A BLUETOOTH-BASED HOME ALARM SYSTEM STATUS EXTENDER

Joel P. Clouse
Technical Advisor - Hal Broberg
ECET 491 Senior Design Phase II
Prof. Paul I-Hai Lin
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PRESENTATION OUTLINE

- Abstract
- Introduction
  - Background
  - Problem Statement
- System Requirements
- Project Management
- System Overview
- Status of Device
- Hardware Design
- Software Design
- Unit Testing
- Conclusion & Lessons Learned
- Questions
- Demonstration

ABSTRACT

- Purpose: Design a wireless device to visually communicate the status of the home alarm system
- Who would interested in this product?
- Physical Components:
  - Two Arduino Uno R3 Microcontrollers
  - Two class 1 Bluetooth Modules
  - One Visual Display

BACKGROUND

- Worked as a Commercial & Industrial Journeyman Electrician for 18 yrs.
- First Child born October 20th 2016
- Built new home in 2016
- New Career July 2017
- Very little experience with Electronics Prototyping
- Limited knowledge of Bluetooth Communications

PROBLEM STATEMENT

"A Picture Is Worth A Thousand Words"

PROBLEM STATEMENT EXPLANATION

- Is This A Deterrent?
- Eye Catcher To Any Passerby
- Obvious To Any Thief
- Limited Functionality

SYSTEM REQUIREMENTS

- Device Shall Visually Display The Operational State Of The Alarm System
- Device Shall Utilize Timing Feature To Limit The Run Time.
- Device Shall Be Remotely Located
- System Shall Operate On 5 VDC Source
- System Shall Incorporate Bluetooth Communications

PRIMARY PROJECT RISKS

- Cost:
  - Additional components & tools
- Schedule:
  - Limited availability
- Technical:
  - Existing knowledge base

PROJECT MANAGEMENT

1: Cost Risk

5: Technical

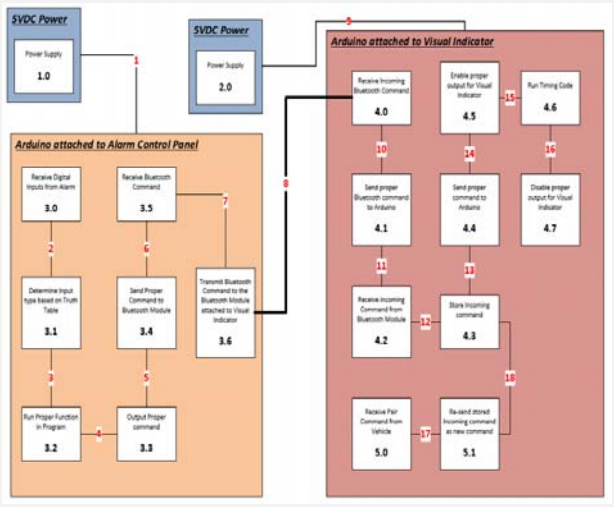
8: Schedule

			1 Insignificant: minor problem easily handled by day to day processes	2 Minor: some disruption possible	3 Moderate: significant time / resources required	4 Major: operations severely damaged	5 Catastrophic: project survival is at risk
5 Almost Certain: >90% chance	Likelihood	5					
4 High: 50 - 90% chance		4			8		
3 Moderate: 10 - 50% chance		3				5	
2 Unlikely: 3 - 10% chance		2	7		2	4	1
1 Rare: <3% chance		1	6				3
			1	2	3	4	5
			Severity				

Project Risk Register Matrix

SYSTEM OVERVIEW OV-1

SYSTEM BLOCK DIAGRAM



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STATUS OF DEVICE

- Master Unit is Assembled & Operational
- Slave Unit is Assembled & Operational
- Visual Indicator Is Assembled & Operational
- Bluetooth Communications are Operational (Between Master & Slave Units)
- All Devices Are Electrically Tested To Meet Requirements

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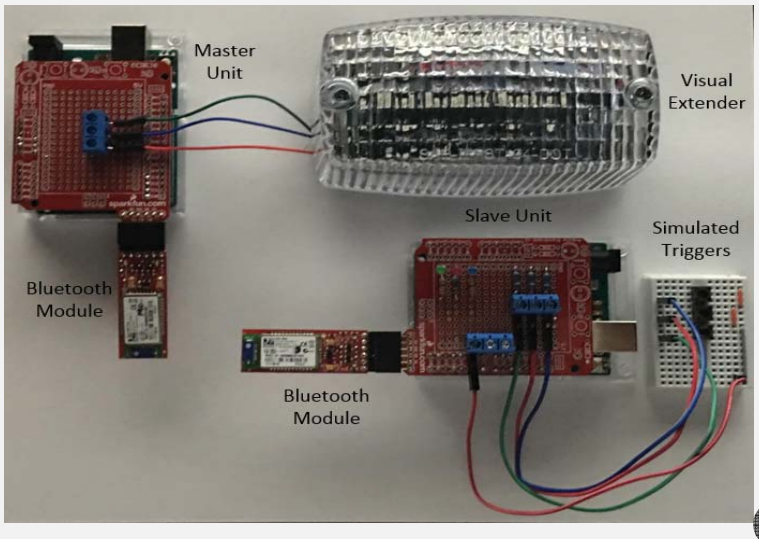
ASSEMBLED PROJECT



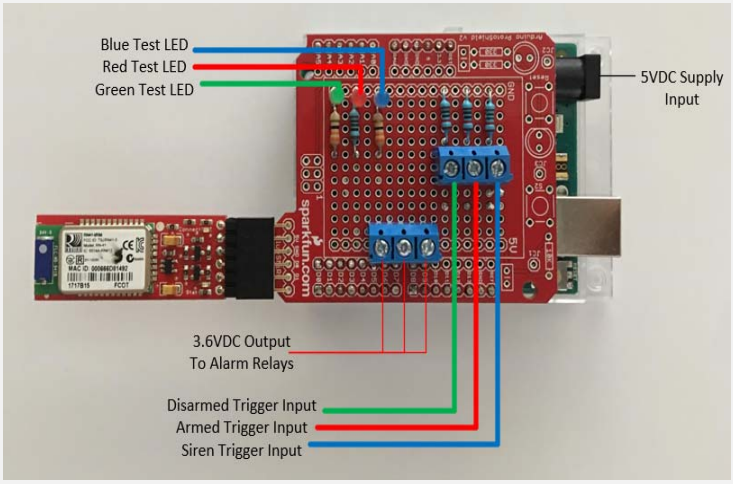
HARDWARE DESIGN

Requirements

Slave Unit – Attached To The Alarm System

- Run on 5VDC
- Contain Bluetooth Module
- Ability To Accept Three Input Triggers
- Added Feature – Onboard LED Indicators

SLAVE UNIT



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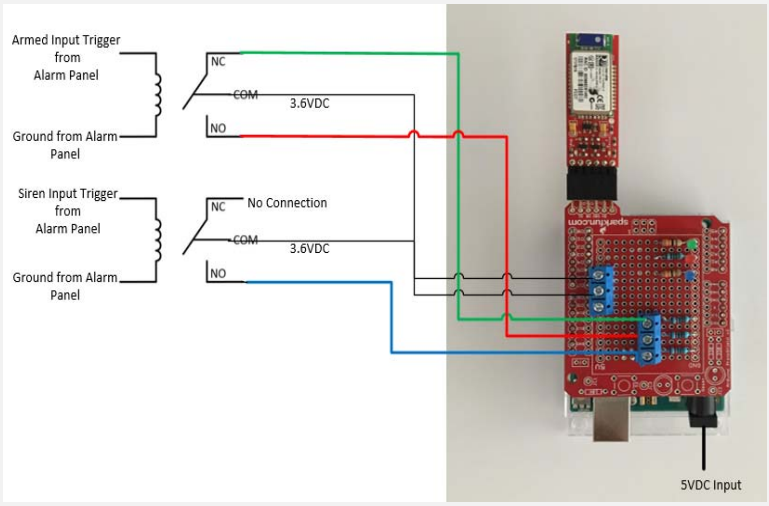
INTEGRATION WITH EXISTING SYSTEMS



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HARDWARE DESIGN

Requirements

Master Unit – Associated with Visual Indicator

- Run on 5VDC
- Contain Bluetooth Module
- Connect To The Visual Indicator With Screw Type Terminals

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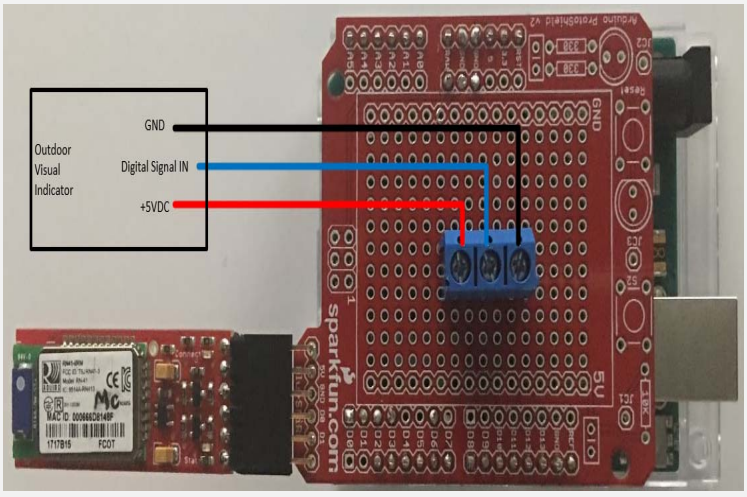
MASTER UNIT PROTOTYPE



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HARDWARE DESIGN

Requirements

Visual Indicator

- Run on 5VDC
- Ability To Illuminate In Two Colors
- Ability To Flash
- Outdoor Rated
- Added Feature - RGB LED's

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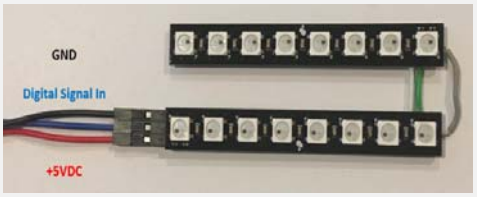
VISUAL EXTENDER

Nulsom Rainbow Stick
8 Individual addressable RGB LED'S Per Stick



Designed For Daisy Chain Series Connection

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VISUAL INDICATOR

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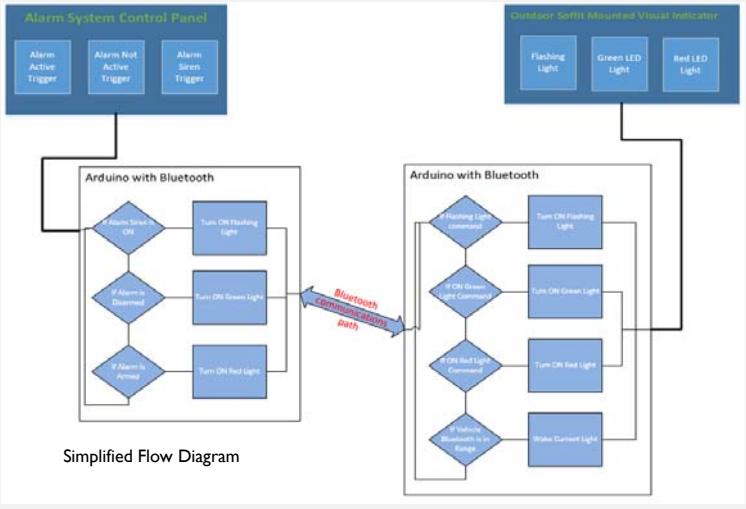
SOFTWARE DESIGN



Simplified Flow Diagram

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SOFTWARE DESIGN

Requirements

Slave Unit – Attached To The Alarm System

- Utilize Digital Input Pins
- Utilize Bluetooth Communications
- Automatic Bluetooth Pairing
- Accept Three Different Trigger Inputs
- Illuminate Corresponding Onboard LED With Trigger Event
- Handle All Possible Combinations of Input Triggers
- Run Timing Function For LED "ON" Time

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SLAVE UNIT TRUTH TABLE

Disarmed Input Trigger	Armed Input Trigger	Siren Input Trigger	Output Character Sent to Master Unit
0	0	0	1
0	0	1	2
0	1	0	3
0	1	1	4
1	0	0	5
1	0	1	6
1	1	0	7
1	1	1	8

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SOFTWARE DESIGN

Requirements

Master Unit – Associated with Visual Extender

- Utilize Digital Output Pins
- Utilize Bluetooth Communications
- Automatic Bluetooth Pairing
- Illuminate Programmed Color For All Possible Inputs Received From Slave Unit
- Run Timing Function For LED "ON" Time

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MASTER UNIT TRUTH TABLE

Disarmed Trigger 0 = low (off) 1 = high (on)	Armed Trigger 0 = low (off) 1 = high (on)	Siren Trigger 0 = low (off) 1 = high (on)	Output Character sent to Master Unit	Verified Result On Slave	Verified Result On Master
0	0	0	1	No Light	No Light
0	0	1	2*	No Light	No Light
0	1	0	3	Red Light	Red Light
0	1	1	4	Red & Blue Light	Flashing Light
1	0	0	5	Green Light	Green Light
1	0	1	6	No Light	No Light
1	1	0	7	No Light	No Light
1	1	1	8	No Light	No Light

* Real World Situation

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C PROGRAMMING

Alarm_Panel_Slave_Class_1_Commented

```
////////////////////////////////////////////////////////////////////
//  File Name:  Alarm_Panel_Slave_Class_1_Commented
//  Revision: 4
//  Date: Novermber 11 2017
//  Programmer: Joel P. Clouse
//  Project: Alarm System Status Visual Indicator
//  Course: Senior Design II ECET 491
//  Professor:  Paul Lin
//  Platform: HP PC
//  Compiler: Arduino IDE Version 1.8.3
//  Board Type: Arduino Uno R3
//  Bluetooth Module: Sparkfun Blue SMiRF Gold (class 1 device)
////////////////////////////////////////////////////////////////////

#include <SoftwareSerial.h> //  H file for using internal serial communication on Arduino Uno R3

#define RxD 2 // Initilize Digital Pin 2 as the Reciever Pin for the Bluetooth Module
#define TxD 3 // Initilize Digital Pin 3 as the Transmitter Pin for the Bluetooth Module
SoftwareSerial mySerial(RxD, TxD);  //  Initilize mySerial to use Reciever and Transmitter
int greentestled = 4; // Initilize greentestled to an integer value of 4
int redtestled = 5; // Initilize redtestled to an integer value of 5
int bluetestled = 6;  // Initilize bluetestled to an integer value of 6
int disarmedtrigger = 7;  //Initilize disarmedtrigger to an integer value of 7
int armedtrigger = 8; //Initilize armedtrigger to an integer value of 8
int sirentrigger = 9; //Initilize sirentrigger to an integer value of 9
int lastState = 0;  //  Initilize lastState to an integer value of 0 (zero)
int x = 0;  // Initilize x to an interger value of 0 (zero)
int armeddelay = 5000;  //  Initilize armeddelay to an integer value of 5000 (5 Seconds)
int disarmeddelay = 5000; //  Initilize disarmeddelay to an integer value of 5000 (5 Seconds)
```

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UNIT TESTING

Types Of Testing and Verification

- All Components Have Two Measurements Taken
  - Voltage Across
  - Current Through

Measurements Taken On Breadboard Assembly

-VS-

Measurements Taken On Finished Prototype

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TESTING SLAVE UNIT

Slave Unit	Prototyping Board	Finished Product
$V_{SOURCE\ 120VAC\ to\ 5VDC}$	5.25V	5.25V
$V_{SOURCE\ NO\ LOAD}$	3.61V	3.63V
$V_{SOURCE\ WITH\ LOAD}$	3.45V	3.42V
$V_{GREEN\ LED}$	2.92V	2.85V
$V_{RED\ LED}$	2.01V	2.01V
$V_{BLUE\ LED}$	3.28V	2.93V
$V_{GREEN\ LED\ RESISTOR}$	0.30V	0.31V
$V_{RED\ LED\ RESISTOR}$	1.13V	1.01V
$V_{BLUE\ LED\ RESISTOR}$	0.25V	0.21V
$I_{GREEN\ LED}$	9.11mA	Note1
$I_{RED\ LED}$	11.36mA	Note1
$I_{BLUE\ LED}$	7.29mA	Note1
$I_{PULLDOWN\ RESISTOR}$	420.00µA	400.00µA
$I_{BLUETOOTH}$	30.00mA	30.00mA
$I_{SOURCE\ IDLE}$	72.00mA	72.00mA
$I_{SOURCE\ TOTAL\ INRUSH}$	106.80mA	108.00mA
$I_{SOURCE\ TOTAL\ WITH\ GREEN\ LED\ ON}$	82.00mA	81.00mA
$I_{SOURCE\ TOTAL\ WITH\ RED\ LED\ ON}$	82.00mA	83.00mA
$I_{SOURCE\ TOTAL\ WITH\ BLUE\ LED\ ON}$	79.00mA	95.00mA

Note 1: Components soldered to board therefore no way to physically make current measurements.

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TESTING MASTER UNIT

Master Unit	Prototyping Board	Finished Product
$V_{POWER\ SOURCE\ 120VAC\ to\ 5VDC}$	5.25V	5.25V
$V_{SOURCE\ NO\ LOAD}$	4.52V	4.52V
$V_{SOURCE\ WITH\ LOAD}$	4.45V	4.49V
$I_{GREEN\ LED}$	112.00mA	113.00mA
$I_{RED\ LED}$	220.00mA	228.00mA
$I_{FLASHING\ LED}$	222.00mA	228.00mA
$I_{IDLE\ RGB}$	7.00mA	8.00mA
$I_{SOURCE\ IDLE\ TOTAL}$	48.00mA	49.00 mA
$I_{SOURCE\ TOTAL\ WITH\ GREEN\ LED\ ON}$	150.00mA	156.00mA
$I_{SOURCE\ TOTAL\ WITH\ RED\ LED\ ON}$	268.00mA	270.00mA
$I_{SOURCE\ TOTAL\ WITH\ FLASHING\ LED\ ON}$	270.00mA	280.00mA
$I_{BLUETOOTH}$	30.00mA	30.00mA

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TESTING
BLUETOOTH COMMUNICATIONS

- **Test done at Purdue Fort Wayne**
- 45' through three solid cinder block walls
- 150' through one cinder block wall
- 300' outdoor with direct line of sight
- **Test done at Home**
- 50' through one floor and four stud walls
- 90' through eight stud walls
- 300' outdoor with direct line of sight

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TESTING
VISUAL EXTENDER

- Visual Indicator Tested Utilizing Current Readings During Triggering Events
  - Armed Trigger
  - Siren Trigger
  - Disarmed Trigger
- Current Readings Taken at Idle State

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TESTING VISUAL INDICATOR

Visual Indicator	Breadboard	Finished Prototype
$I_{IDLE\ RGB}$	7.00 mA	8.00 mA
$I_{GREEN\ LED}$	112.00 mA	113.00 mA
$I_{RED\ LED}$	220.00 mA	228.00 mA
$I_{FLASHING\ LED}$	222.00 mA	228.00 mA
V_{SOURCE}	4.52 VDC	4.52 VDC

CONCLUSIONS AND LESSONS LEARNED

- Do Not Procrastinate and Take Time For Granted
- Keep An Open Mind To Outsiders Ideas and Points Of View
- The Struggles Within A Project Are Learning Experiences
- Collaborative Teamwork Is Essential To Any Project
- Never Stop Researching

QUESTIONS?

DEMONSTRATION