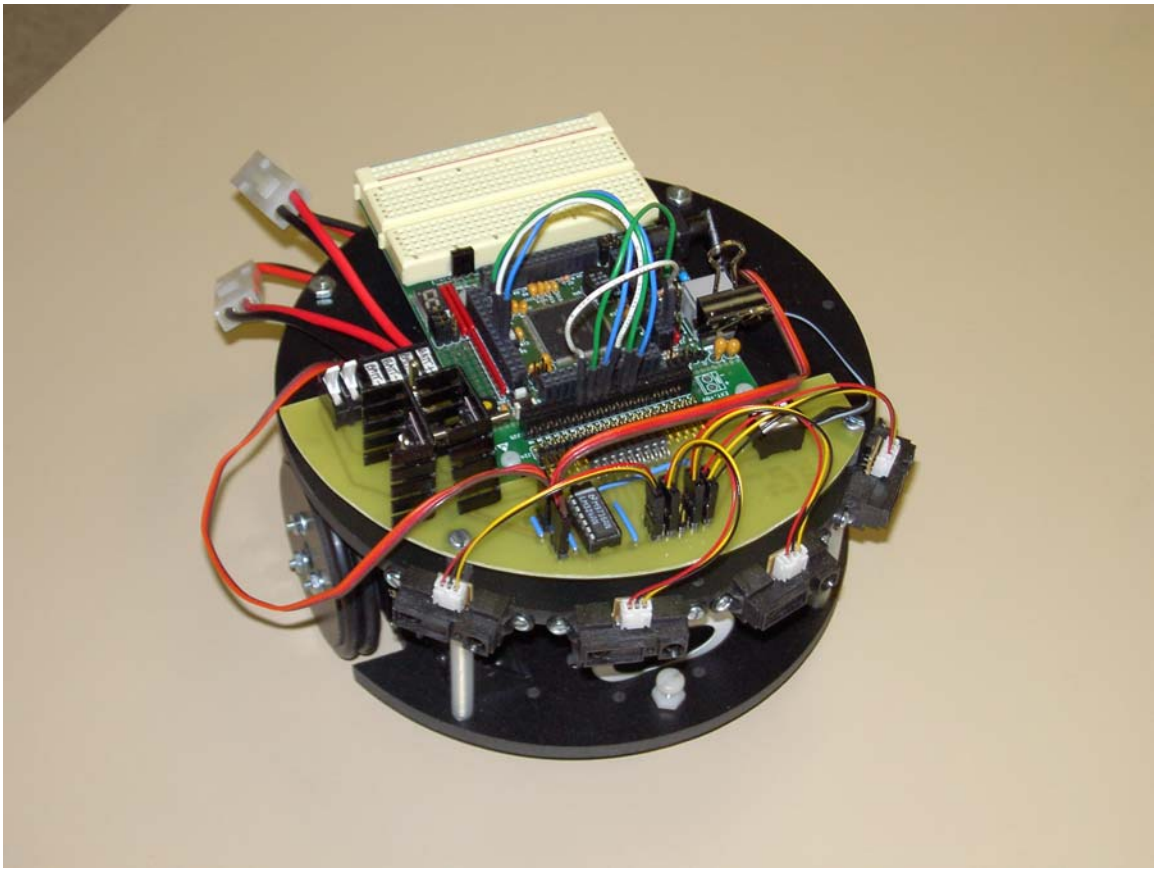
PROFBOT
Robot “Owner’s Manual”



PROFBOT designed and fabricated in house
at the
Department of Electrical and Computer Engineering
University of Wyoming
Laramie, WY

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Overview
The purpose of this manual is to provide detailed information on the design and operation of the PROFBOT educational robot. We will begin with an overview of the robot subsystems followed by a detailed description of each. We then provide details of interfacing the robot sensors and motor drive systems to the host processor. The manual concludes with detailed information on the host processor to aid in hardware interfacing and software programming.

PROFBOT Subsystems

Figure 1 provides a top view of the PROFBOT. The PROFBOT is equipped with a number of subsystems including a:

- Sensor subsystem comprised of four Sharp Electronics GP2D12 infrared (IR) emitter-detector pairs,
- Robot motor drive subsystem consisting of two servo motor driven wheels,
- Interface subsystem consisting of a printed circuit board (PCB) which links subsystems together,
- Power subsystem that provides either onboard battery power or offboard power from an AC adapter, and
- Host processor subsystem.

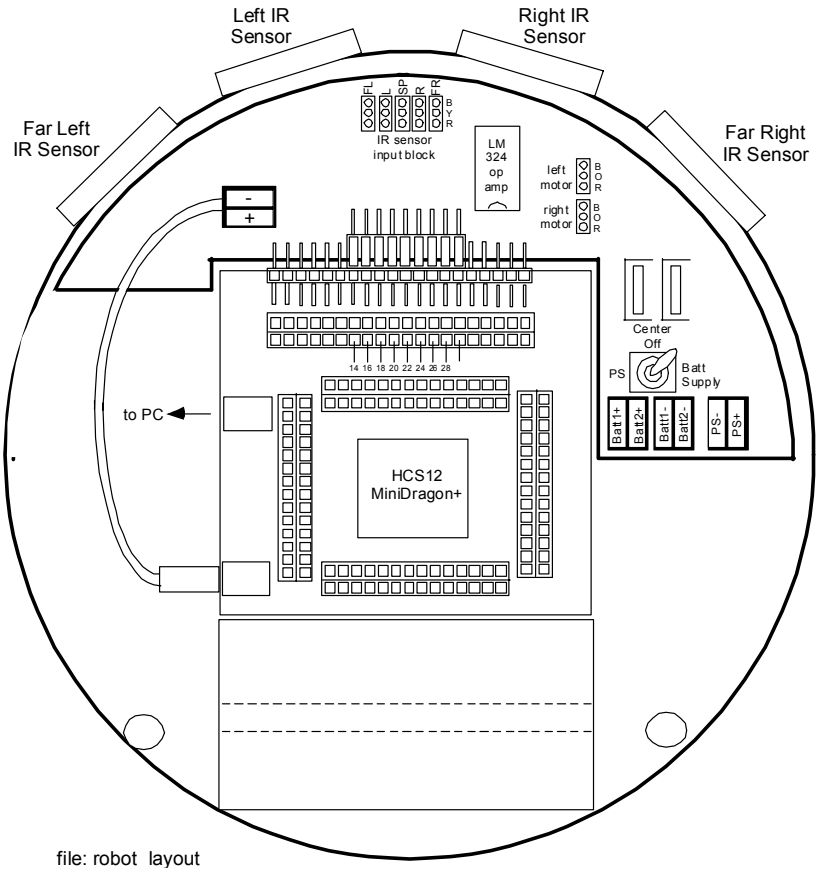

Figure 1. Robot Layout

Subsystem Description

Sensor Subsystem. The Sensor Subsystem consists of four Sharp GP2D12 IR sensors designated the far left, left, right, and far right sensors. The sensor module consists of an infrared emitter and a detector. The emitter provides a monochromatic infrared signal. Upon reflection from an object, the detector senses the infrared signal. Based on the intensity of the received infrared signal, the infrared detector outputs an analog voltage. The closer an object, the higher is the received infrared intensity, resulting in a higher output voltage.

The GP2D12 has a non-linear output based on the distance measured. The detector can sense an obstacle from 4 cm to 40 cm. The object detector cannot sense an obstacle if it is within 5 cm. The graph (experimentally measured) in Figure 2 illustrates an actual response curve that was determined based on the reflective surface of the maze. The response curve will be different for different reflective surfaces in front of the infrared object detector. The GP2D12 detector provides continuous readings when powered. The operating voltage of the detector is 4.5 volts to 5.5 volts DC. A detailed description along with device data for GP2D12 is found in Appendix C.1 of the laboratory manual.

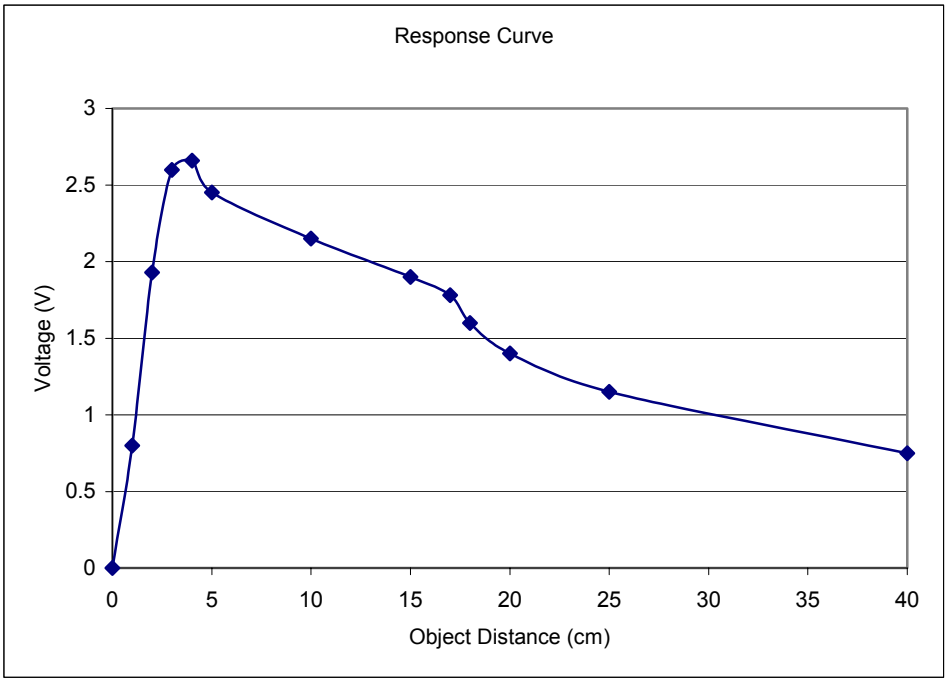

Figure 2. Voltage versus Distance to Reflected Object Curve.

Robot Drive Subsystem. Two servo motors are used for robot motion. A servo is a small motor that has an output shaft. This shaft can be positioned to specific angular positions by sending the servo a coded signal. As long as the coded signal exists on the input line, the servo will maintain the angular position of the shaft. As the coded signal changes, the angular position of the shaft changes.

The servo motor is equipped with a small potentiometer. The potentiometer allows the control circuitry to monitor the current angle of the servo motor. If the shaft is at the correct angle, then the motor shuts off. If the circuit finds that the angle is not correct, it will turn the motor to the correct direction until the angle is correct. The output shaft of the servo is capable of traveling on the order of 180 degrees. Usually, it is somewhere in the 210 degree range, but it can vary from one manufacturer to another. Generally a servo is used to control an angular motion between 0 to 180 degrees. A servo is mechanically not capable of turning any further due to a stop built on to the main output gear. However, the manufacturer removed the stop for the servo motors being utilized for this project, which allow continuous rotation.

The operating voltage of the servo motor utilized in the project is 4.5 volts to 6 volts DC. The motor for motion in one direction requires a periodic square wave pulse that is greater than 1.5 milliseconds in duration. Applying pulse lengths less than 1.5 milliseconds will cause the robot to be in motion in the opposite direction. In either case, the frequency of the pulse must be 20 to 50 Hz. Motor action is illustrated in Figure 3.

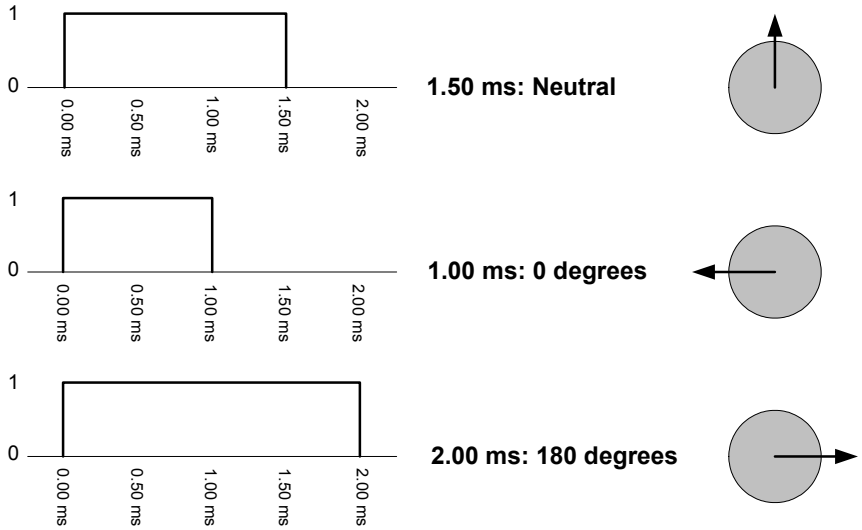

Figure 3. Duration of Pulse That Dictates Rotation Direction.

Interface Subsystem. The subsystems are interfaced to the host processor via a printed circuit board (PCB). The PCB provides connections for the Sharp GP2D12 IR sensors, the motors, the power subsystem, and the interface electronics. A schematic of the interface is provided in Appendix A. A PCB layout diagram is provided in Appendix B.

Power Subsystem. Robot power is selectable from one of two sources: onboard battery supply or remote DC voltage provided by a remote power supply. The desired robot supply is chosen using the toggle switch just forward of the battery terminal block. The switch has a center off position.

Battery power is provided by two onboard 7.2 VDC, 1500 mAh rechargeable batteries. The batteries are connected to the robot by two terminal blocks labeled Batt1+, Batt2+, Batt1-, and Batt2-. To recharges the batteries they must be disconnected from the terminal block and connected to Tower Hobbies, Tower Power 420 AC/DC battery chargers. This is easily accomplished via the quick disconnect battery cables.

The remote power supply is attached to the robot via the terminal block labeled PS+ and PS-. Remote power is provided by a 120 V, 60 Hz to 7.5 VDC, 1,100 mA AC adaptor (Jameco #280250).

Whichever robot power source is chosen, it is then routed through a 7805 5 VDC voltage regulator. The unregulated voltage source is also routed to the Minidragon power terminal block designated + and -. A short cable connects the terminal block to the Minidragon processor power supply jack. The Minidragon processor has its own onboard 5 VDC regulator. The regulator is equipped with a binder clip which serves as a heatsink.

Host Processor Subsystem
The following is the list of resources available onboard the MC9S12DP256 microprocessor:

- 16-bit CPU,
- Memory, 16-bit wide addressable,
- Two 8 channel analog to digital converters, with 8 or 10 bit resolution,

- Multiplexed external bus,
- Maskable interrupts,
- 8 Channels Input Capture/Output Compare enhanced capture timer,
- 8 Pulse width modulation channels with programmable period and duty cycle,
- Serial interfaces, and
- Extensive input/output port systems.

Processor Notes
The Minidragon+ processor board hosts a DP256 HCS12 processor. Considerable technical data is provided by the manufacturer on this processor board including:

- PCB Layout and Pinout
- Interrupt Vector Map
- Onboard hardware and important notes

Interfacing to the Processor

Connections are made between the PCB and the processor using male-to-male equipped braided wire jumper connectors.

Constructing Your Own Robot

As we designed this robot, we wanted to use readily accessible off-the-shelf parts. Here is a listing of the component robot parts, parts numbers, prices, etc.

Part Description	Quantity	Manufacturer	Manufacturer Part #	Price Each	Total Price
Robot Platform w/wheels and motors	1	Budget Robotics (www.budgetrobotics.com)	KIT250-II	$54.95	$54.95
Infrared Emitter Detector Pairs	4	Acroname (www.acroname.com)	Sharp GP2D12	$12.95	$51.80
Rechargeable Battery Pack, 7.2 VDC	2	Tower Hobbies (www.TowerHobbies.com)	Available under various part numbers	$25.00/ pair	$25.00
Minidragon+ Evaluation Board (includes MC9S512DP256) with female header connectors	1	Wytec www.wytec.com and www.evbplus.com	Minigragon +/FH	$119.00	$119.00
Power Supply (7.5 VDC, 1.1A)	1	Jameco www.Jameco.com	280250	$6.29	$6.29
Battery cable connectors	2	Radio Shack	23-444	$2.99	$5.98
Aluminum Heat Sinks	2	Radio Shack	276-1363	$1.29	$2.58
Printed Circuit Board w/components	1	Local Manufacture	--	$30.00	$30.00
	1	- DPDT switch (on-off-on)			
	2	- 7805 5 VDC regulator			
	1	- LM324 operational amplifier			
	4	- power supply header blocks			
	1	- edge connector			
	6	- ½" circuit board spacers			
				Total	**$295.60**