Remotely Operated Intrusion Alarm

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Outline

- Introduction
- Background
- Objectives
- Conceptual Design
- Design Solution
- Risk Analysis
- Budget
Introduction

- Radar operating in stand-alone mode which will detect an intruder
- Radar will calculate range and speed of the intruder
- Information about the intruder will be sent to the user via text message and email with a timestamp of the intrusion
Requirements

- Speed
- Size
- Remote Operation
- Communication
Background: Radar Introduction

- Utilizing a Frequency Modulated Continuous-Wave Radar (FMCW)
- Easy to build
- Easy to process information
- Not perfect
Background:
Frequency Modulated Continuous-Wave Radar

- High frequency wave is continuously transmitted
- Signal is varied from 2.3GHz to 2.6GHz
Transmitted signal is reflected off objects, back towards receiving antenna.

Received signal is identical to transmitted signal, delayed in time and reduced in amplitude.

Background: FMCW Radar Principals

Diagram showing frequency $f$ and time $t$ with $\Delta f$ and $\Delta t$.
Background: FMCW Radar Operation

- Received time delayed signal is mixed with the transmitted signal
- Output from the mixed signal is in the audio range, below 20kHz
- Output signal frequency is proportional to the round-trip distance the transmitted signal traveled.
Background: MIT Open-Courseware Radar

- Audio range signal is measured with stereo microphone input to PC
- Synchronization signal measured with unused channel of microphone input
- Synchronization signal used to identify transmit frames for signal processing
- Stereo audio signal is recorded by a user and later processed with MATLAB
Background: MIT Open-Courseware Radar

- Difficulty in using radar in current form
  - Results must be interpreted by user
  - Results are not always obvious
Background: MIT Open-Courseware Radar

- Difficulty in using radar in current form
  - User must constantly record files and manually process with MATLAB application
  - Very slow to operate, unable to detect objects in real time
  - Difficult to deploy, difficult to move once deployed
Objectives

- **Overall Mission**
  - Modified MIT Lincoln Lab IAP 2011 Laptop Based Radar

- **Design Specs**
  - Speed
  - Size
  - Remote Operation
  - Communication
Conceptual Design: Project Flow

Antenna → RF Stage → Low Pass Filter → Ramp Generator

[Diagram of electronic components and computer]
Conceptual Design: Project Flow
Design Considerations: Processing On PC

- Programming On PC
  - Limitless coding options
    - MATLAB
    - LabView
  - Plenty of space for data storage
  - Plenty of computation capability

- Communication with PC
  - Bluetooth
  - Wi-Fi
  - Serial (115 kbps)
  - USB (480 Mbps)
  - Ethernet (10 Mbps - 100 Gbps)
Analog to Digital Converter

- 24 Bit – High Resolution
- 96 kHz Sampling rate - Higher than Nyquist Rate of 44kHz to avoid aliasing
- I²S – Not a standard interface for MCU’s
Analog to Digital Converter

- 24 Bit – High Resolution
- 96 kHz Sampling rate - Higher than Nyquist Rate of 44kHz to avoid aliasing
- I²S – Not a standard interface for MCU’s
- This concept was rejected by our Sponsors
Design Considerations: Choosing a Micro Controller

- PIC32 no I²S interface
  - Requires ADC with I²S
  - Converting IC
    - dsPIC
  - Extra Code
    - Communication between devices is more challenging

- Stellaris
  - Requires ADC with I²S
  - Easier code
  - Interfaces: Ethernet, I²S
Design Solution: Fast Diagram

- **Detect Object**
  - Record signal
  - Process signal

- **Alert User of Intrusion**
- **Send text/email**
  - Transport data

- **Determine Information**
  - Measure speed
  - Measure distance
  - Compare data
System Design: Block Diagram

Antenna

RF Circuitry

LPF
Corner Freq: 15KHz

24 bit ADC
PCM1808

Stellaris
LM3S9D92
MCU

PC

Remote Users

Detection System

Input

Ramp Generator

Synchronization Signal
## Risk Analysis

<table>
<thead>
<tr>
<th>Impact (Level)</th>
<th>Probability (Level)</th>
<th>Risk Assessment</th>
</tr>
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<tbody>
<tr>
<td>Battery Overload resulting in injury (Low – 2)</td>
<td>Low (2)</td>
<td>Broadly acceptable (4)</td>
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<td>RF electronics overload – no injuries, but high impact on system performance (High – 4)</td>
<td>Low (2)</td>
<td>Narrowly acceptable (8)</td>
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The table above illustrates the risk assessment matrix, with Impact on the vertical axis and Probability on the horizontal axis. The colors in the chart correspond to the different levels of risk assessment as follows:

- **Very Low** (1): Green
- **Low** (2): Green
- **Medium** (3): Yellow
- **High** (4): Orange
- **Very High** (5): Red

The values in the chart indicate the risk assessment level for each combination of impact and probability.
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### Impact vs. Probability Matrix

```
   Very Low  Low  Medium  High  Very High
  +------------+-----+---------+-------+--------------+---------+
Very High     5    10     15      20      25
High          4     8      12      16      20
Medium        3     6      9       12      15
Low           2     4      6       8       10
Very Low      1     2      3       4       5
```

- **Probability Levels:** Very Low (1), Low (2), Medium (3), High (4), Very High (5)
- **Impact Levels:** 1 (Very Low), 2 (Low), 3 (Medium), 4 (High), 5 (Very High)

- Battery Overload: Low (2) Probability, Broadly acceptable (4) Risk Assessment
- RF Electronics Overload: Low (2) Probability, Narrowly acceptable (8) Risk Assessment
## Risk Analysis

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### Risk Matrix

- **Impact Levels:**
  - Very Low (1)
  - Low (2)
  - Medium (3)
  - High (4)
  - Very High (5)

- **Probability Levels:**
  - Very Low (1)
  - Low (2)
  - Medium (3)
  - High (4)
  - Very High (5)

- The matrix shows the risk assessment based on the intersection of impact and probability levels.

- For example, battery overload resulting in injury is considered broadly acceptable (4) with a low probability (2).
Budget

**Budget = $500**

<table>
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<tr>
<th>Design</th>
<th>Amount ($)</th>
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<tr>
<td>RF Stage</td>
<td>$235.55</td>
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<tr>
<td>Cantenna Design</td>
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<td>Circuit Building</td>
<td>$71.60</td>
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<td>ADC Breakout Board</td>
<td>$13.08</td>
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<tr>
<td>Stellaris</td>
<td>$11.00 (Estimate)</td>
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<tr>
<td>Extras</td>
<td>$11.72</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$395.76</strong></td>
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QUESTIONS?