RFID Mapping and Localization

Project Proposal

Submitted January 27, 2012

Project Definition

Radio frequency identification (RFID) chips are found everywhere, from passports, textbooks, credit cards, etc. This project proposes the feasibility of determining the relative location of RFID tags based on repeated communication attempts. Given that the range of most readers is less than twelve inches, this project will also explore the ability to extend that range through intelligent signal processing (DSP), as well as improved antenna design.

This project was initiated by Honeywell's National Secure Manufacturing Center (NSMC) in Kansas City, thereby making them the customer. Employee Will Plummer will act as the point of contact on behalf of the company. All deliverables will be turned over to his possession following the completion of the semester. Team members include Aaron Gillespie, Matthew Greenlee, Matthew Hannon and Priya Mishra, while project leadership will be performed by Danielle Fuller.

Project Objectives

The main objective of this project is to provide a proof-of-concept system, meeting the minimum requirements as specified by the customer. A final version of the prototype would ideally be a portable, inexpensive reader capable of precisely locating a specific RFID tag in three-dimensional space. However, the scope for our proof-of-concept is much more modest. The minimum specifications provided by the customer are that the device be inexpensive, capable of determining if an RFID tag is within a modest range, and localizing the tag with respect to the reader.

Limited by time, technology, funding, and knowledge of the conditions in which the final product will be used, the following assumptions are made: (1) The customer will use RFID tags of a single ultra-high frequency (UHF) following protocol ISO 18000-6C; (2) The environment will allow for a direct line-of-sight between the reader and the tags with no multipath; (3) Localization will be determined successful if claimed distance is within 12" of the actual distance.

In summary, the primary objectives of this project are outlined below. (Secondary objectives, such as three dimensional locating and tag counting will only be expanded upon if the primary objectives are met ahead of schedule.)

a) Extend the range of RFID detection to more than 60".
b) Localize the RFID tag using a digital output to indicate distance and direction.

Strategy for Achieving Objectives

Extending the range of detection will be one of the biggest hurdles for this project, as the goal distance of 60" is over ten times the average detectable distance. To achieve this, extensive research will be done in antenna construction and homemade antennas will be incorporated into the transmitter and receiver designs. Along with improved antennas, low power consumption by the Tx/Rx network will be a key focus, as a transmitted signal of higher power will travel further than if too much power is lost in the initial circuitry. One more way of improving range is by incorporating intelligent signal processing. If an efficient algorithm is designed and implemented, the weak signal returning from the RFID tag could be successfully decoded through repetitive pinging, reducing the uncertainty.

Localizing tags will be done by incorporating a two-antenna array. Through the use of a switching network, the antennas will be directed in one of three discrete directions—roughly 45^0 left and right, as well as straight ahead. This should reduce the need for the reader to be directly pointing at a tag in order to detect it. Depending on the directionality from which the return signal reaches the receiver, the DSP algorithm will be able to determine in which direction the tag is located. Figure 1 demonstrates the preliminary concept, but may be adjusted.

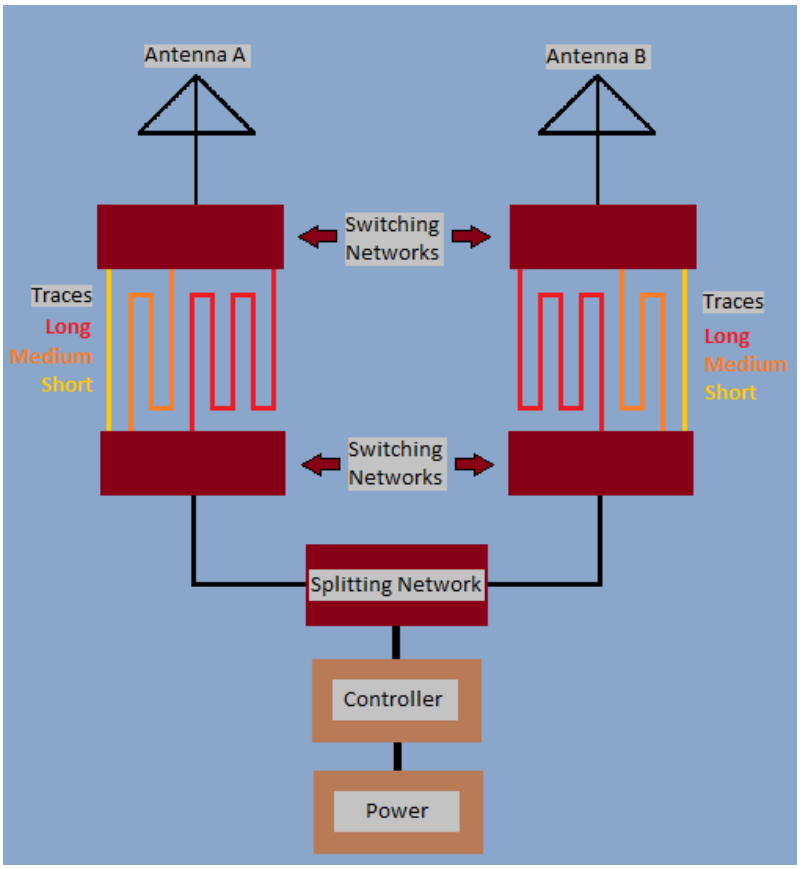

Figure 1: Design concept for controlling antenna directionality

Plan of Action

For this project to be a success, the following tasks must be completed in a timely and orderly manner. Team members have been divided into groups to accomplish each goal; however, each member will work to ensure every step is a success, meaning help will be given from everyone regardless if they were initially in the subgroup.

Task 1: Initial Background Research/Concept Creation
Team Members: All
Estimated Completion: February 3rd

Task 2: Detailed Antenna Design and Direction Control
Team Members: Greenlee, Mishra
Estimated Completion: February 23rd

Task 3: Design of Tx/Rx System with Computer Interface and Stand-Alone Power
Team Members: Fuller, Gillespie, Hannon
Estimated Completion: February 23rd

Task 4: Algorithm Formation for DSP
Team Members: Gillespie, Hannon, Mishra
Estimated Completion: February 23rd

Task 5: Theoretical Testing/Perfection of Design
Team Members: All
Estimated Completion: March 14th

Task 6: Component Ordering
Team Members: Fuller
Estimated Completion: March 21st

Task 7: Hardware Construction
Team Members: TBD
Estimated Completion: April 16th

Task 8: DSP Coding
Team Members: TBD
Estimated Completion: April 26th

Every aspect of the project is to be completed no later than April 26th. Figure 2 shows a Gantt chart of the work schedule.

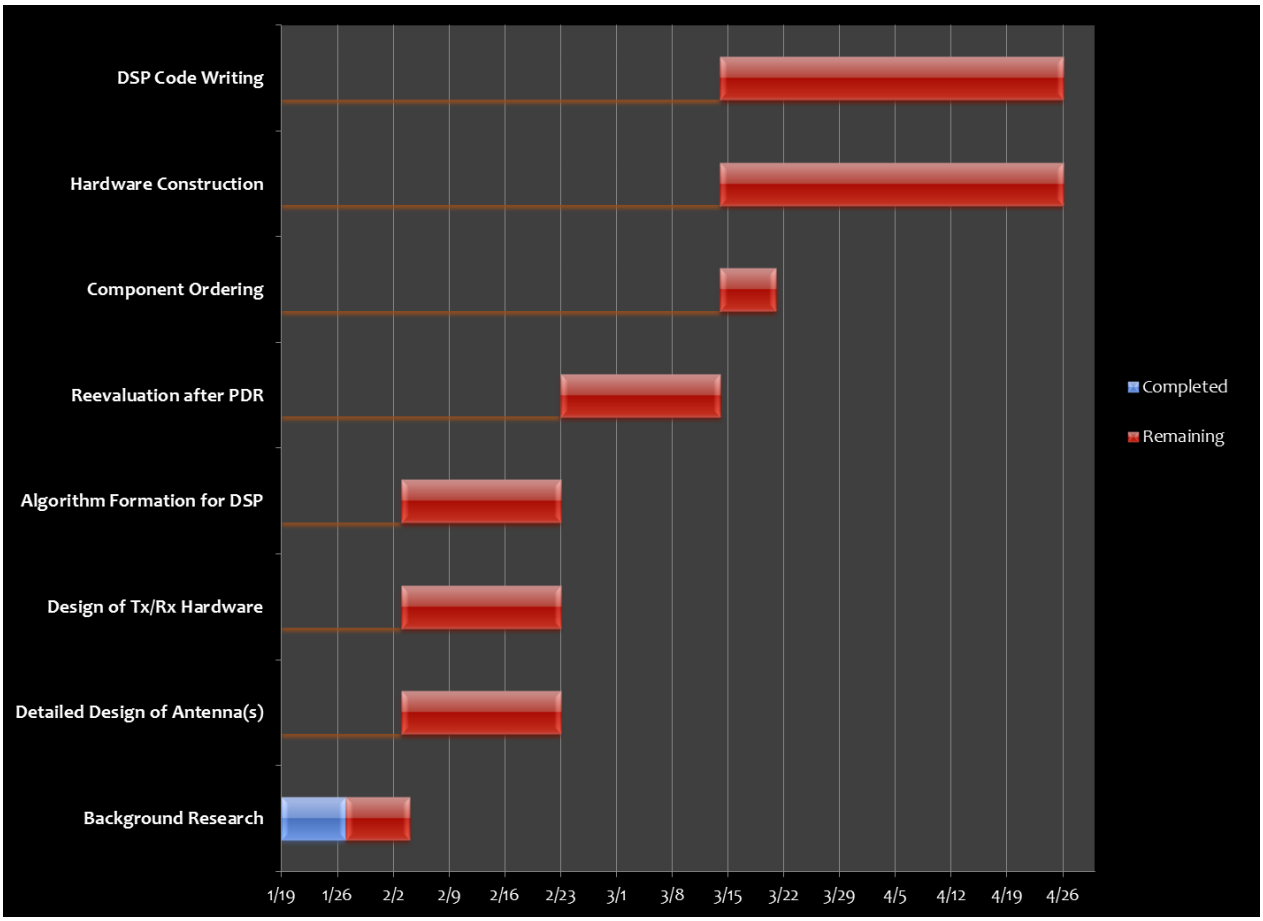

Figure 2: Gantt Chart for RFID project

Reporting

A weekly meeting will be held with Professor Allen on Wednesdays at 11:30am. The goal of these meetings will be to report on project progress, as well as bring up problems that occur along the way. A face-to-face meeting will be held with the customer every other Wednesday evening to provide a progress report. Any simple questions or clarifications will be resolved with the customer's representative, Mr. Plummer, over the phone or via email.

Budget

Time: Team members will spend between six and fifteen hours a week working on the project, with the following breakdown:

Monday: Group work from 12:00-1

Wednesday: Meeting with Professor Allen from 11:30-12 // Group work from 12-1 // Semi-weekly customer meeting from 6-7pm

Thursday: Group work from 12:30-2:30

Other: As-needed team or subgroup meetings // Individual research

Money: The $500 allotted for the project will (roughly) be divided up as follows:

$200 – Antenna design or purchase
$50 – RFID tags from various vendors
$75 – Transmitter/Receiver hardware
$175 – Contingency

Additional funds or supplies may be provided from customer if needed. One instance might be the purchase of a UHF reader, which costs around $600. Use of one of these COTS would nullify the need for transmitter/receiver design, allowing the $75 designated for that to be reassigned elsewhere.

Evaluation

Test results will be verified by comparing:

- Detectable range of fabricated antennas vs. COTS
- Reported distance of RFID tag vs. actual distance of tag
- Claimed localized direction of tag vs. actual direction of tag

Successful results in these three areas will determine the level of accomplishment achieved.