School of Engineering Science, Burnaby, BC V5A 1S6
*http://www.sfu.ca/~chrism/ss * ss-ensc@sfu.ca*

October 31, 2002

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, BC V5A 1S6

Re: ENSC 340 Design Specification for a Motion Sensitive Laptop Anti-theft Device

The attached document, *Design Specification for a Motion Sensitive Laptop Anti-theft Device*, describes the functions of our entire system for ENSC 340.

We are currently designing and prototyping a laptop anti-theft device that comprises of a pair of programmable units that will alert a laptop owner of any possible theft attempts. The contrivance, called the Infiltrator, features automatic arming and disarming based on the proximity of the owner to his laptop, and enables the owner to screen for false alarms.

The purpose of this design specification is to highlight the technical outlay of the entire Infiltrator system, and the design details of various subsystems. The main components that will be discussed are the hardware and software for the Base and the Remote and the communication protocol for the RF portion of the design.

Secure Solutions consists of five engineering students: Vincent Au-Yeung, Matt Brown, Steve Lau, Hani Mehrpouyan, and Chris Mitchell. If you have any questions or concerns in, please feel free to contact Chris Mitchell, our contact person, by phone at (604) 984-8771 or by email at chrism@sfu.ca.

Sincerely,

Chris Mitchell

Chris Mitchell
COO
Secure Solutions

Design Specification for a

Motion Sensitive Laptop Anti-theft Device

Project Team: Vincent Au-Yeung
Matt Brown
Steve Lau
Hani Mehrpouyan
Chris Mitchell

Contact: Chris Mitchell
chrism@sfu.ca

Submitted to: Dr. Andrew Rawicz – ENSC 340
Steve Whitmore – ENSC 305
School of Engineering Science
Simon Fraser University

Issued: October 31, 2002

Executive Summary

Theft of laptops continues to be on the rise for business people and others who travel with their notebooks. Over 600,000 laptops were stolen in the United States last year, an increase of 53% from the previous year. Unfortunately, the increasing popularity of laptop computers has spawned substantial black markets in both stolen computers and stolen confidential business data.

Secure Solutions is developing the Infiltrator, positioned as a stand-alone anti-theft device that will advance the combat of laptop theft. Our invention will consist of two microcontroller and transceiver based units: a theft detector mounted on the laptop itself and a remote control unit to be carried by the owner of the laptop. Once the detector senses any kind of motion, it sends a discrete signal (beep) to the remote. The owner can then activate the alarm on the theft detector, thereby interrupting an attempted theft, or they can screen the signal and suppress the alarm, thereby avoiding false alarms. If the user does not reply to the discrete notification signal after a short period of time, the siren will be automatically activated.

The development of the Infiltrator will transpire in two phases: the prototyping phase, to be completed in December 2002; and the second phase that will lead to a production-quality device.

The initial phase will include these key features:

1. The automatic arming and disarming of the device based on proximity of the remote to the detector.
2. Instant notification to the owner upon movement of his/her laptop.
3. Owner has ability to suppress alarm when located within range of the system.

The second phase will also accomplish the following:

1. Be a fully usable consumer device.
2. Be contained and enclosed in a package with sufficient battery life.
3. Be a reliable consumer device.

Table of Contents

1 Introduction 1

1.1 Acronyms 1
1.2 Glossary 1
1.3 Referenced Documents 1
1.4 Intended Audience 1

2 System Requirements 2

2.1 System Overview 2

3 System Hardware 3

3.1 Base 3
3.1.1 High level Base Unit Operation Algorithm 3
3.1.2 Microcontroller 3
3.1.3 Tilt switches 5
3.1.4 Siren 5
3.1.5 Transceiver 5
3.1.6 Antenna specs 6
3.1.7 Power supply 6
3.2 Remote 7
3.2.1 High level Remote Unit Operation Algorithm 7
3.2.2 Microcontroller 7
3.2.3 Notification 7
3.2.4 Transceiver 8
3.2.5 Antenna specs 8
3.2.6 Power 9

4 Communication Protocol 11

4.1 Micro to transceiver interface 11
4.2 Transceiver to transceiver interface 12

5 Firmware Design 12

5.1 Modular Description 12
5.2 Layer 1 13
5.2.1 Serial Driver 13
5.3 Layer 2 13
5.3.1 Calibration and Configuration 13
5.3.2 Communication 14
5.3.3 Power Management 14
5.4 Layer 3 15
5.5 Additional Interrupts 15

6 Test Plan..15

6.1 Hardware Testing.. 15
6.1.1 Tranceiver Plug and Play Module.. 15
6.1.2 Microcontroller.. 15
6.1.3 Siren.. 15
6.1.4 Tilt Switches.. 16
6.1.5 Buttons.. 16
6.1.6 Power Management.. 16
6.2 Firmware Testing.. 16
6.3 System Testing.. 16

Appendix A – Schematics..17

List of Figures

Figure 1 – Dual unit anti-theft device overview 2
Figure 2 – Block diagram of Base 3
Figure 3 - Flow chart of Base unit logic 4
Figure 4 – Block diagram of Remote 7
Figure 5 - Two different orientations of loop antenna 8
Figure 6 - Flow chart of Remote unit logic 10
Figure 7 – CC1000 to AT90S8515 interface 11
Figure 8 – Packet Information 12
Figure 9 – System Decomposition 12

List of Tables

Table 1 - Serial driver interface functions 13
Table 2 - Calibration and configuration interface functions 13
Table 3 – Communication interface functions 14
Table 4 - Power management interface functions 14

1 Introduction

The Infiltrator is a dual-unit system that uses RF communication to interact between its Base unit and Remote to send the status of the owner's laptop to him/her and notify of any possible theft attempts. The entire device will automatically arm and disarm itself based on the proximity of the owner to his/her laptop.

The Infiltrator is intended to improve the user's capability of preventing laptop thefts and provides piece of mind to the owner that their laptop's safety is virtually guaranteed. A proof of concept prototype will be completed in December of 2002 and will be followed by additional improvements in preparation for commercial deployment.

1.1 Acronyms

CC	Chipcon
EVB	Evaluation Board
FAQ	Frequently Asked Questions
IC	Integrated Circuit
LED	Light Emitting Diode
QA	Quality Assurance
PWM	Pulse Width Modulation
RF	Radio Frequency
RX	Receive Mode
SS	Secure Solutions
TX	Transmission Mode
UART	Universal Asynchronous Receive/Transmit

1.2 Glossary

Remote:	Keychain- like device carried by the owner that is notified by the Base unit upon any movement of the laptop.
Base/Console:	Package mounted on the laptop that senses motion and sends notification and receives commands to/from the Remote.

1.3 Referenced Documents

[1] Proposal for a Motion Sensitive Laptop Anti-theft Device with Mobile Screening and Automatic Proximity Arming/Disarming. Secure Solutions.
[2] Functional Specification for a Laptop Anti-theft Device. Secure Solutions.
[3] AN001 -- SRD regulations for license free transceiver operation. Chipcon.

1.4 Intended Audience

The document will act as a technical reference for the design engineers of the Infiltrator system. It will also be used by the project manager to measure project performance and by the QA team for testing of the designs in each subsystem.

2 System Requirements

2.1 System Overview

Figure 1 offers a visual perspective of the Infiltrator and its functionality. The base and the laptop will be attached, essentially making it near impossible to separate, while the remote will be encased in the key chain item that the user will carry. The base and remote will communicate via transceivers, and once the remote is found to be a certain distance apart from the laptop, the system will arm itself. Once armed, the base will wait for a detection of movement of the laptop and it will then send a signal to the remote wherein the user can screen the alert and choose to abort the alarm from sounding if a theft is deemed to not be in progress.

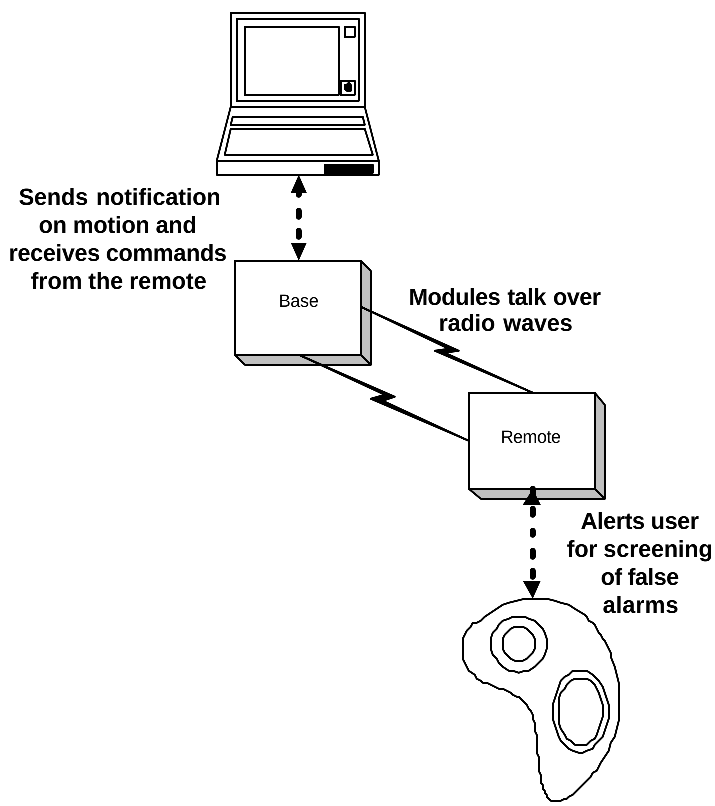


Figure 1 – Dual unit anti-theft device overview

3 System Hardware

3.1 Base

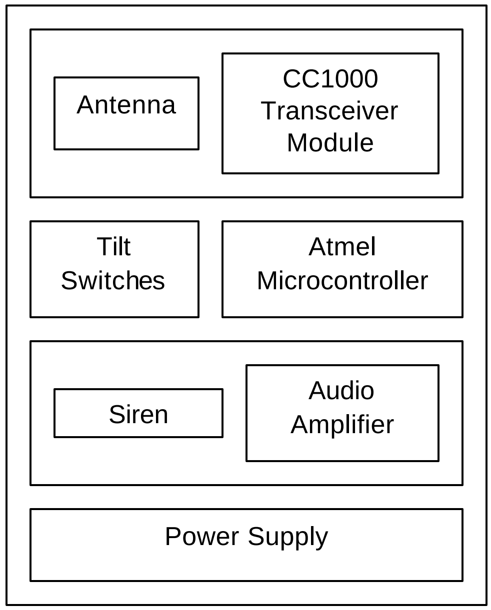


Figure 2 – Block diagram of Base

3.1.1 High level Base Unit Operation Algorithm

The Base unit implements the algorithm shown in Figure 3 below.

3.1.2 Microcontroller

For the prototype, the microcontroller used in the Base is the Atmel AT90S8515 (low voltage version). It is an 8-bit RISC processor with 16K of flash memory and 1K of RAM memory, with many other features useful for debugging purposes. More details may be found in the datasheet available at http://www.atmel.com/atmel/acrobat/doc0841.pdf.

The microcontroller is programmed using In-System programming through the STK500 development kit. Four general I/O pins are used for communicating with the transceiver using a "bit-banging" approach for low speed serial communication (Figure 7). One external interrupt pin is used for clocking the microcontroller during data transfer with the transceiver, and the other external interrupt pin is dedicated to monitoring the motion-sensitive switch circuit. Another pin will turn the siren circuit on and off.

The microcontroller will setup the RF transceiver on power up as well as run all other initialization routines. The commercial version will utilize a cheaper microcontroller that meets the minimum requirements of the system.

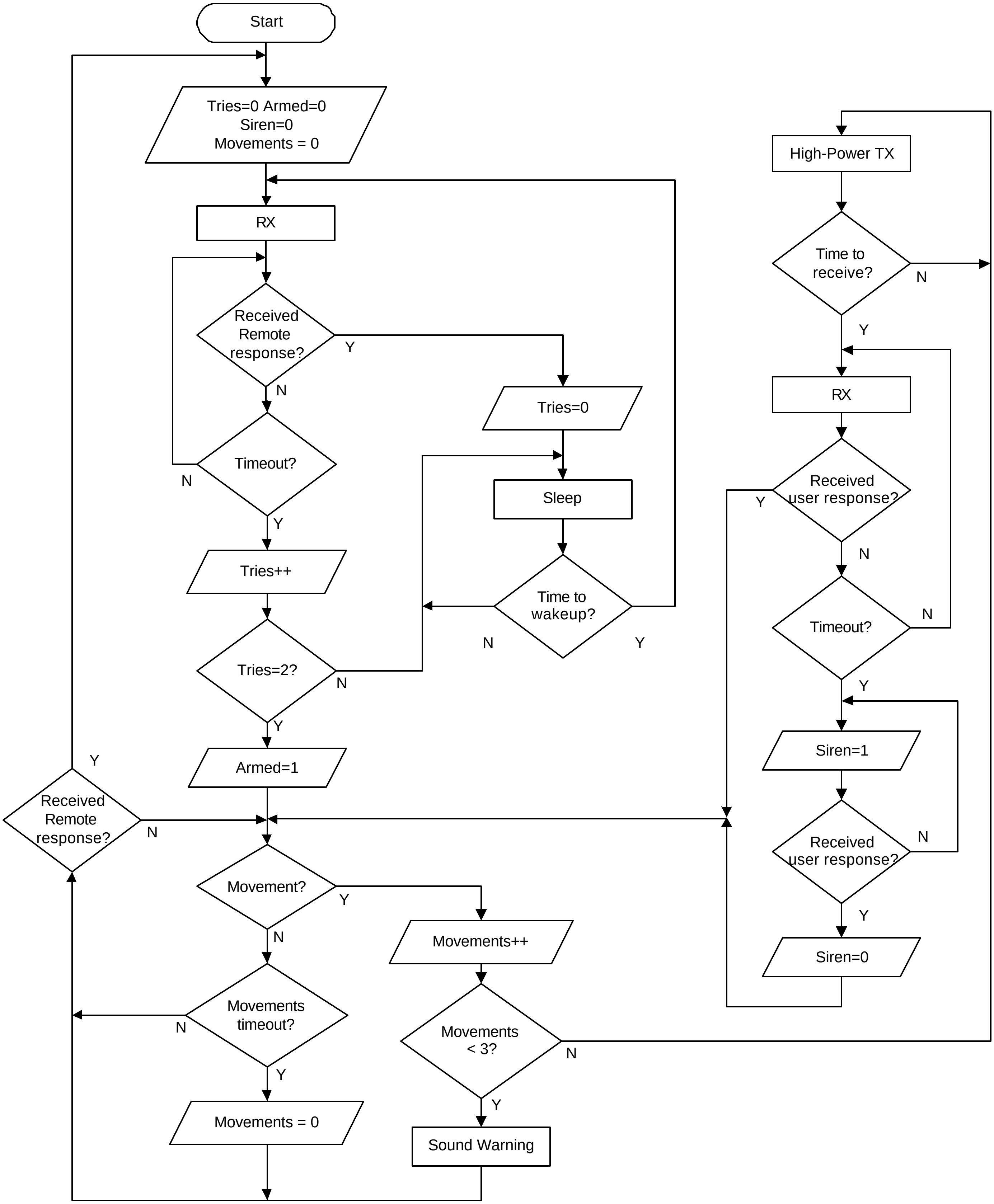


Figure 3 - Flow chart of Base unit logic

3.1.3 Tilt switches

Three mercury tilt switches supplied by American Electronics Components Ltd. are used to form the motion sensing part of the system. Each tilt switch is designed to work in one geometric plane and thus three are used in the base, with each oriented in a way so as to cover the entire three dimensions. Each switch is sensitive to movement within its plane as well as rotation around its axis, therefore also providing sensitivity to pitch, yaw, and roll. Electrically, the three switches are connected in parallel. This system of switches is connected in series with a 30MΩ resistor tied to ground. The other end of the parallel-connected switches is tied to VDD. One of the external interrupt pins on the microcontroller is to contact the point between the resistor and the parallel switches to enable motion-triggered interrupting.

The switches are normally closed (i.e. they are closed when at rest) and will open momentarily upon any detected movement, thereby generating an interrupt to the microcontroller (high to low transition on the interrupt pin). The circuit has been tested and the microcontroller successfully captures this interrupt. A 30MΩ resistor was chosen for this circuit because the switches are normally closed, and thus at a VDD of 3V, only 0.1uA will be drawn.

3.1.4 Siren

The siren consists of a piezo-electric speaker. This specific type of speaker is capable of producing loud sounds (70 to 90 decibel) without consuming a large amount of current. Its pitch (frequency) and all other effects are controlled by a PWM wave generated by the microcontroller. This PWM feeds into a standard 741 op-amp powered by the 9V battery supply.

3.1.5 Transceiver

The primary purpose of the transceiver is to allow the base unit to communicate with the remote. The communication itself consists of a protocol discussed further on in this design specification and occurs at a rate of 1Hz. Both the microcontroller and the transceiver will be powered down during non-transmission times in order to conserve power. The transceiver used is the Chipcon CC1000, a tried and proven low-power transceiver designed by a Norwegian company. Further details may be obtained by referring to the CC1000 datasheet.

The microcontroller has the ability to switch between two transmission power levels by writing to the configuration registers in the CC1000. High power transmission is only used to notify the remote when the full-blown alarm is about to sound due to persisted motion detected by the motion sensitive switches. All other transmissions occur at a low power setting.

When the remote is within range of the periodic low-power transmissions of the base, it will reply as described in the communications protocol section. It is when the remote goes out of range that the system will arm itself. This entire process is shown in Figure 6 below.

3.1.6 Antenna specs

An external antenna will be used in the design of the Base unit. The advantage of an external antenna is longer transmission range and simplicity of design. A dipole antenna will be used for the base unit to provide the best performance possible.

The dipole antenna can be mounted horizontally in a "T" format, thereby providing horizontal polarization, or it can alternatively be mounted vertically. In our design we will mount the antenna horizontally which results in improved performance and better directivity. The equation shown below is used to find the Q-Factor of the dipole antenna.

$$Q_{dipole} = \frac{0.0315}{\left(\frac{r_r}{\lambda}\right)^3}$$

3.1.7 Power supply

The power supply consists of a rechargeable 9V battery. A standard 3V 3-terminal voltage regulator from Texas Instruments will regulate power to both the microcontroller and the RF transceiver. The 9V battery directly powers the audio amplifier for siren operation.

3.2 Remote

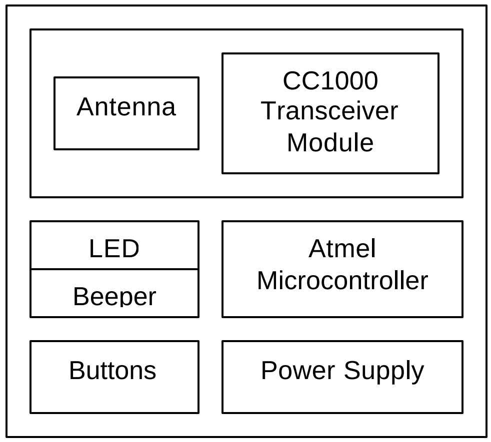


Figure 4 – Block diagram of Remote

3.2.1 High level Remote Unit Operation Algorithm

The Remote unit implements the algorithm shown in Figure 6 below.

3.2.2 Microcontroller

For the prototype, the microcontroller used in the Base is the Atmel AT90S8515 (2.7-4 volts version). It is an 8-bit RISC processor with 16K of flash memory and 1K of RAM memory, with many other features useful for debugging purposes. More details may be found in the datasheet available at http://www.atmel.com/atmel/acrobat/doc0841.pdf.

The microcontroller is programmed using In-System programming through the STK500 development kit. Four general I/O pins are used for communicating with the transceiver using a "bit-banging" approach for low speed serial communication (Figure 7). One external interrupt pin is used for clocking the microcontroller during data transfer with the transceiver, and the other external interrupt pin is dedicated to monitoring the motion-sensitive switch circuit. One more I/O pin is used for outputting a PWM signal to the audio amplifier for control of the siren.

The microcontroller will setup the RF transceiver on power up as well as run all other initialization routines. The commercial version will utilize a cheaper microcontroller that meets the minimum requirements of the system. AT90S2323 is a candidate for the final product. Since the microcontroller is quite cheap comparing to the AT90S8515 and it has fewer I/Os making the design of both Base and Remote smaller and lighter.

3.2.3 Notification

The LED and sound generator on the remote are capable of informing the user of the status of his laptop. Both the LED and sound generator will run off a 3V rechargeable battery. Both LED and sound generator are controlled by the micro controller.
In the on state the LED will be flashing to both save power and also to attract user’s attention.

Sound generator's pitch and all other effects are controlled by a PWM wave generated by the microcontroller.

3.2.4 Transceiver

The primary purpose of the transceiver is to allow the base unit to communicate with the remote. The communication itself consists of a protocol discussed further on in this design specification and occurs at a rate of 0.2 baud. Both the microcontroller and the transceiver will be powered down during non-transmission times in order to conserve power. The transceiver used is the Chipcon CC1000, a tried and proven low-power transceiver designed by a Norwegian company. Further details may be obtained by referring to the CC1000 datasheet available at www.chipcon.com.

The microcontroller has the ability to switch between two transmission power levels by writing to the configuration registers in the CC1000. High power transmission is only used to notify the remote when the full-blown alarm is about to sound due to persisted motion detected by the motion sensitive switches. All other transmissions occur at a low power setting.

When the remote is within range of the periodic low-power transmissions of the base, it will reply as described in the communications protocol section. It is when the remote goes out of range that the system will arm itself. This entire process is shown in Figure 6 below.

3.2.5 Antenna specs

The antenna for the remote will be placed on to the PCB to save space and make it easier for the user to carry the remote. This will sacrifice some transmission distance but will ease the use of the remote.
A loop antenna will be used in our design since a loop antenna is mounted horizontally on to the PCB for optimal performance. Horizontal design will make the PCB design cheaper, smaller, and easier.

Figure 5 - Two different orientations of loop antenna

$$Q_{loop} = \frac{0.0185}{\left(\frac{r_r}{\lambda}\right)^3}$$

The above equation is used to calculate the Q-factor for a loop antenna.

3.2.6 Power

Remote is powered using a 3V rechargeable battery. The battery is charged when the remote is plugged into the base unit. The transceiver on the remote side is always in power down mode unless it is used for data transmission. This will lengthen the operability of the battery and will reduce power consumption. The microcontroller will also be in idle mode to make sure minimum power consumption.

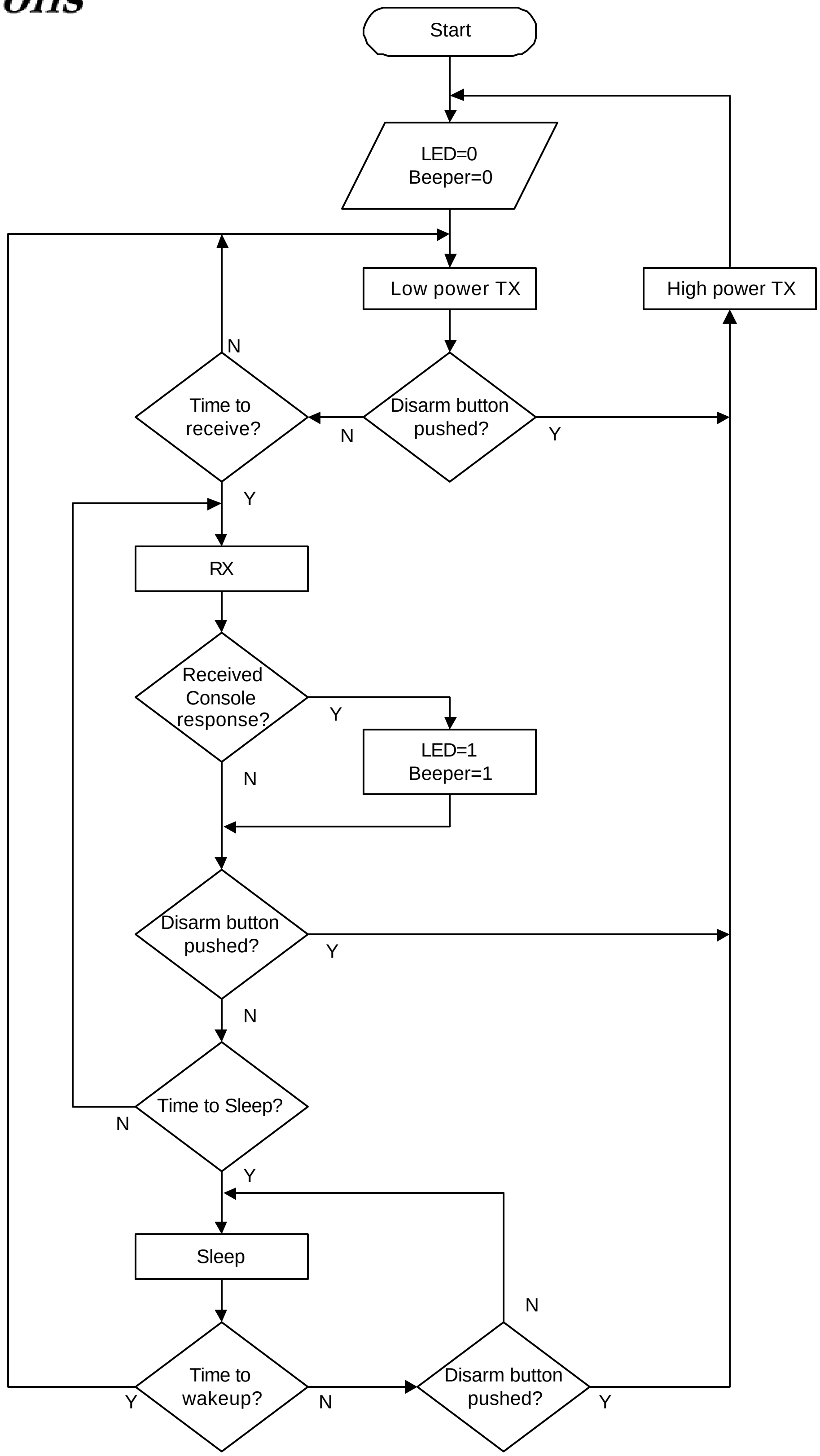


Figure 6 - Flow chart of Remote unit logic

4 Communication Protocol

4.1 Micro to transceiver interface

Five I/Os are used for both setting up the transceiver and also sending receiving data from the transceiver. The functionality of each one of the I/Os is described below.

PCLK: PCLK is an output from the microcontroller to the transceiver. It is used to clock the data sent by the microcontroller to the transceiver (Figure 5).
PDATA: PDATA is a serial data bus used for sending or receiving data from CC1000. Data sent is used to setup the registers of CC1000 for different operational modes. The values of the registers can also be retrieved using PDATA. PDATA is used to send both register address and register data (Figure 5).
SS: SS is an output from the microcontroller to the transceiver. SS is used to make the distinction between address and data. SS = 1 represents data transmission on PDATA and SS=0 represents address transmission (Figure 5).

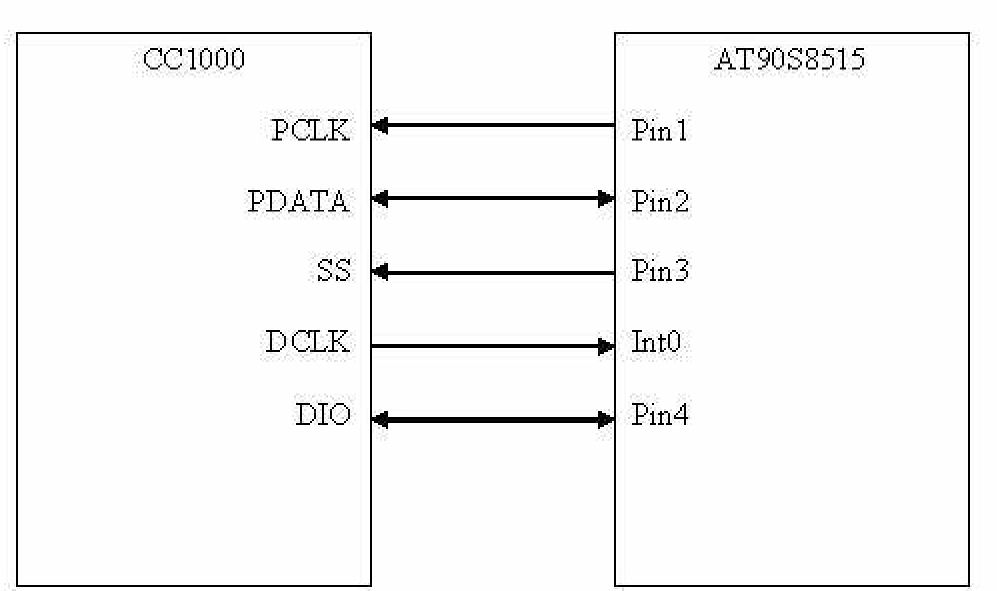


Figure 7 – CC1000 to AT90S8515 interface

DCLK: DCLK is an output from CC1000 to the microcontroller. It is use to clock transmission on the DIO bus.
DIO: DIO is a bidirectional serial bus between the microcontroller and CC1000. It is used to receive and send data from or to CC1000.

4.2 Transceiver to transceiver interface

Data is transmitted through 86 bit packets. Each packet consists of a preamble, a header and 30 bits of data. The data on the packet is used to make the user of the security device unique and it also enables different messages to be transmitted between the Base and Remote unit.

Figure 8 shows the contents of each packet transmitted between the Remote and Base.

40 bits of Preamble	16 bit Header	22 Bits user identification	8 Bits of data

Figure 8 – Packet Information

The 40-bit preamble is used to synchronize the receiver and transmitter and it is also used by the receiver to lock its internal free running filter. The 16-bit header is used to signal the start of the data packet. It separates the preamble and data. The 22 bits user identification code is used for identification purposes. It makes the owner of the remote unique and it stops others devices from tampering with the security system. The 8 bits of data are used to transmit different messages between the Remote and Base, corresponding to the different modes of Infiltrator.

5 Firmware Design

5.1 Modular Description

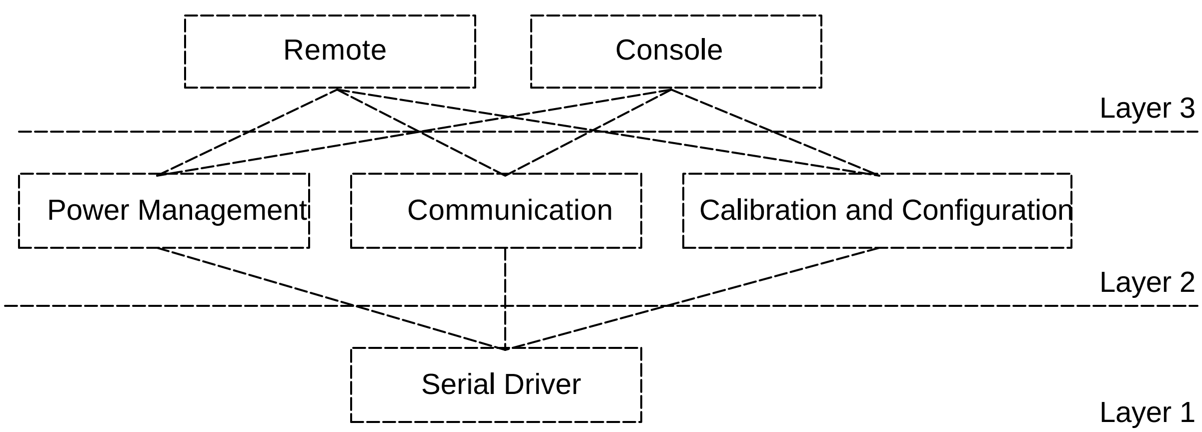


Figure 9 – System Decomposition

The system firmware can be divided into a 3 layer hierarchy. Layer 1 contains the low-level communications drivers required to communicate with the CC1000 over the serial interface. Layer 2 contains device drivers relating to the functionality of the CC1000 and the Microcontroller. This includes the Rx, Tx, and Power management (PM) subsystems which all depend on the drivers from layer 1. Layer 3 - the application layer - contains the control logic for the remote and console units, which use the functions from layer 2.

Functions from all layers are built on top of the standard instruction set of the AVR microcontroller.

5.2 Layer 1

5.2.1 Serial Driver

Due to the interrupt driven nature of transmitting and receiving data on the CC1000 through the serial interface, the functions that perform the receiving and sending of data packets have been implemented as interrupt service routines to maintain synchronization.

Table 1 - Serial driver interface functions

Function Name	Function Description
`ConfigureCC1000(char Count, short Configuration[])`	Write the data contained in the array Configuration[] to contiguous addresses on the CC1000.
`WriteToCC1000Register(char addr, char data)`	Write data to a single register on the CC1000
`ReadFromCC1000Register(char addr)`	Read data from a single register on the CC1000

5.3 Layer 2

5.3.1 Calibration and Configuration

To switch modes and for proper operation of the CC1000, configuration registers must be set to certain calculated values on the transceiver. The functions in the Calibration and Configuration subsystem mainly abstract writing certain combinations of register values to perform the desired task.

Table 2 - Calibration and configuration interface functions

Function Name	Function Description
`CalibrateCC1000(void)`	Calibrates the CC1000
`SetupCC1000RX(char RXCurrent)`	Sets up the CC1000 to Rx mode from Tx mode. When switching to Rx from PD, WakeupCC1000RX() must be used first.
`SetupCC1000TX(char TXCurrent)`	Sets up the CC1000 to Tx mode from Rx mode. When switching to Tx from PD, WakeupCC1000TX() must be used first.
`ReadCurrentCalibration(char *val1, char *val2)`	Reads the current calibration values from the CC1000
`OverrideCurrentCalibration(char val1, char val2)`	Overrides the current calibration of the CC1000
`StopOverridingCalibration(void)`	Stops override of the CC1000 calibration values

5.3.2 Communication

As stated before, much of the communication subsystem is implemented in interrupt service routines to realize the serial protocol described in the CC1000 specifications.

When the transceiver is in receive mode, it will send the data bit by bit over the serial DIO line synchronized to a clock signal that it generates over the DCLK line. The DCLK is connected to an interrupt pin on the microcontroller which, upon being interrupted on the rising edge of the DCLK, will sample the data on the DIO line at that instant and store the data into a receiving buffer. The incoming data is then checked for validity by checking for a valid user identification number and CRC.

In transmission mode, the CC1000 will constantly generate a clock signal on the DCLK line to which the microcontroller must synchronize the data to be sent onto the DIO line.

The functions implemented in this subsystem are mainly for the preprocessing and post-processing of data before it is sent and when it is received.

Table 3 – Communication interface functions

Function Name	Function Description
`RxPacket(data_t* data)`	Unpacks the latest packet received from Layer 1 interrupt routines
`TxPacket(data_t* data)`	Packages data into a packet and sends it using Layer 1 interrupt routines.

5.3.3 Power Management

The power management subsystem contains all of the functions that pertain to the switching of power modes on the transceiver and microcontroller.

Table 4 - Power management interface functions

Function Name	Function Description
`WakeUpCC1000ToRX(char RXCurrent)`	Wakes up the CC1000 to Rx mode from PD. SetupCC1000RX() must be called after unit is powered up.
`WakeUpCC1000ToTX(char TXCurrent)`	Wakes up the CC1000 to Tx mode from PD. SetupCC1000TX() must be called after unit is powered up.
`SetupCC1000PD(void)`	Puts the CC1000 into PD mode. Can be called from either Tx or Rx modes.
`SleepAVR(void)`	Puts the microcontroller into idle mode. The microcontroller will wake on an interrupt (see component specification sheet).
`TimerAVR(unsigned int usec)`	Call for a timer interrupt after usec microseconds.

5.4 Layer 3

The remote and console subsystems are the control logic for each of the components of the system. They are implemented as interrupt driven state machines to allow the microcontroller to spend as much time in idle mode as possible to conserve power.

5.5 Additional Interrupts

There are two interrupt pins available on the AVR microcontroller. The first of which is connected to the DCLK line of the CC1000 for the transmission and receiving of data.

On the remote unit, the second interrupt pin is connected to the buttons of the unit. When a button is pressed the interrupt is triggered. To decipher which button was pressed, each button is also attached to a unique GIO pin. When the interrupt is triggered, GIO pins are polled to find the button that was pressed.

On the console unit, the second interrupt pin is connected to the motion sensing vibration switches. When a switch is triggered, the interrupt is triggered and the user will be warned that the laptop is in motion.

6 Test Plan

6.1 Hardware Testing

6.1.1 Tranceiver Plug and Play Module

To test the plug and play module to ensure that it is functioning properly, we will complete the testing procedures outlined in the CC Module Testing document and compare with the typical values suggested by the manufacturer. The type of tests that are involved with this procedure are current consumption in Rx, Tx and Power Down modes, crystal frequency, receiver sensitivity, and output power to name a few.

6.1.2 Microcontroller

The microcontroller will be tested by downloading basic code to it and checking the output at the ports with the oscilloscope. This basic code will initialize the microcontroller and it's ports, and then simply toggle the output at the port pins so that the oscilloscope will detect the square wave forms.

6.1.3 Siren

To test the siren to ensure proper operation, we will measure the voltage at the input and the amount of current being drawn when in the on state. Also the decibel output of the speaker will be measured to ensure the minimal loudness is reached by each siren to ensure the siren will be heard when it is sounding.

6.1.4 Tilt Switches

The tilt switches will be tested separately from the alarm unit. We will hook the sensors up in parallel with a resistor in series to a power supply, as seen in Appendix A – Schematics. The oscilloscope will be hooked across the resistor to measure the voltage drop across it as the tilt sensors are rotated and moved. As the tilt sensors open and close from the movement, a series of square waves will be visible on the oscilloscope. We will be looking for these square waves to be present for any small movement in the switches since this will be the motion-sensing device in our console.

6.1.5 Buttons

The buttons will be tested by clipping an ohm meter across the 2 pin outs and making sure the switch is closed (no resistance) when the button is deployed, for the case of an normally open switch. For the normally closed button, we will test with the ohmmeter to see that there is no resistance when the button is not pressed and there is infinite resistance when it is pressed.

6.1.6 Power Management

To test the voltage regulators and batteries, we need to apply a voltage meter across the terminals to ensure the right voltages at the various hardware devices.

6.2 Firmware Testing

To test the firmware on our microcontroller we can utilize the UART feature of the microcontroller and write the register values to the computer screen. To test the firmware before downloading it to the microcontrollers, we will run the firmware on the Atmel emulator to debug and ensure the firmware is operating the desired manner.

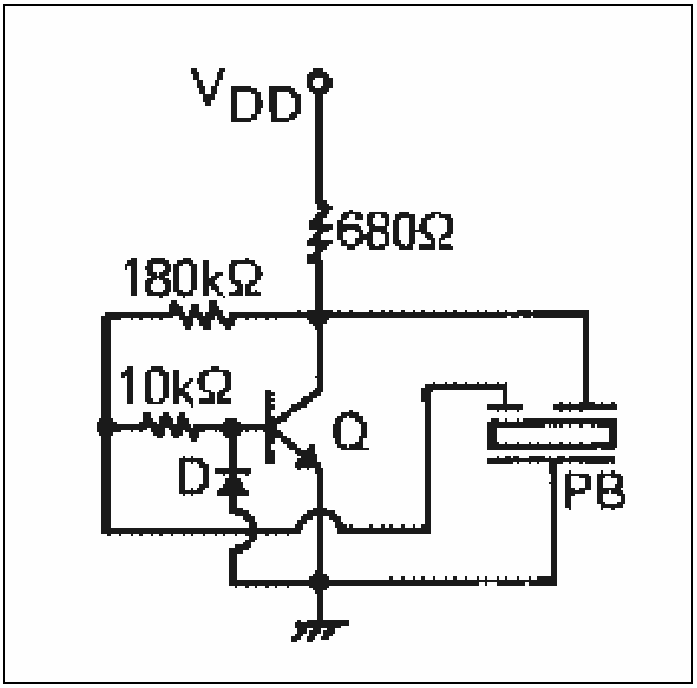
6.3 System Testing

Once the remote and console hardware and firmware are integrated together, we will need to perform a walk through test of the device to guarantee that the components are operating correctly together. The tests that will be performed with the device are:

1. Console arms when Remote is out of range.
2. Console disarms when the Remote is back in range.
3. The tilt sensors only activate the siren when the armed Console is moved.
4. The Remote receives a “false alarm” notification from the Console right after the armed Console is moved.
5. The button on the Remote activates the false alarm mode, if pushed, right after the notification is received.
6. The siren turns on after a short delay when the armed Console is moved.
7. The button on the remote deactivates the siren when the siren in on.

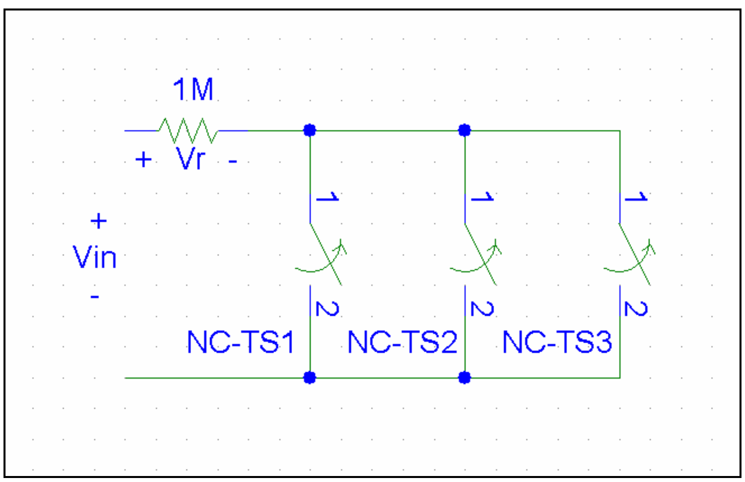
Appendix A – Schematics

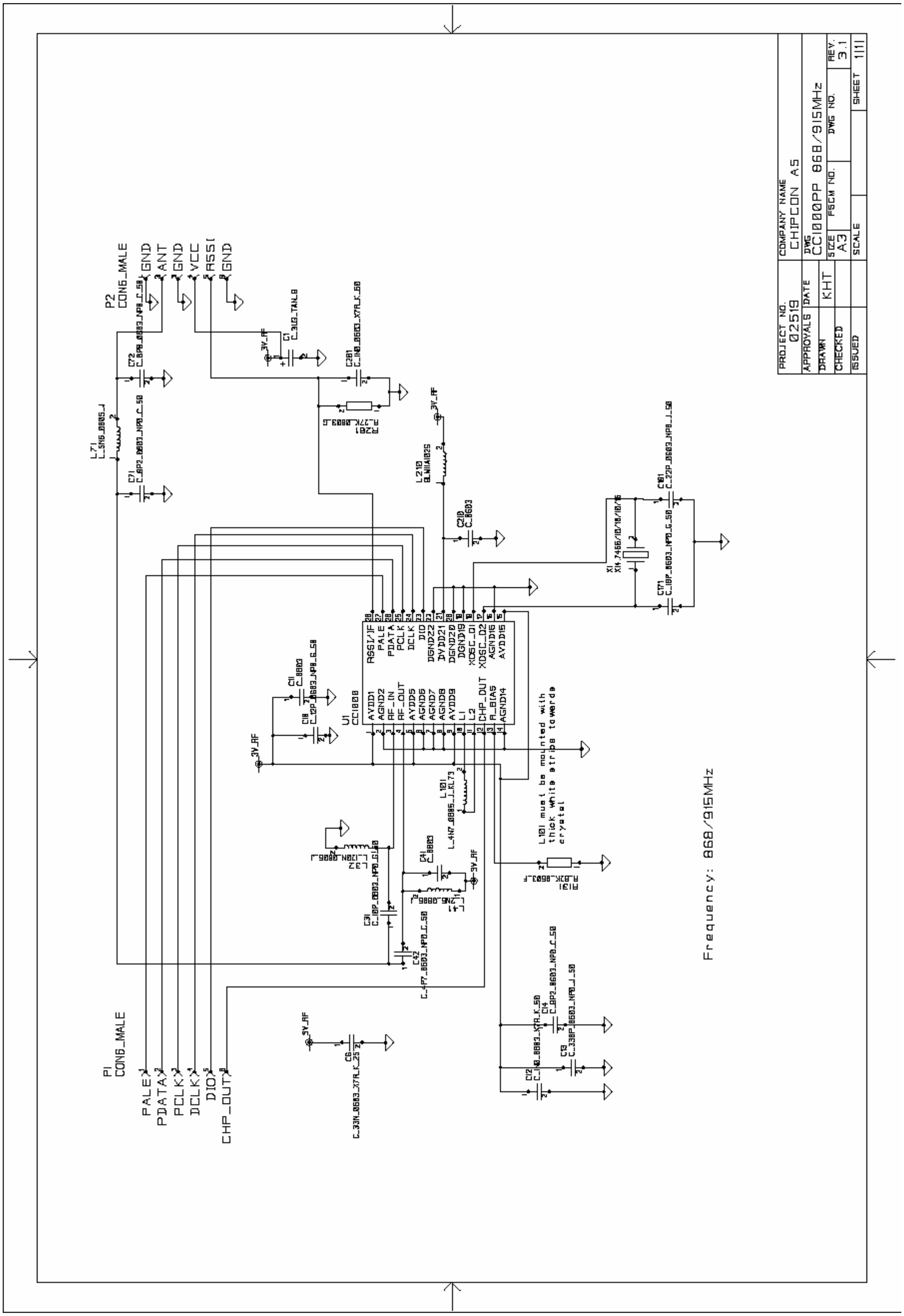
Circuit schematic for the piezo-electric speaker used for the console siren.



Q – ZTX451 D – 1N4148

Circuit Schematic for the tilt switches




PROJECT NO. 02519
COMPANY NAME CHIPCON AS
DWG CC1000PP 868/915MHz
DRAWN KHT
SIZE A3
REV. 3.1
SHEET 1(1)
Frequency: 868/915MHz
U1 CC1000
P1 CON6_MALE
P2 CON6_MALE
L101 must be mounted with thick white stripe towards crystal