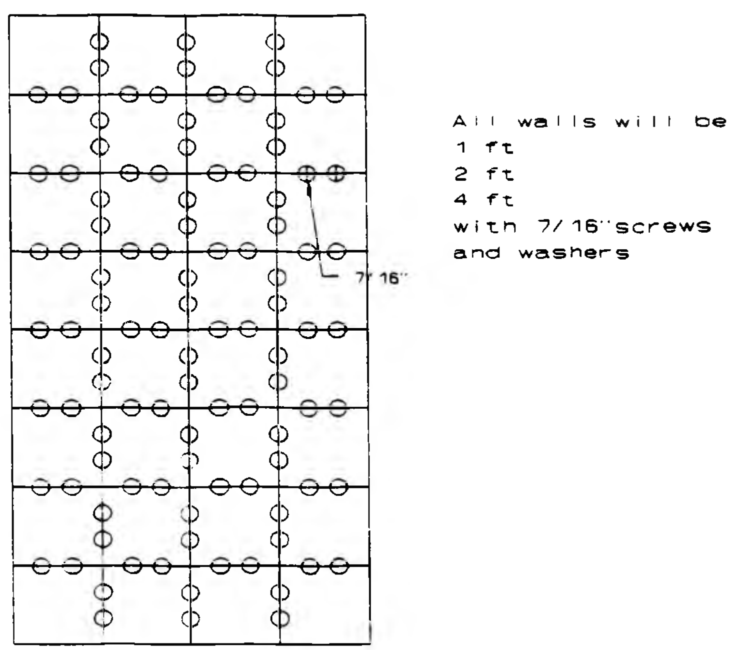

Figure 5: Demonstration Maze for Robot Exhibition

APPLICATIONS FOR RESEARCH

This research is useful in several areas. In places of business or health that humans really shouldn't go a robot can go. Hazardous waste containment someday will be done by robots. Area scavenging where a hand cannot reach. Getting the harvest in faster than man can.

This research was also a great learning tool for the people involved. We learned how to communicate with other engineers from different backgrounds and got a glimpse of what their training has been the past four years. The project also helped our understanding in what it takes to take an idea on paper and make it real. All of these are valuable market tools that must be developed in successful engineers of any discipline.

ACKNOWLEDGMENTS

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