EEL4914 ECE Design II
Preliminary Report

SITH HAPPENS

by

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Abstract

Our project is to build the Star Wars R2-D2 using RC Robot and Controller. The objective is to build a fun robot that people can play with that will behave like the robot from the Star Wars series. The roles for the robot and controller are described below.

For the controller, we must choose between two options of implementation. The first option is a physical controller with keyboard using XBee. This controller will have a joystick to control the robot's movement. Additionally, it will have several buttons/controls to operate different functions of the robot such as audio output, shooting "Nerf-Gun" bullets, and other potential tasks. Finally, the keyboard will allow for text-to-speech operation for communication. The second option is a glove controller with combination of accelerometer, gyroscope, and/or flex sensors. With this implementation, each finger's flex sensor will control a different operation as described in the previous implementation, but this would exclude the text-to-speech commands because there would be no input to drive that output. This method simulates controlling the R2-D2 robot with "The Force" as the Jedis do in the Star Wars movies. Both implementations will be battery operated and will have battery recharge circuits.

For the robot, a microcontroller will drive servo/stepper motors to control the robot's movement. The control will be received via XBee from the controller for motion. The microcontroller will also drive the other operations of the robot, based on the data communication from the XBee module such as weapon control, text-to-

speech audio, and other sound outputs from the robot. For aesthetics, the R2-D2 robot will have a thermistor circuit which will control the microcontroller to display different colors on RGB LEDs. For example, the LEDs will default to “Blue”, just like the original R2-D2, but will adjust to “Red” for temperatures that exceed a predefined threshold. This robot will be battery powered, and it will use the same battery recharge circuit as the controller.

Chapter 1

Project Objectives

In order to meet our goal of developing a remote-controlled car, we require both digital and analog circuitry. To allow the user to control the robot, we desire various inputs to the system; these inputs come in the form of sensors such as buttons, switches, and an analog joystick. At the same time, the robot needs to be able to receive commands from the controller and exercise those commands in real-time. As such, an XBee module is attached to both the robot and the controller for wireless communication, and the microcontrollers can interact with the XBee modules using UART.

On the robot end, we will have PWM for motor control, an audio circuit including an external DAC to output sound effects from the Star Wars universe, and LEDS. Both the controller and the robot require batteries for power.

Our specific objectives include the following:

Digital Objectives:

- XBee UART Communication
- PWM Control for Motors
- Microprocessor Controls for R2-D2 and Controller (GPIO)

- Nerf Bullet Control

Analog Objectives:

- Battery Recharge Circuit
- Joystick Control
- Thermistor-LED Control
- Audio Output from Speaker

Chapter 2

Technology Selection

2.1 Microcontroller

Because the project consists of both a controller and a robot, we need two separate microcontrollers with the ability to communicate with each other. The MSP432P401R was chosen to serve as the microcontroller on both the controller and robot sides. This specific microcontroller was selected because it is low-power, relatively inexpensive, and provides much of the desired functionality (including UART, an ADC with sufficient resolution, and timers) for our purposes. We will use two MSP432s.

- MSP432P401R: Up to 48MHz CPU, FPU, 14-bit ADC, UART, 16-bit Timers with PWM (Robot/Controller)

2.2 Wireless Communication

The XBee module is used to have two MSP432s communicate with each others wirelessly through UART. This type of communication was selected because it is easy to use and interface with.

- XBee: RF Module IEEE 802.15.4 Standard, UART Communication (Robot/Controller)

2.3 Audio Circuit

To output sound from the microcontroller on the R2-D2 robot side, we use the MSP432 to send signals to a 10-bit external DAC (LTC1661). The output of the DAC is sent through an amplifier circuit before sending it to a speaker. The LTC1661 was selected because we are both familiar with the chip, and it supports sufficient resolution (10-bit) for audio.

- LTC1661: 10-bit External DAC, 2.7V to 5.5V Supply (Robot)
- Audio Power Amplifier Circuit (Robot)

2.4 Motor Driver

The motor driver circuit consists of an H bridge to drive four motors for movement.

- PWM Motor Driver Circuit (Robot)

2.5 Inputs

The following digital buttons and switches and analog joystick will serve to provide user input to the system for robot control.

- Push Buttons
- Switches
- Joystick: Analog Joystick (Controller)

Chapter 3

Flowcharts and Diagrams

We include a block diagram to give an overview of our entire system as well as software flowcharts to describe the functionality of both the controller and the robot.

3.1 Block Diagram

The block diagram is divided into two parts: the controller and the R2-D2 robot.

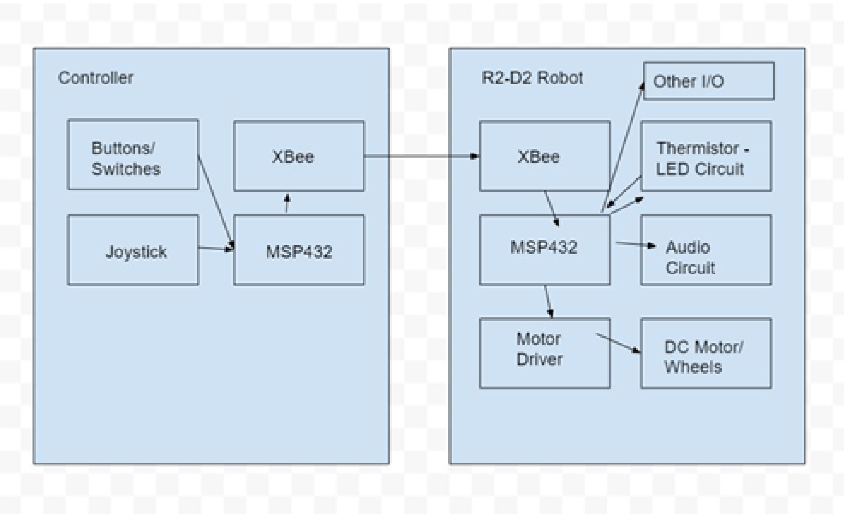

Figure 3.1 Block Diagram

The controller is powered by a microcontroller (MSP432), and it accepts different inputs including digital buttons and switches and an analog joystick. The digital buttons and switches are for controlling sound, "Nerf-Gun" bullets, and motion.

The analog joystick is used for determining which direction to move the robot. These control signals are sent via XBee wireless communication to the R2-D2 robot.

The R2-D2 robot is also powered by the same microcontroller (MSP432). On the robot end, the XBee is used to receive the different user inputs. Then, the MSP432 is used to drive various functions on the robot itself by sending digital outputs to control LEDs and bullets, PWM signals to the motor driver for movement (which are sent to the robot's wheels), and sound to the DAC and amplifier circuit for audio.

3.2 Software Flowcharts

The first flowchart describes the functionality of the controller.

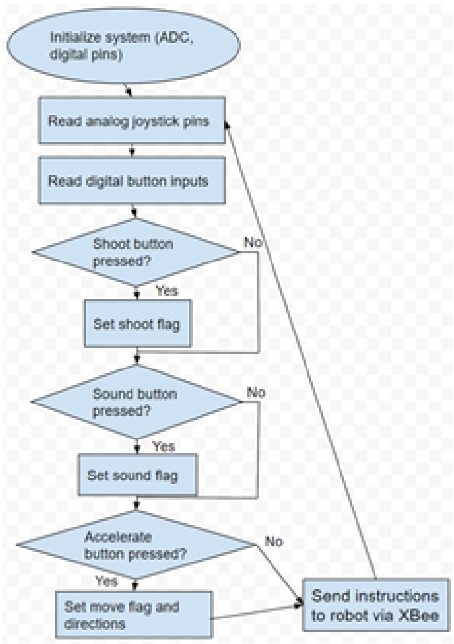

Figure 3.2 Controller Flowchart

At the start, the controller initializes all of the systems including the digital ports and ADC. The software consists primarily of a while-true loop in which the program alternates between reading the analog joystick pins and the digital inputs and then making decisions. The analog joystick determines which direction to move the robot while the digital inputs are used to determine motion, sound, and whether to shoot weaponry. These commands are all sent via XBee to the R2-D2 robot.

The second flowchart describes the functionality of the R2-D2 robot.

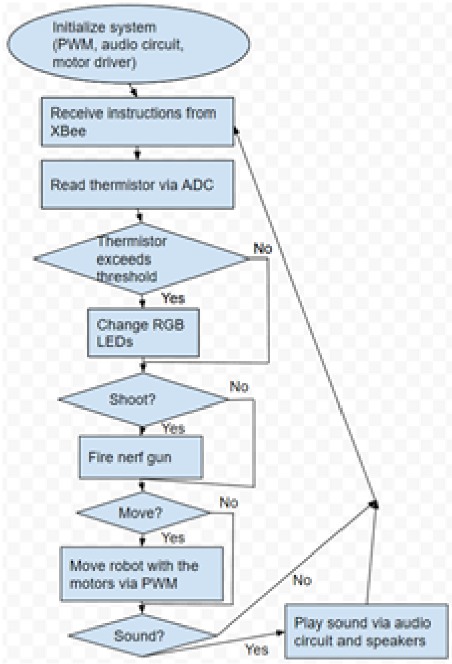

Figure 3.3 Robot (R2-D2) Flowchart

The software for the robot initializes all the necessary systems and consists of a while-true loop. In the loop, the program receives the instructions from the controller via XBee and reads the thermistor value using the ADC. By comparing the inputs to preassigned thresholds and checking to see if the digital inputs are on or off, the R2-D2 robot makes decisions to interact with its environment. These actions include movement, audio, changing colors for LEDs, and shooting “Nerf-Gun” bullets.

Chapter 4

Work Responsibilities

For the project, Steven Paek was assigned to be in charge of the R2-D2 robot, and Daniel Suen was assigned to be in charge of the controller. As such, the work responsibilities were divided as follows:

Steven Paek	**Daniel Suen**
R2-D2 PCB	Controller PCB
Motor PWM	Battery Recharge PCB
Audio Circuit with External DAC	Joystick Control
Thermistor-LED	Controller I/O for Sound, Nerf Gun, and Movement
Other I/O - Nerf Gun, etc.	XBee Communication

Chapter 5

Gantt Chart

The Gantt chart outlines the proposed timeline for completing the project and meeting our own internal deadlines. There is a focus on completing the most of the PCB designs and analog circuitry towards the beginning of the semester.

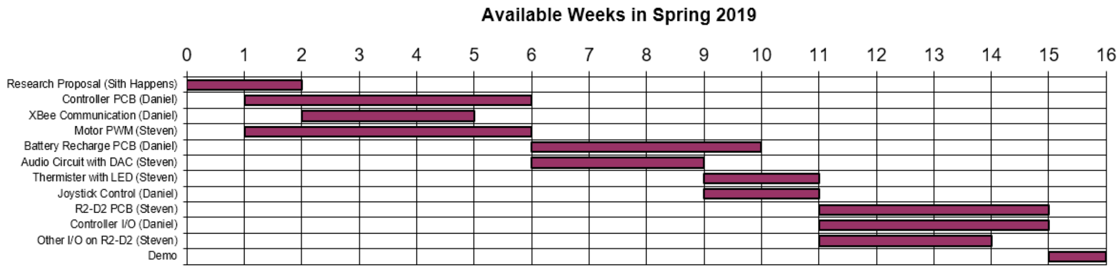

Figure 5.1 Gantt Chart