The ECO-SEC Home Security System

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***Abstract* — This paper presents the prototype design for a home security system. The system described here is used to detect the presence of intruders in a user's home and inform the user about these intrusions through messages. The system allows the user to change the system's mode using either a LCD touch screen display or a dedicated website hosted on an embedded web server –included as part of the prototype design. Solar power is used for charging the battery.**

***Index Terms* — Embedded Web Server, LCD Touch Screen, Security System, Sensor Array, Solar Power, Stellaris Microprocessor.**

I. Introduction

In recent years the rate of crime has steadily increased, most notably in urban locations. This increase is particularly true with regards to home invasion rates. In order to provide a solution to remedy this problem, the authors proposed a design for a home security system. This system would be capable of detecting the presence of intruders and alerting the home owner to any break in when they occur.

While researching current models of home security systems that are able to be purchased on the public market today, the authors noticed several disturbing trends. Most professional grade models were very difficult to install, very expensive, and often required costly additional fees in upkeep each month to a security firm. These conditions make such systems often unattainable for lower income individuals.

The system prototype, designed by the authors, attempts to make a noticeable impact on solving this problem. The ECO-SEC system was envisioned to be a completely functioning home security system that is able to not only provide security to a home that the user can trust in, but to provide it at an affordable rate that makes the system both economically as well as environmentally friendly.

II. Overview of the System Objectives and Requirements

As previously stated in the introduction, the system was designed to be both economically and environmentally friendly in order to enable lower to middle class income individuals to be able to afford to purchase the system if it ever were to be marketed. In order to accomplish the first objective the system was required to be able to be purchased for less than $1300. This price would place the system at the lower end of the price range for professional systems on the market today. Additionally, the price for this system is reduced further when you consider the fact that the prototype was created so it requires no additional monthly fees after its purchase. In the lifetime of the prototype, this makes the system drastically cheaper than its direct competitors.

The second objective of the system was the ability to be environmentally friendly. The authors wished to create a prototype that was as green as possible by creating a system that requires as little power as possible. This was accomplished by powering the majority of the system using a solar power source; reducing the amount of AC power required by the system. The prototype in turn draws less power and will result in a lower electric bill than most standard security systems. The maximum amount of power provided by the solar cells was required to be at least 30 W in order to be able to power the majority of the system. In the case of no sufficient sunlight being available to power the system using solar power, the system is supported by a backup battery that is capable of providing power to the system for 24 hours.

The third objective of the system was for the prototype to be easy to install; allowing any user to implement it into their home without requiring an outside technician to install the system. As such, the final prototype created is able to be installed by simply mounting a few pieces of hardware and connecting a few cables.

The main objective of the prototype was the ability for the system to provide security to a user's home. For the sake of demonstration and testing purposes the system prototype was designed to provide coverage to an area. However, the manner in which the prototype was designed allows it to be easily expanded to cover additional space. As such, the sensors used to detect intruders were required to be able to cover a room size of 32 x 32 ft. These sensors provide full coverage of an area by being able to detect the opening of a door or window, the breaking of a window, and the presence of intruders already inside the house by using motion detection. When any of these sensors are tripped, signaling the presence of an intruder, the system automatically alerts the resident by sending an alert to any email address assigned by the user, as well as any mobile device capable of receiving either email or text messages.

Finally, the user of the prototype will be able to physically interact with the system using a LCD touch screen installed at the system's location; or remotely, through a website hosted by an embedded web server attached to the prototype.

The rest of this paper will provide a detailed examination of how the final prototype, created by the authors, was able to meet the objectives and requirements given above.

III. Overall System Prototype Design

The ECO-SEC prototype can be best considered as a series of six individual subsystems that are interfaced together to create the final working prototype. These six subsystems include the microprocessor subsystem, the power subsystem, the LCD touch screen subsystem, the embedded web server subsystem, the sensor array subsystem, and the security camera subsystem.

Figure 1 shown below illustrates the ECO-SEC system broken down into these six individual subsystems as well; it also shows how these various systems interact with each other.

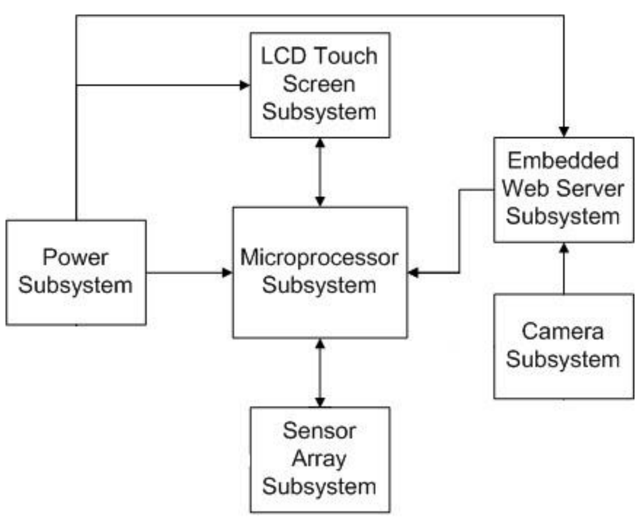


Fig. 1. Overall System Architecture Design

As seen in Fig. 1 the power subsystem provides power to the microprocessor, the LCD touch screen, and the embedded web server. This power is provided by three power connectors that allow power to be easily removed from an individual subsystem. The power subsystem does not provide power to the camera subsystem or the sensory array subsystem. This is because the sensor array subsystem required so little power that it is provided as part of the internal subsystem design. The camera subsystem power requirements were too high to be provided by solar power and, as such, the power for this individual subsystem is provided by an AC power source.

The LCD Touch Screen communicates with the Microprocessor by the use of a RS-232 Serial Connection. This connection is used to pass data and instructions between the LCD screen and the processor. A similar setup is used for the embedded web server. Data is passed using a RS-232 connection. Similar to the LCD, this is used to pass data entered through the web site to the processor and instructions for the web server from the processor to the server.

The sensor array passes data on the state of the sensors, regardless of whether they have been tripped or not, to the microprocessor. This communication is accomplished through the use of a matching pair of XBee Wireless Communication nodes. Each individual sensor in the array connects to a home node that is included as part of the microprocessor subsystem. This allows the user to have wireless sensors instead of requiring a physical connection to the system.

IV. ECO-SEC System Modes

The ECO-SEC prototype is capable of functioning in four unique modes. These modes govern how the prototype responds when it detects the presence of an intruder. These four modes are OFF, AWAY, STAY, and BURGLAR.

While the system is operating in the OFF mode, it ignores the results of any of the sensors being triggered. This is the mode used when the user wishes to deactivate the security provided by the ECO-SEC. The AWAY mode is used when the user is not present at their home and wishes the system to be fully activated. While operating in this mode the prototype correctly alerts the homeowner of an intrusion anytime a sensor is tripped. The STAY mode comprises the OFF and AWAY modes. In this mode, the system responds to any intrusions detected either by having the sensors detect a window or door being opened, or a window being smashed. This mode however, ignores the results of the motion sensor being tripped. This allows the user to have some sense of security while at home, by activating the perimeter alarms. ,Disabling the motion sensor allows the user to move freely at their home without constantly setting of the system due to the motion detection sensor triggering.

The final mode the system is capable of operating in is the BURGLAR mode. The prototype cannot be directly entered into this mode. This mode becomes activated if the correct sensor is tripped in either the STAY or AWAY modes, as previously described. When the system enters this mode, the prototype sounds an alarm and alerts the user about the intrusion by email or text message.

BURGLAR mode can be entered not only by the triggering of a sensor, but by the user entering the code for the silent alarm feature on the password screen of the LCD touch screen. This feature allows the user to trick an intruder into thinking the ECO-SEC is disabled. This feature causes the system to not sound an audible alarm but send out an alert message as normal. Although for the sake of this prototype which is limited to contacting the homeowner only, it serves little functional purpose. However, this feature is designed mostly to show how this feature would work if the system instead of contacting the user, was expanded to be able to also contact emergency services. Contacting emergency services was not implemented in this prototype in order to simplify testing and avoid the sensitive laws/requirements behind contacting these services.

V. Microprocessor Subsystem

The microprocessor subsystem was one of the most important subsystems in the design of the ECO-SEC prototype. This subsystem was primarily responsible for controlling the logic behind the prototype as well as facilitating communications between the other subsystems to guarantee uniformity of operation between the various components of the prototype.

The microprocessor chosen to implement this subsystem was the Stellaris ARM Cortex-M3 LM3S1968 from Texas Instruments. This processor was chosen because it best fit the criteria required for the prototype. The most important of these criteria was the number of UART connections available to the microprocessor. The prototype designed required three separate unique UART connections, one for the serial connection to the embedded web server, one for the serial connection to the LCD touch screen, and one to allow the microprocessor to connect to the XBee home node that is used by the microprocessor subsystem to communicate with the sensor array subsystem. The microprocessor also required several different open GPIO pins. These pins were used by the microprocessor to illuminate LEDs which are used to display important status information on the prototype as well as to connect a buzzer, and accept or transmit power logic. This buzzer is used to create an audible alarm for the system to sound when the burglar mode is triggered. Even though the buzzer used does not create the loudest alarm possible, it is audible enough to be heard from a distance and works for the purpose of this prototype. If the system introduced here was taken beyond the prototype stage, it would be easy to integrate a louder sounding audible alarm into the system design to replace this buzzer.

The microprocessor itself was coded using a wait and respond style of control logic for the system. This resulted from using a series of interrupts and their appropriate handlers to control how the system changes functionality. Each UART device, the LCD touch screen, embedded web server, and sensor array, uses its own interrupt handler to deal with requests made to the system by these subsystems.

The UART interrupt for the LCD touch screen is invoked when the microprocessor receives a serial communication from that subsystem. The handler then reads data from the microprocessor's receive buffer and uses this to determine what information was sent whether it was a command instructing the system to change the alarm mode the prototype operates in or if it was an passcode for the microprocessor to determine if it was correct or not. Once the handler determines what command was sent, it will call the necessary functions to respond correctly to the received input. This typically involves updating the status of the prototype as well as the status displayed on the embedded web server web site.

A similar handler is used for the embedded web server. The embedded web server handler is responsible for reading input reached from the web server and, similar to the LCD, instructing the rest of the components on how to respond to the data sent. For example, when a change is made to the system status, the status displayed on the LCD should update accordingly.

The sensor array's interrupt handler functions slightly different from the other interrupt handler. This handler listens for information on what sensor was tripped as well as checking what mode the system is functioning in to determine whether the prototype should respond or ignore the result of that particular sensor being tripped based upon what mode the prototype is currently in.

In addition to the above previously described three UART handlers the microprocessor also was coded using a few support functions. The most important of these functions were ones used to handle the prototype activating the alarm and another to handle initially configuring important parameters for the microprocessor when it is first powered up.

The set up function is used by the microprocessor to set up the three UART connections used by the subsystem and to configure the parameters for them such as the baud rate they use. Also, the pins for the LEDs and the buzzer are set up in this function as well. Finally, this function initializes the system clock used by the microprocessor subsystem.

The final important support function for the microprocessor is used to handle the event of an intrusion occurring and an alert is required by the prototype. This function correctly causes the buzzer to emit its audible alarm as well as send the serial command to instruct the embedded web server to dispatch its email alert message as appropriate.

VI. Power Subsystem

The power subsystem consists of three main parts. The first part is a switch which interfaces the 30W solar panel and the output of an AC to DC converter with the rest of the circuit. Following the switch, there is a three stage charge controller to efficiently charge the battery. Finally, the battery is loaded by three voltage regulators which provide power to the other subsystems.

One of the most important components in the power subsystem is the solar panel. Since the Eco-Sec is a relatively low power device, it was decided not to use maximum power point tracking with the solar panel due to its cost and complexity. Instead, a larger than needed panel (30 W) was purchased to provide power to the system. The solar panel measures approximately four square feet and costs under $100.

Another important issue was the selection of the battery. The Eco-Sec requires a battery that has a long life, does not require full discharges, and can continuously be recharged. Therefore, it was decided to use a lithium-ion battery. Since the average power consumption of the Eco-Sec is roughly 1.4Wh, a 50Wh battery should provide a battery backup of at least one day after calculating for the power losses in the power subsystem. Such batteries can be found for $70.

The first circuit in the Eco-Sec is the switch. The switch will block one power source while allowing the other one to charge the battery. A cost efficient solution was to always use the solar panel unless the battery voltage is low. To do this, a Schmitt trigger was designed that goes low when the battery is below 10V and goes high when the battery reaches 12V. To perform the switching operation, the LTC4412 was used, which can block or allow signals based on the control line input.

The switch provides power to a three stage lithium ion battery charge controller. The circuit is based upon the MAX745 IC. This charger will set a current limit of 1.8A by a small resistor connected in series with the battery. The charger will begin to regulate voltage once the battery reaches 12.8V. This is set by a voltage divider at the Vadj line. A schematic is shown below.

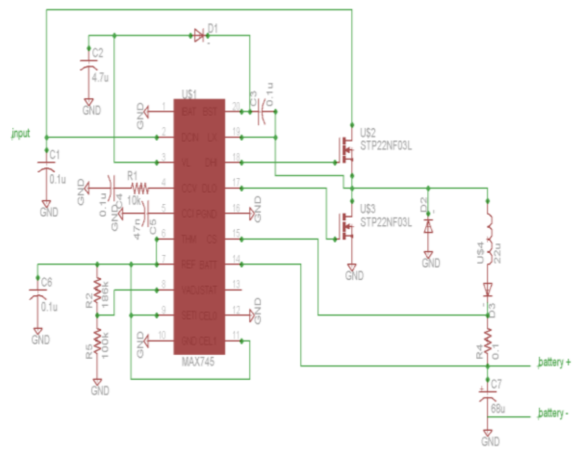


Fig. 2: Charge Controller

The final part of the power subsystem is the voltage regulators. The LM2675 step-down switching regulator was used to step-down the battery voltage to a 3.3V signal (to the microcontroller) and 5V signal (to the touch screen). The 12V regulator (to the web server) was more of a challenge since a step-up and step-down regulator was required. The LT1372 was used to do this. The schematic for the 12V regulator is shown below.

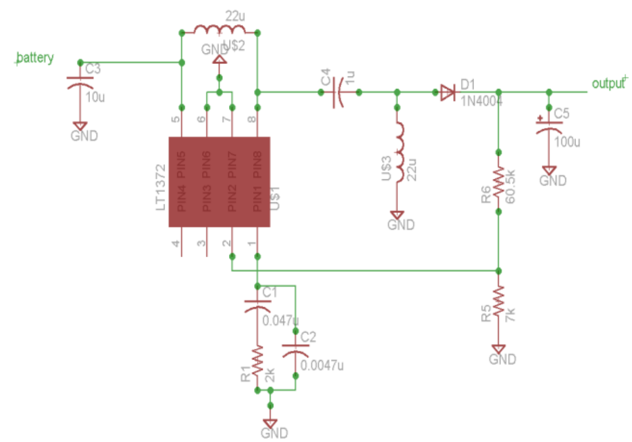


Fig. 3: 12V Regulator

In switching regulators, part selection and layout are critical. Low ESR aluminum capacitors were used on the output of each regulator. The output capacitors can also see a great deal of current, so a high RMS current rating was required. Inductor selection is also important. The regulators use ferrite core inductors which can create a large amount EMI, but this issue is not of great concern in the Eco-Sec. The inductors also have a high saturation current. Due to the high frequencies of switching regulators, long wires can have a significant voltage drop across them. This is primarily due to the inductance of the wire. If this issue is not resolved, large voltage variations can appear on the output of the regulators because the ground point is not ideal. This issue also interferes with the charge controller's ability to read the battery voltage and appropriately regulate current. To fix the problem, a ground plane was used on the power circuit board. A ground plane allows short traces from the circuit to ground and also provides a very wide trace further reducing impedance.

VII. Sensor array subsystem

The main purpose of the sensor array is to provide a means for the ECO-SEC system to detect the presence of intruders. This subsystem is comprised of three main sensors. The first is used to detect when a window or door is opened. When such an event occurs the sensor will send that it was triggered to the microprocessor system. The second sensor listens for the sound of glass breaking. This is used to provide the prototype a means to protect the user's home from an intruder attempting to enter it by breaking in through a window or sliding glass door. The third sensor is a motion detector that is used as a last resort sensor. This sensor is used to look for the presence of intruders already inside the user's home if the previously described two proximity sensors did not already detect them.

The sensor used to detect when a door or window was opened was constructed around the use of Total Internal Reflection (TIR). TIR occurs when light travels down a medium of a different reflective index. For case of the sensor construction in the prototype infrared light is passed through an experimental optical fiber made of polycarbonate with a diameter or approximately 1mm and a negligible core, essentially an all cladding fiber. This fiber was manufactured and donated by CREOL (Center for Research and Education in Optics and Lasers at UCF). The photo detector chosen was a highly specialized infrared receiver module for remote control systems TSOP348 Vishay Semiconductors. The advantage of this photo detector is that it has a PIN diode and a preamplifier with an IR filter that rejects most noise from fluorescent lamps that when triggered it sends a digital signal. The principle of this sensor is very simple yet effective as light is emitted by a flashing LED at a given frequency on one end of the fiber on the other end has a photo detector monitoring this signal. The signal can be of a constant frequency or one that varies with a logarithm pre-programmed into the microcontroller. When a door or window is opened the signal that is being detected by the photo detector is interrupted and the alarm is triggered. When this occurs the sensor will pass this information from the MSP430G2553 to the main Microcontroller via Xbee ZB RF Modules.

The glass break sensor was designed to be able to detect the sound of glass breaking in a room with a size of approximately 300 m^2. This sensor was based on a Texas Instruments Application Note SLAA389 and the Olimex MSP430-GBD development module. This sensor uses a microphone to listen for sounds inside the room. This sound information is then passed to a MSP430F2274 microprocessor that detects an initial "thud" and upon finding this it continues to filter and attempt to verify that in fact glass has broken. When this occurs, the MSP430F2274 Microcontroller will pass this information through the XBee ZB RF Module. This will allow the microprocessor subsystem previously described to be able be informed that this particular sensor has been tripped and have the prototype respond appropriately.

The motion detection sensor was the most basic of all three of the sensor employed by the ECO-SEC prototype. This sensor made use of an integrated AMN44122 Motion Detector from Panasonic. This sensor detects changes in the average range infrared radiation within its field of view. When it detects such event apparent motion it is then said to be detected and it outputs a digital signal of high. These sensor outputs are in turn connected to another MSP430G2553 microprocessor. The microcontroller waits in a sleep state until the signal is received from the motion detector it waits for a second trigger of the motion detector and triggers the alarm. The Alert is transmitted via XBee ZB RF Module chip for processing by the rest of the prototype similar to how the other two sensors function.

With the successful implementation of these three sensors the ECO-SEC prototype is capable of providing security to a user's home. The current prototype was limited to one sensor of each type for testing and demonstration purpose. But because each sensor uses the same XBee protocols to transmit to the microprocessor the sensor array subsystem is able to be expanded upon with the addition of extra sensors, although this was not done for the scope of this design.

VIII. Embedded Web Server Subsystem

The main purpose of the embedded web server subsystem is to host a website that can allow the user to interact with the system remotely. This was accomplished through the creation of a website dedicated to the prototype that allows the user to view the status of the ECO-SEC as well as to make changes to what modes the system operates in.

The embedded web server chosen to be used to in the design of the ECO-SEC prototype was the Site Player SP1K Board available from NetMedia Inc. This web server was specifically designed to support small scale embedded projects with a small simple website. The SP1K features 48 KB of internal memory for the creation of the website. This amount limited the design of the website to be simple in appearance but was still enough to create a fully functioning website.

The website was designed using standard HTML code. This code however required a few small modifications to adjust to the platform of the SP1K server but the majority of the design was standard HTML. The website was split into two web pages, the first being a login page and the second the main page for the system.

The login page displays simply contains the logo for the system and a single input field and submit button. This field is used to allow the user to enter a password to login to the system website. If the password is incorrect the system will prompt the user informing they entered the wrong login information. If the password entered is correct the website will load the main web page for the ECO-SEC.

The main webpage displays several important points of information about the system. The first is a live video stream of the user's home provided by the security camera subsystem. This stream is placed inside the website using a java script embedded into the HTML code for the page. This video feed allows the user to remotely see the physical state of their home anytime they wish for an added sense of security. The next information on the site is status text that informs the user of the current mode that the ECO-SEC system is currently operating in. The most important part of the website is a series of links that allow the user to remotely adjust the mode of the system. Anytime the user clicks on these links a serial command is sent to the microprocessor subsystem informing it to update the mode the system operates in to match the link used on the web site.

Figure 4 shown below illustrates the flow of the web pages that were used to create the ECO-SEC web site. This figure is important in understanding how website reacts to the different input it can receive from the user while operating the ECO-SEC prototype.

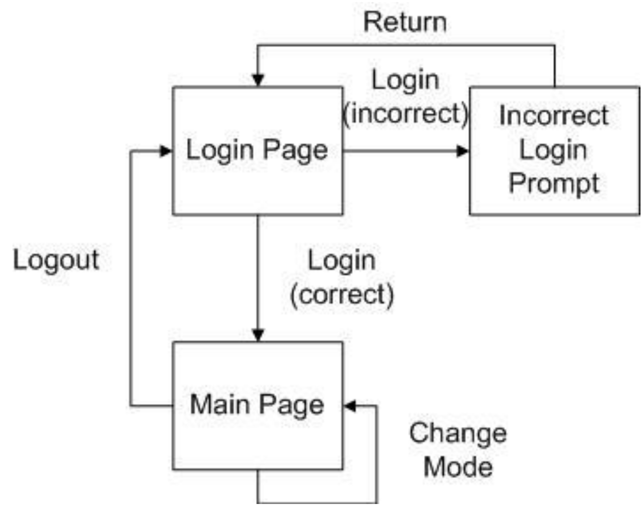


Fig. 4. ECO-SEC Website Software Flow

As previously described this Fig. 4 shows how the website correctly transitions from the login page to the main page when the user enters the correct password. If the password is incorrect they receive a popup prompt informing of this before returning to the login screen. While on the main screen itself, when the user changes the mode of the ECO-SEC the web site automatically reloads with the update status. When the user logs out of the website it automatically returns the user to the login page.

The embedded web server is also capable of receiving serial commands from the microprocessor. This is used to allow the microprocessor to instruct the web server to update the status of the system that is displayed on the website. This is invoked with the user makes a change to the ECO-SEC's operating mode using the LCD touch screen interface and this change needs to be echoed onto the website for the sake of uniformity.

The embedded web server subsystem is also responsible for sending out the email/text message alerts for the prototype. The web server is capable of sending out UDP packets to any IP address on the network that the server is connected to. However most email servers do not support receiving UDP packets. However a work around was used to mitigate this problem. A second PC attached to the same local network as the web server was used. This PC runs a program provided by the manufacturer of the SP1K that listens for the presence of UDP packets on the network from the Site Player. When the PC detects the presence of one of these packets it records the time and sends out a preset email message to preset email addresses using the TCP/IP protocol stacks provided by the PC. Although this was not the most optimal solution as it requires an additional expensive component to the prototype the authors assumed that in today's culture almost any home would have a PC available for use. This is especially true for individuals whom would be most interested in using a home security system.

IX. LCD Touch Screen Subsystem

The LCD touch screen subsystem was designed to provide an interface to allow the user to access the system locally. Although everything that the can be accomplished using the touch screen can also be done by the web site the authors felt that it provided more ease of use to the overall prototype. This was because it allows the user to interact with the system quick and easy without the need to use a device to access a webpage on the internet. This is intended to be used when the user is entered or leaving their home and wish to change the operation of the system.

This subsystem was designed using the 4.3" LG Phillips Touch Screen Development Kit with the SLCD43 controller board available from Reach Tech Inc. This kit was used primarily since it included all the hardware necessary to develop this subsystem including the LCD screen itself as well as the necessary controller boards used to manage how the LCD functions. The LCD Touch Screen uses a serial connection as previously described to communicate with the microprocessor subsystem. This is used to both inform the microprocessor when a change is made to the system using the LCD as well as to allow the microprocessor to instruct the LCD to update its status when a change is made elsewhere in the system such as by using the website hosted on the embedded web server subsystem.

The interface itself was comprised of three main screens; a locked screen, passcode screen, and the main screen for the ECO-SEC system. Each of these three screens was created using a series of macros that invoke different built in API commands used to program the chosen LCD screen model.

The locked screen is the default screen that the LCD is expected to spend the most time in. This screen simply displays a single button to allow the user to unlock the interface. The primary purpose of this screen is to provide a way to secure unauthorized users from making changes to the system using the LCD.

If the user decides to use the interface to the system provided by the LCD by choosing to unlock it the interface by using the passcode screen. This screen allows the user to enter a passcode to unlock the interface. The microprocessor will receive the entered passcode by the serial connection between the two and determine if it is correct. If it is correct the screen will unlock while incorrect passcode will result in the interface remaining locked. Additionally this is where the user can enter the silent alarm code to activate this feature as previously described.

The most important screen for the interface is the last screen which is only able to be accessed upon the user entering the correct passcode into the interface. This screen is used to serve two primary functions. The first is to display a line of status text that informs the user what mode the prototype is operating in. This prevents the user from having to access the website to check the status while they are still home. The second function is a series of buttons that when pressed allow the user to switch the mode system operates in based on which button the user pressed. This information is then relayed to the microprocessor by the serial port so that subsystem is able to adjust the behavior of the rest of the system to match the user's new choice on mode of operation for the prototype.

When the user is finished making changes to the system using the LCD interface, they can return the system to the locked state by using a button on the main screen of the interface. More details on how to use this interface to control the system will be given later in this paper.

Figure 5 shown below illustrates this flow of the interface as previously described above.

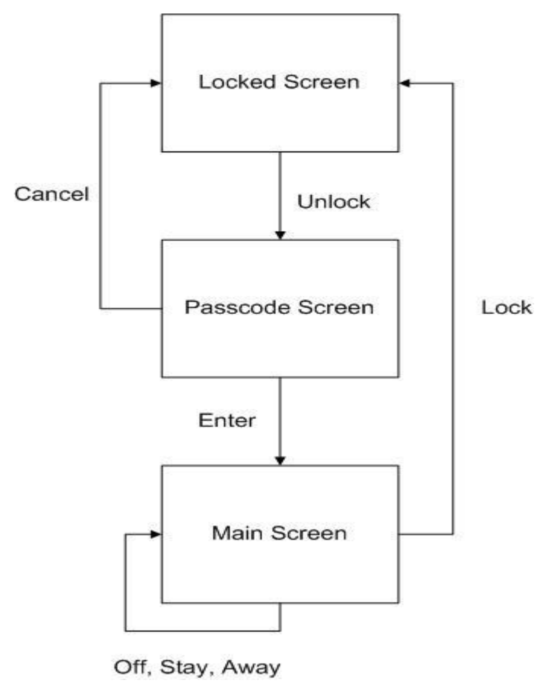


Fig. 5. ECO-SEC LCD Touch Screen Interface Flow

As can be seen in Fig. 5 the flow of the LCD touch screen interface was kept relatively simple. The user can transition between the three different screens by using the appropriate button on the interface. The one exception to this rule was the Enter button on the Passcode screen. Pressing this button does not immediately cause a transition to the main screen. Instead the passcode the user entered is passed to the microprocessor subsystem which then performs a check to confirm that the passcode is correct or not which determines which screen to transition to.

X. CAMERA SUBSYSTEM

This subsystem is responsible for providing a live video feed of the user's home. The embedded web server uses this stream in a website, to provide the user with a remote view of their home at anytime. The security camera used in the creation of the prototype is the AXIS M1011 camera.

The AXIS M1011 is capable of providing a video stream in several formats. To optimize the balance between the quality of the video and the amount of bandwidth required to stream this video to the embedded web server, the authors decided to encode the video in Motion JPEG (MJPEG) format. Additionally, the video was set to stream at a 640x480 quality resolution.

The main requirement for this camera was that it was network camera capable of being assigned a static IP address. This was important for streaming the video onto the website using JavaScript; which was hosted on the embedded web server. The configuration of the M1011 was accomplished through the built-in API of the camera.

XII. CONCLUSION

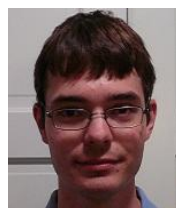
Successful completion of the ECO-SEC prototype resulted in a functioning security system that met the criteria originally established for the development of the system. Despite fulfilling these objectives and requirements, the prototype presented contains flaws and should not be considered as a one hundred percent secure security system. Instead, the prototype should be considered primarily for demonstration purposes to show what can be accomplished by a security system using this set up.

The primary flaw of this prototype was that it did not provide coverage for an entire home. This design was limited to providing coverage to an area. However, the same logic can be followed to secure the entire house with little additional work and or money.

Despite the few flaws, the authors consider the prototype created to be a good step forward in creating an economically and environmentally friendly security system that, with some improvements, could one day serve as an example of how to create a professional and fully functional security system that is both easy to use and inexpensive. At the time of this publication, the authors do not have the intent to pursue such a task. Instead, they leave the possibility open to others who wish to use the background laid down by the ECO-SEC prototype to expand upon this design.

BIOGRAPHIES

Nathan Schroeder is a major in computer engineering with a minor in computer science. His main focus of study is software engineering and programming. He hopes to locate obtain a job as a software engineering upon graduation.



Brian Kelly is an undergraduate student studying electrical engineering at the University of Central Florida. He expects to graduate during the following fall 2011 semester. After graduation, he plans to pursue a Master's degree in computer science.

Diana E. Escobar-Pazo will graduate from the University of Central Florida with two degrees: Computer and Electrical Engineering in the summer of 2011. She currently works as a UCF/LM CWEP participant and plans to keep doing so while continuing her education at the same university.

David Gardner is a senior pursuing his Bachelor's Degree in Electrical Engineering at the University of Central Florida. He plans to graduate in Fall 2011. His interests are in Imaging and Optics. He is currently working with Dr Sassan Fathpour. After graduation, he plans to start a career as an optoelectronic Engineer.