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March 11, 2010

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

Re: Design Specification for DispensAlert™, a Medicine Dispensing Alert System

Dear Dr. Rawicz:

Please find attached the design specification for the product DispensAlert™ by Xypnios Innovations Inc. We are designing and implementing a device that reminds individuals to take their medication and to dispense the correct combination of medicine at a given time. DispensAlert™ will increase the probability of maintaining a healthy lifestyle.

Our design specification provides the technical approach to satisfy the requirements presented in our functional specification. In this document, you will also find alternative design methods that will satisfy functional requirements, but will not be physically implemented. This will allow for future enhancements to the product in the latter stages of product development.

I will be more than happy to discuss any additional questions or comments you may have regarding the design specification. Please do not hesitate to contact me via email at rdl2@sfu.ca or by phone at 604-613-1611.

Sincerely,

Ryan Laing

Ryan Laing
President and CEO
Xypnios Innovations Inc.

Enclosure: *Design Specification for DispensAlert™—Medicine Dispensing Alert System*

Xypnios Innovations

DispensAlert

Design Specification

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EXECUTIVE SUMMARY

In a world where memory loss is an inevitable consequence of aging, it is important for technology to counteract this loss and work towards an effectual solution. At Xypnios Innovations, we will develop DispensAlert, a simple low technology solution that reminds its users to take their medication on a timely basis and as a result, maintain a healthy life style.

This documentation provides detailed description for the research and development portion of our DispensAlert model. General system and sub-system flow charts are also provided. In addition, detailed specifications of each hardware components and their respective communication methods with the microcontrollers are discussed.

DispensAlert allows its user to manually input or scan a barcode to program the unit's dispensing information. DispensAlert consists of two units: the main unit and the wristband unit. The main unit contains the mechanical dispensing mechanism that will be driven by the stepper motors. In addition, the main unit contains a microcontroller that drives the main software portion of the product as well as communications with other hardware components. The touch screen panel serves as the user interface for the entire product. The user can easily acknowledge the dispensing or modify the dosage information through the LCD display.

The wristband unit is an ergonomically designed and easily adjustable component that resembles a watch. The wristband unit's microcontroller has user-friendly functions that alerts the user at the scheduled time and updates its internal schedule when synchronized with the main unit.

In future iterations of DispensAlert, we will work towards minimizing the dimensions and other mechanical parameters of our product in order to make our product smaller, lighter, and more convenient. In addition, we hope to further improve the product's response time, energy consumption, aesthetics, as well as durability and reliability.

The design layouts and test plans for our first iteration model DispensAlert are outlined in the following document. The Xypnios team is committed to deliver a safe, useful, easy to use, and memorable device.

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GLOSSARY

MCU	Microcontroller Unit
UI	User Interface
GUI	Graphical User Interface
LCD	Liquid Crystal Display
USB	Universal Serial Bus
I^2C	Inter-Integrated Circuit
SPI	System Packet Interface
GPIO	General Purpose Input Output
TFT	Thin Film Transistor
ROM	Read Only Memory
UART	Universal Asynchronous Receiver Transmitter

1.0 INTRODUCTION

DispensAlert™ is a two-piece electro-mechanical device which is designed to improve the health of medicine-dependent individuals. The wristband unit provides a method for the user to be reminded remotely without being limited on mobility. The main unit is the central hub of entire medicine dispensing alerting system. It is responsible for cleverly dispensing the correct combination of medicine to the user and managing daily dosage requirements.

DispensAlert™ is designed with ease-of-use and versatility. The device can quickly learn the new dosage requirement with a scan of a medicine label. In addition, a change in daily dosage requirements can be simply updated through wireless telecommunication between the main unit and wristband.

The combination of the two devices will improve the chances that individuals will take their daily medication requirements on a prescribed schedule. The technical approach for achieving the aforementioned functionality for DispensAlert™ is outlined in this document.

1.1 Scope

The purpose of this document is to clearly outline the technical design approach in developing the DispensAlert™ system. The document will provide discussion with respect to functional requirements marked with “1” and “2” only. Requirements marked with “3” will be out of the scope of this document as they pertain to production units. These requirements will be further addressed in the latter stages of development.

This document is to be used in conjunction with Xypnios Innovations’ functional specification document.

1.2 Intended Audience

The use of this document is targeted towards the design team of Xypnios Innovations Inc. The design specification will provide a foundation for the engineers to ensure that all requirements, conjured in the functional specification document, are fully met.

Quality assurance engineers should refer to this document for test plan criteria to measure the designed behavior of DispensAlert™.

Lastly, the detailed design specification can also be used in supplementary reference material for documents such as user and service manuals.

2.0 SYSTEM OVERVIEW

The DispensAlert™ system is comprised of two units: the main unit and the wristband unit as illustrated in Figure 1.

Figure 1: DispensAlert™ System Components

The main unit is the primary component for the DispensAlert™ system. By embedding a touch screen display and creating an easy to use graphical user interface (GUI), the user is able to enter required system information such as the time the medication needs to be taken, quantity per intake, or change system settings. As a special feature, the required system information can be encoded in a 2D barcode which allows for ease of use. The user simply scans this barcode with the included scanner. After entering such information, the user places their medication in one of the chosen reservoirs (for the prototype unit, there will be two reservoirs).

The MCU in the main unit which connects to the touch screen and the barcode scanner via RS232 then takes the system inputs in order to process and save them. When the wristband unit is in close proximity to the main unit, a sensor circuit sends a signal to the MCU in order for it to control the transfer of the time to take medication data to wristband unit. This transfer of data is achieved by using a wireless receiver embedded into the wristband unit and a transmitter embedded into the main unit. The MCU in the wristband unit then processes and saves this data in order to initiate audible or vibration alerts when it is time for the user to take their medication.

When such alerts are made, there user will have to press the “dispense” button on the main unit. The main unit will not dispense the medicine automatically. This is a safety feature since it is undesirable to have some medication exposed to light and since this could be hazardous for children. However, when the button is pressed, the MCU will send control signals to the mechanical system in order for it dispense the correct number and combination of medicine.

3.0 OVERALL SYSTEM DESIGN

The DispensAlert™ system design consists of two parts: software and hardware. The software portion deals with creating the GUIs for both the main unit and the wristband unit, as well as programming the MCUs using the C programming language. The hardware portion for the main unit deals with the touch screen display, barcode scanner, mechanical system, wireless transmitter and the LPC2148 MCU, while the hardware portion for the wristband unit deals with the wireless receiver, a vibration device and the ATmega169 MCU.

3.1 Software Design Overview

The GUI of the main unit is one of the components that requires software design. It will be created using bitmaps and the flash burning utility provided for the touch screen display. The bitmaps are created using a graphics editing program such as Adobe Photoshop and then they are burned into the flash memory of the touch screen. When an appropriate command is sent to the touch screen via the RS232 connector on the MCU, the selected bitmap file is fetched and displayed. This MCU will be programmed using C in order to fulfill the various GUI functions, which are shown as a high level menu tree in Figure 2.

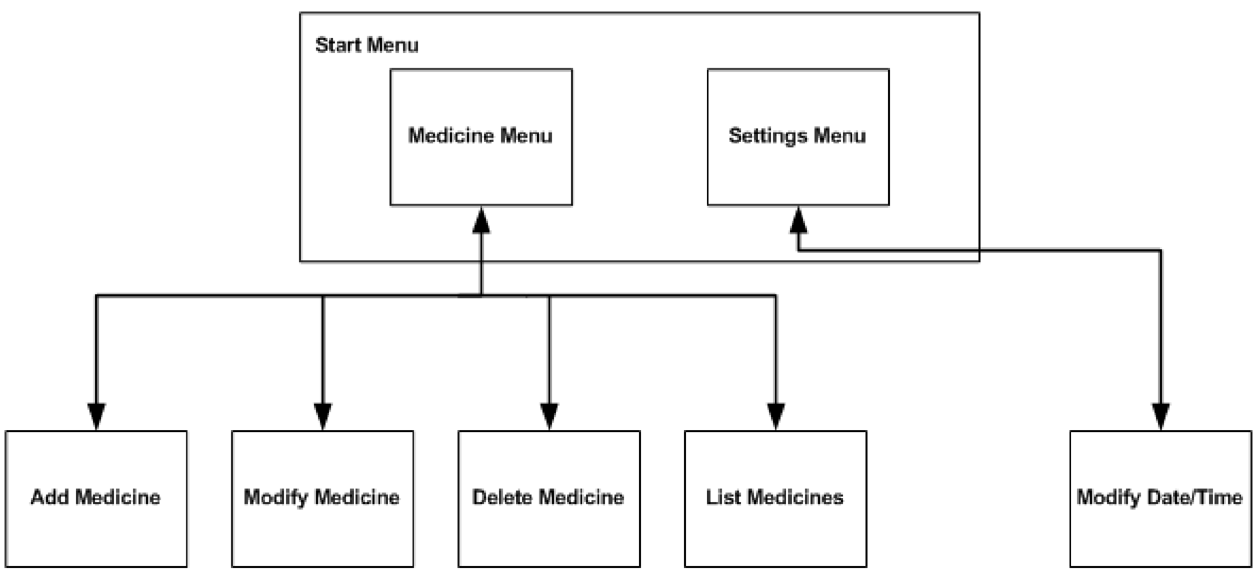


Figure 2: Main Unit GUI Menu Tree

Upon turning on the DispensAlert™ system, there will be a screen showing Xypnios's logo for a few seconds. Afterwards, the start menu is displayed and the user is presented with two options: to go to the medicine menu or to the settings menu. If the medicine menu is selected, the user will be able to add, modify, delete and list medications. If the settings menu is selected, the user will be able to change the date and time saved on the system.

The C programming language will also be used to program the main unit's LPC2148 MCU in order to fulfill the following functions: control the barcode scanner, control the mechanical system, control the wireless transmitter and to process and store medicine related information. The barcode scanner will be controlled using an RS232 connection. In order to accomplish this connection, appropriate RS232 settings will be programmed such as the baudrate, number of data bits, stop bits and parity. Such settings will also be programmed in order to interface the MCU with the touch screen display. To control the mechanical system, the MCU will be programmed to send two signals to the stepper motors driving circuit: a direction signal and a clock signal. The direction signal will control in which direction the stepper motors move and the clock signal controls how fast they are spinning. A custom solution will be used to process and store medicine related data.

3.2 Hardware Design Overview

In order for our product to meet all its functional specifications, having the accurate hardware component is of paramount importance. After reviewing various microcontrollers for the main unit, the research team at Xypnios Innovations decided to use the ARM7 LPC2148 Microcontroller. Factors such as multiple interface options and small compact size make this development board ideal for DispensAlert's main unit. For the wristband unit, the AVR Butterfly development board, was selected because it integrated several features which we intend to utilize in the wristband unit in a compact space. The Butterfly has a display, buzzer, RTC, and input device all build around the ATmega169 MCU. A block diagram of the hardware systems for both the main unit and the wristband unit is shown in Figures 3 and 4.

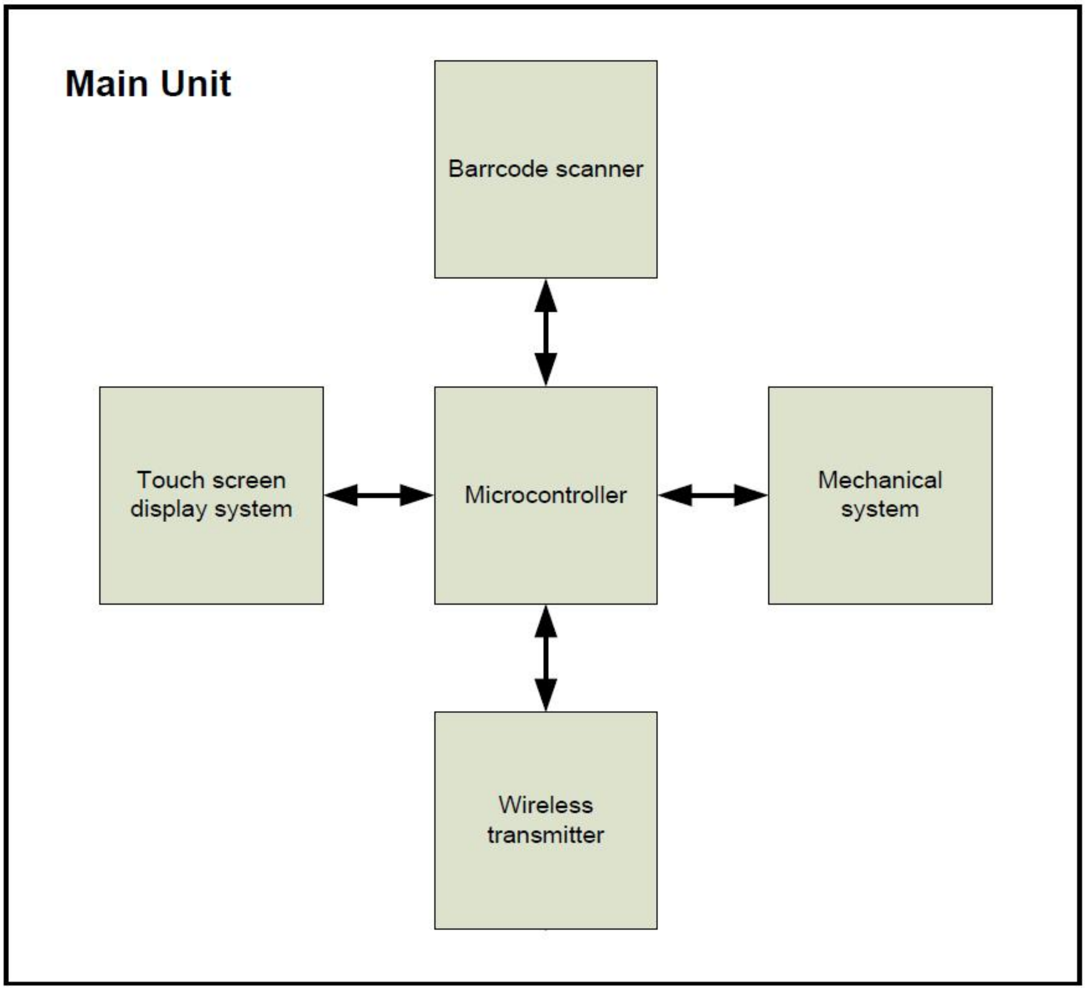


Figure 3: Main Unit Block Diagram

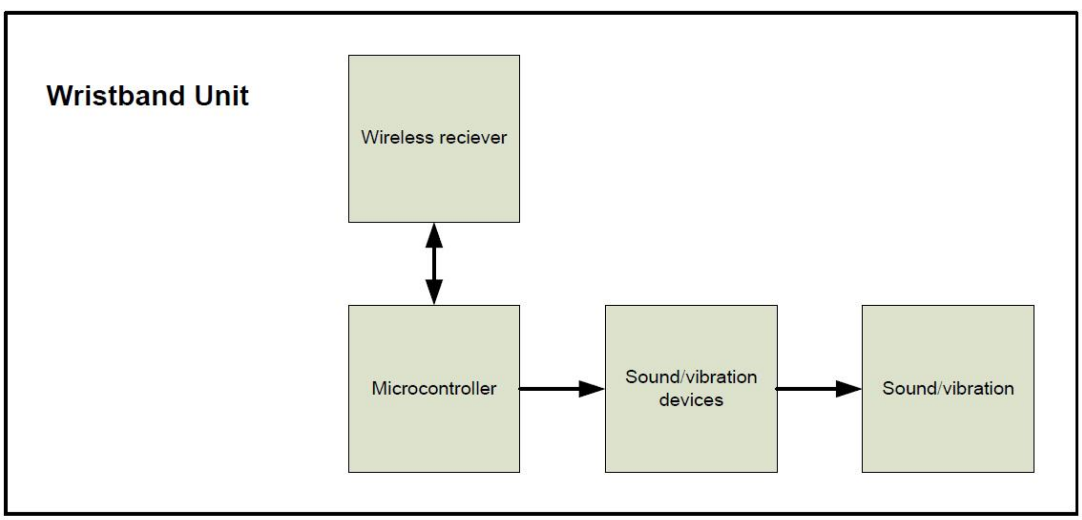


Figure 4: Wristband Unit Block Diagram

As can be seen, the main unit and the wristband unit can be treated as two different entities with one common interface: the wireless transmitter and receiver.

The main microcontroller acts as the central system for transmitting and receiving signals and will be embedded into the main unit. The user interacts with the product system via Earth LCD's ezLCD-002 intelligent programmable LCD module with touch screen. The LCD touch screen will interface with the microcontroller via the RS232 connection due to the slightly easier coding methodology. In addition, the LCD has memory reserved on board for storage of user-programmable icons/images which can greatly enhance the user interface.

A special feature our product has is its ability to read inputs through a barcode scanner. The MCU receives such data and in turn processes and saves it. For this particular design, we chose the IMAGETEAM 4410 2D Series Hand Held Imager from Hand Held Products which will interface with the MCU via the RS232 connection as well. The research team chose this particular barcode scanner because it is inexpensive, durable and ergonomically designed for comfort, and ease of use. For the mechanical design portion of the main unit, we have decided to use Japan Servo Co., Ltd's KH42JM2B140E stepper motor driven by Sanyo's STK672-600 2-phase stepping motor driver. This particular stepper motor is 2-phase and is ideal for our product due to its smooth movement in fine incremental angular displacements. This smooth fine movement is vital to the mechanical design as it will allow for maximum control while dispensing specific medicine requirements. Lastly for the main unit, the wireless transmitter with the main unit transmits the data when synchronized with the wristband unit, and updates the information.

The wristband unit's hardware component comprises of the ATmega169 MCU, VPM2 Vibrating Disk Motor, and the MO-RX3400 Wireless Receiver mentioned above. The research team at Xypnios Innovations choose the ATmega169 model for the wristband unit microcontroller due to its small size, and other features such as built-in LCD screen that are useful for DispensAlert. In addition to the ATmega169 MCU, the wristband unit also consists of small VPM2 vibrating disk motors that will be placed discretely for the product's first iteration model. The lack of exposed component and small figure are the main reasons behind choosing this particular vibration device.

For the wireless modules, we chose MO-RX3400-A Receiver and MO-SAWR-A Saw Resonator Transmitter from Holy Stone Enterprise Co., Ltd. We chose this pair of transmitter/receiver because of its excellent performance, wide range of receiving/transmitting, and ease of use.

4.0 SOFTWARE DESIGN - MAIN UNIT

The software for the main unit will be created to satisfy three main functions: The first is the storage of the pill dispensation schedule, the second is the user interface through the touch screen and the third is the control of peripherals. This section of the document will elaborate on the specifics of what the implementation of each part entails.

4.1 Schedule Storage

In order to know when each pill should be dispensed, each pill needs to have a dispensation schedule stored within the main unit allowing the unit to know when each pill should be dispensed next and when to alert the user. The major issue with this storage is that it must be of variable size. Each pill may be dispensed as many as six times a day or as few as one time per week. In order to make this possible a custom storage solution had to be designed. This storage solution will be as follows.

There will be one byte used to save the weekly schedule. Each bit in the byte will be used to indicate if pills need to be dispensed on a day of the week, starting from Monday going through to Sunday. Obviously since a byte is eight bits and there are only seven days a week one bit will be wasted.

The next half byte is used to store an unsigned integer which indicates how many times per day pills must be dispensed. Since we already know which days pills will be dispensed we do not need any indication of zero times per day and any number that is stored is in fact one less than the actual number. This allows us to store from one time per day up to sixteen times per day.

After that there are several one and a half byte variables which store the times of day that the pills should be dispensed. Each one and a half bytes is split into two halves, each one is a six bit unsigned integer. The first integer stores the hour that a pill should be dispensed using a twenty-four hour format. The second integer stores the minutes.

Finally, there is half a byte to indicate how many pills to take each time.

As an example, below is the broken down binary representation of the storage of a pill dispensation schedule for a pill which needs to be dispensed once per day at noon.

11111110	0000	001100	000000	0001
Pills are dispensed every day of the week	Pills are dispensed one time per day	Pills are dispensed during the 12th hour	Pills are dispensed at the 0th minute of the hour	One pills are to be dispensed each time

4.2 User Interface

The user interface will be utilized through the LCD touch-screen. The LCD part of the touch-screen runs on 8-bit commands sent from the microcontroller unit. Each different screen will actually be a 24-bit bitmap image which has been premade. All images are then loaded into the on-chip flash memory. Then the microcontroller unit sends commands using no parity, eight data bits and one stop bit through an RS232 connection. Since all screens are known, once a screen is displayed the MCU will then wait until the screen is touched and decide what to do based on what screen is shown and where the screen has been touched.

The main program itself will simply be a menu list which jumps from one menu screen to another based on where the touch-screen has been pressed. Depending on what function is needed based on where you are in the menu, the main program will simply call separate functions to perform the actual work. The functions related to peripherals are listed and described in the next section.

The user interface will have eight main functions. It will have to allow you to add a new pill schedule, modify a current pill schedule, delete a pill schedule, list the current medication schedules, dispense pills you have been alerted for, update the wrist unit when information has changed, and modify the current time.

Adding a new pill schedule can be done one of two ways. Both ways begin with you selecting 'new medication' from the pill functions menu, which can be found on the main menu. The first way is through the barcode scanner which will simply absorb all the necessary information from the barcode. The second way is by entering the information manually. In entering the information manually you simply say which days of the week you take pills. Then you say how many times a day you take this pill. Then for each time you indicate what time of day you would like the alarm to sound. Then you indicate how many pills should be dispensed each time you are taking pills. Finally you enter how many pills you have put into the container.

Modifying a pill schedule is much easier, you select pill functions from main menu, select modify schedule then you select the pill to be modified, you select the part of the schedule that needs to be modified, and then modify it. The parts of the schedule are the same as the ones set above you just only change one, rather than setting them all.

Deleting a pill schedule is quite simple, from the main menu you select pill functions then select delete pill then select the pill to be deleted. Once that is done you simply have to confirm that you want to delete.

In order to dispense the pills you simply press the dispense button that is displayed when the alarm is triggered.

In order to update the wrist unit, you will be alerted the next time you are dispensing pills after you have changed some of the scheduling information. You are reminded to bring the wrist unit within range and when it is within range the update begins. Once the update is complete you are informed that you may now remove the wrist unit from beside the main unit.

In order to change the current time you simply press the time button from main menu and modify the date and time to the current date and time.

4.3 Control of Peripherals

Each separate peripheral will have its own set of functions controlling it. These peripherals are the touch-screen, the LCD, the motors, the barcode scanner, wireless transmitter and the light sensors.

The touch screen will need a function which waits for then reads the location where the screen has been touched. This function will be used whenever the touch-screen is being used to navigate menus or select anything shown on the screen.

The LCD will have a couple functions. The first function will be display image. This function will be used to display a menu or an image on the screen. Since all menus will simply be full screen images, this function will only need to be used once each time the screen changes. The second function will be blank screen. This function will be used to turn the entire screen to black.

The motors will have a single function which will have two values passed in. The first value is the direction that the motor should turn. The second value is the amount of time that the motor should turn. These functions will be used whenever a motor needs to turn at all in either direction.

The barcode scanner will have one function which activates the scanner and waits until a barcode has been scanned then returns the value to the original function. This function will only be used when scanning a barcode when adding a new medication.

The wireless transmitter will have a couple of base functions. One function will simply find out if the wrist unit is within range of transmission. The other function will transmit data wirelessly from the base unit to the wrist unit.

Light sensors will only need one function. This function will be a function which simply reads the value of the light sensor whenever it is called and returns that value. This function will be used in conjunction with the motor function in order to cause the dispensing of the pills.

5.0 HARDWARE DESIGN - MAIN UNIT

The hardware components associated to the main unit are comprised of the following: Microcontroller, touch-screen LCD, stepper motors, and 2D barcode-scanner. This section of the document will elaborate more on each of these components and how they are interconnected.

5.1 ARM7 LPC2148 Microcontroller

We have decided to use the ARM2148 USB Development Board from Futurlec Electronics in designing DispensAlert™. This development board is ideal for this project due to its small form factor and its powerful USB LPC2148 microcontroller. The development board is equipped with multiple interface options such as 2 x RS232, 1 x USB, 1 x I^{2}C, and 1 x SPI connections (Futurlec Electronics, 2010). In addition, the microcontroller development board allows for 47 GPIO ports which are more than sufficient to interface the most extensive requirements. The most significant feature of the chosen microcontroller is its 512 kB of memory. The embedded memory offers more flexibility in coding and will also allow users to save many dosage requirements without having to overwrite old requirements to free up space.

The microcontroller interfaces the touch-screen LCD through one of the RS232 UART channels. The second RS232 UART channel is used to receive data obtained by the 2-D barcode scanner. With 47 GPIO ports, we are able to produce clock signals to control the speed of the stepper motors and to also transmit wireless data to update the wristband unit with new dosage requirements.

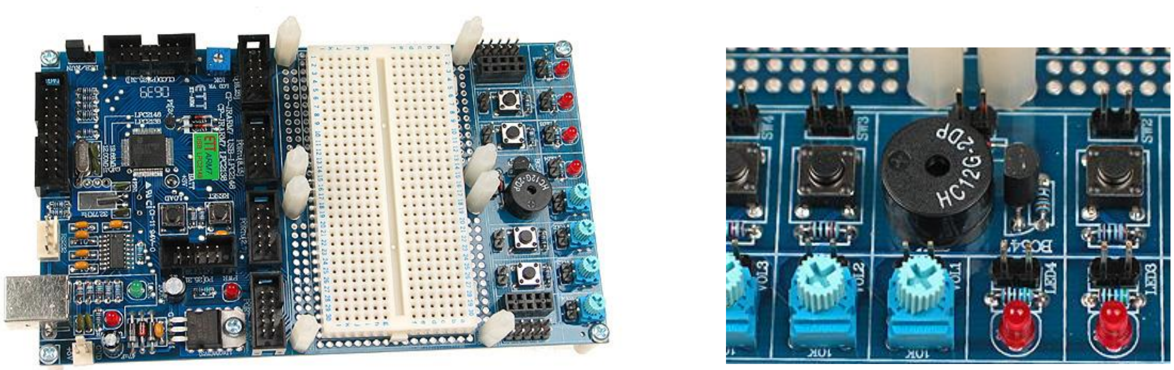


Figure 5: ARM7 LCP2148 Microcontroller Development Board (Futurlec Electronics, 2010)

Figure 5 illustrates the actual development board that we are working with. The board is equipped with various push-buttons, buzzer, and multiple LEDs for debugging purposes. The development board can be shrunk in size by separating the board in half. The right-hand side can be completely separated without affecting the performance of the left-hand side circuit. This is useful in the latter half of the project to reduce the size of the prototype.

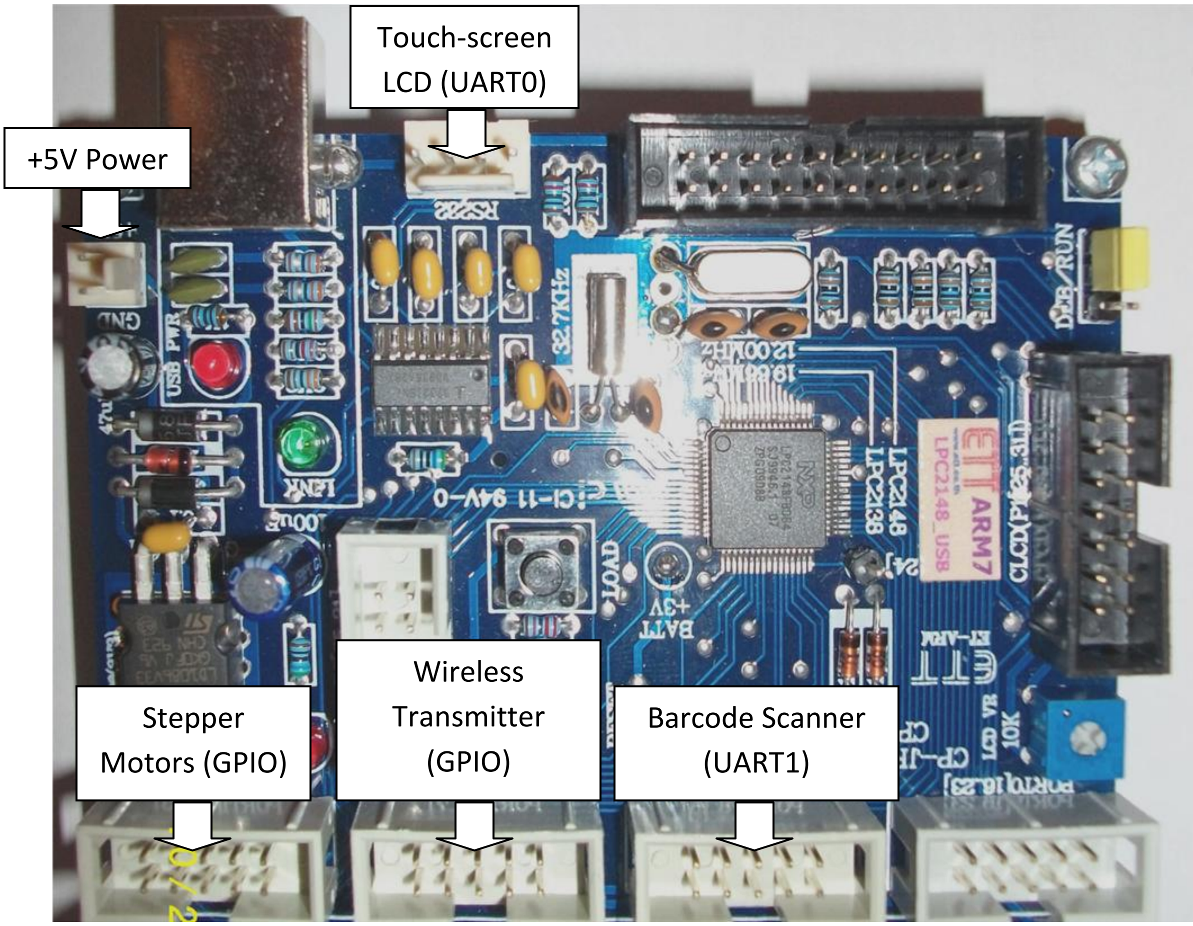


Figure 6: Development Board Connections to Peripherals

Figure 6 shows how other peripherals devices are connected to the microcontroller development board.

5.2 Touch-screen LCD Display

The touch-screen liquid crystal display (LCD) is used to provide a user-friendly graphical user interface. We have chosen Earth LCD's ezLCD-002 intelligent programmable LCD module with touch screen. The LCD measures 2.7" diagonally and is built with a TFT color LCD display. The touch-screen technology used is of a resistive type. Resistive touch-screens offer the advantages of being cost-effective, consistent, and durable (TVI Electronics, 2010).

The touch-screen LCD module offers two interfaces: USB and RS232. We have decided to couple the microcontroller and touch-screen LCD module through the RS232 interface because we can greatly reduce the amount of code needed to interface both the touch-screen LCD module and barcode scanner.

The ezLCD-002 touch-screen LCD module offers many features such 1MB of memory reserved for user-programmable icons/bitmaps and an additional 64 kB of flash ROM for custom fonts.

Figure 7: ezLCD-002 Touch-screen LCD Module (EarthLCD.com, 2006)

The ezLCD-002 touch-screen LCD module is easily controlled by sending 8-bit commands (Figure 7). By sending 8-bits of information through the RS232 interface, we can turn on the backlight of the LCD. With additional 8-bit commands, the touch-screen LCD display is able to output the desired image to guide the user through the process of dispensing medicine or editing dosage requirements. Figure 8 exemplifies how an 8-bit command is interpreted and translated into an image on a LCD display.

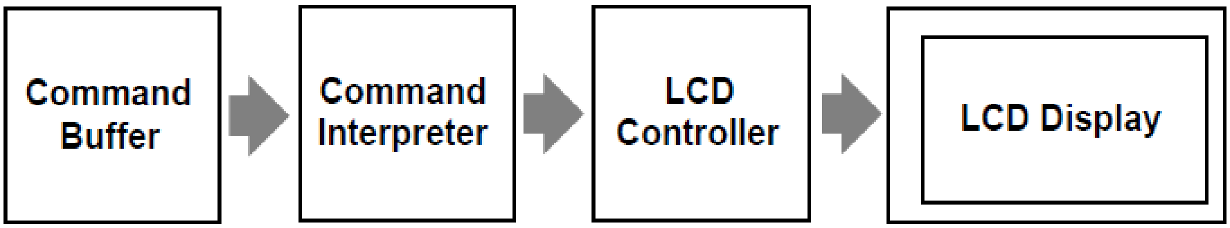


Figure 8: ezLCD-002 Command Dataflow (EarthLCD.com, 2006)

5.3 2-Phase Stepper Motors

Stepper motors have been incorporated into the development of DispensAlert™ because they are designed to move in fine incremental angular displacements. We have chosen to use Japan Servo Co., Ltd's KH42JM2B140E stepper motor. This stepper motor operates under 5.16 V and 1.2 A. The stepper motor is able to rotate in increments of 1.8 degrees and provides 200 steps per revolution. The fine control of this stepper motor will allow for maximum control while dispensing crucial medicine requirements.

The stepper motor is driven by Sanyo's STK672-600 2-phase stepping motor driver. The STK672-600A requires a constant 5V supply voltage. This is a perfect requirement because the microcontroller development board, touch-screen LCD, and stepper motors all require the same supply voltage which makes the design more convenient.

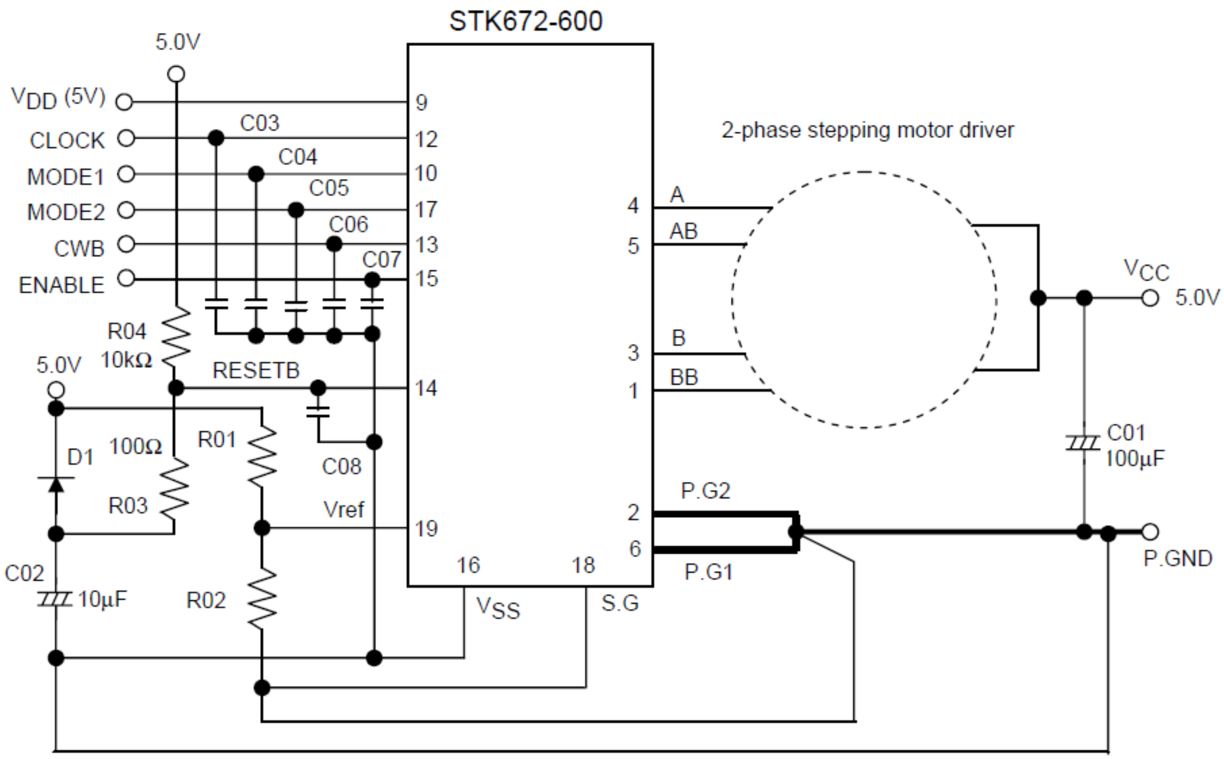


Figure 9: Stepping Motor Driver Circuit (SANYO Semiconductors Co., Ltd., 2010)

Figure 9 illustrates the stepping motor driver circuit designed to provide the necessary pulse signals to control the movement of the stepper motors. C03 through C08 are all 1,000 pF ceramic coupling capacitors used to short noise to ground. R01 and R02 are respectively 10kΩ and 1kΩ resistors in a voltage divide configuration used to provide a voltage of approximately 0.5 V to Vref.

The MODE 1 pin is set tied to ground to provide a 2-phase excitation to the motor. The MODE 2 pin is tied to 5V to configure the stepper motor driver to trigger on a rising edge of a clock signal. The CLOCK pin and CWB pin will be connected to GPIO ports of the microcontroller. Depending on the frequency provided to the CLOCK pin, the stepper motor will rotate accordingly. The faster the clock signal, the faster the stepper motor will spin. Conversely, the slower the clock signal, the slower the stepper motor will rotate. The CWB pin is used to control the direction of rotation.

5.4 2-D Barcode Scanner

A Barcode Scanner has been selected as one of the DispensAlert's unique feature to scan in input data instead of manual operations. The IMAGETEAM 4410 2D Series Hand Held Imager from Hand Held Products serves as an ideal scanner for DispensAlert because it is ergonomically designed for comfort and durability. In addition, it has a tough thermoplastic housing that effectively secure the inner components. The scanner communicates through RS232 connection, and can image 2D matrix symbologies. The barcode scanner requires a power supply of 4 to 9V to operate.

Figure 10: IMAGETEAM 3310 Series Hand Held Imager

The focal point for long range parameter is 5 inches while the field of range covers an area of 3 inches by 2.25 inches. Also, the barcode scanner has a rotational sensitivity of 360 degrees around the optical axis with 45 degrees of viewing angle at the nominal operating distance. The scanner is able to operate from 0 to +50 degree Celsius and can sustain mechanical shock up to 10 drops from 5 feet to concrete.

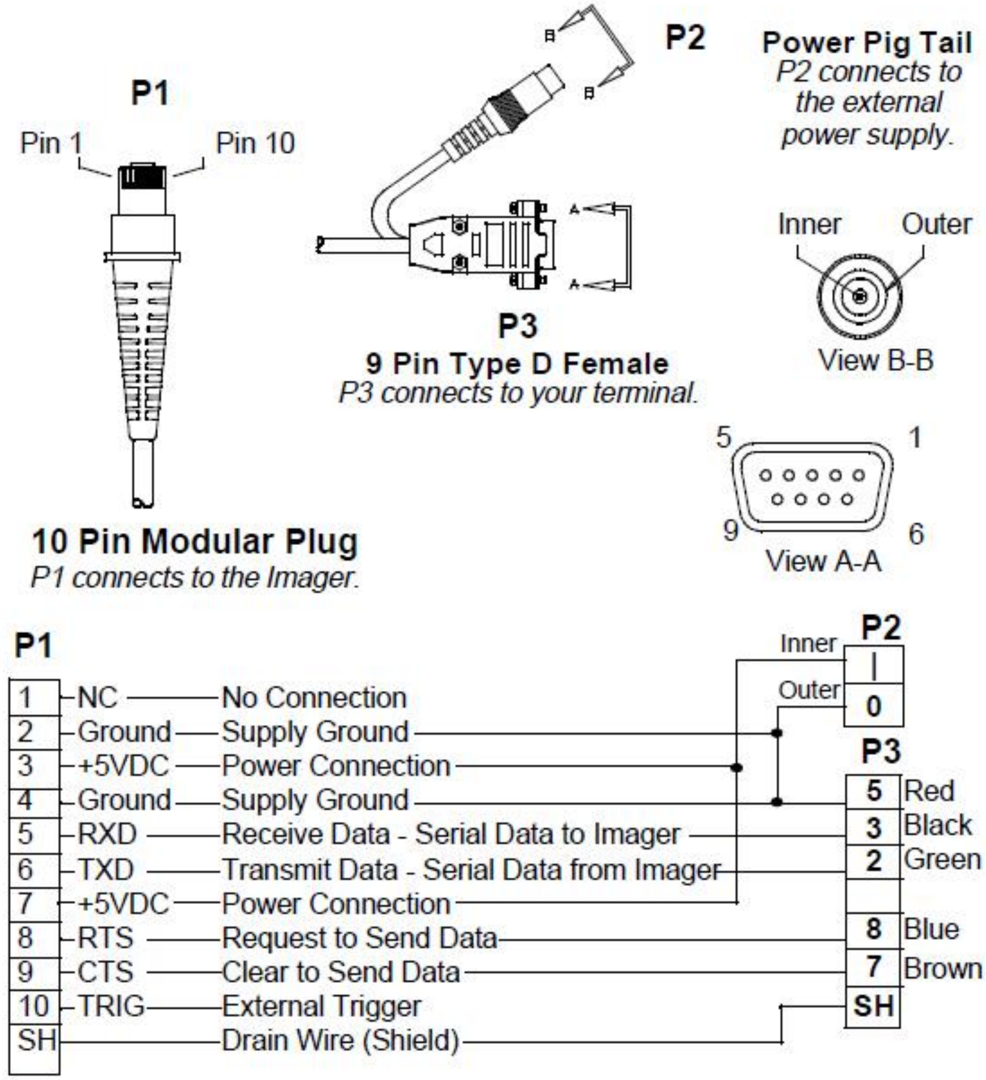


Figure 11: RS232 Output, external power connections

5.5 Dispensing Mechanism (Mechanical)

The dispensing mechanism is purely mechanical and will be driven primarily by the stepper motors previously mentioned. The motors will drive both the rotational movement of the reservoir and the sweeping mechanism. The reservoir consists of openings that will allow a number of pills to drop into the sweeping mechanism at specific time. Following the drop, the sweeping mechanism, consisting of a round flat platform and a rotating arm that sweeps in a circular pattern, can move the pills steadily into the outer perimeter via centripetal force and friction. As the pills approach the edge of the mechanism, they will continue to brush against the edge until it reaches an opening, where it will drop into the holding place for the dispensed pills. An optical encoder will be incorporated in this area to detect the presence of the pill(s) and can communicate with the stepper motor via the MCU to halt the sweeping movement when the right amount has been dispensed.

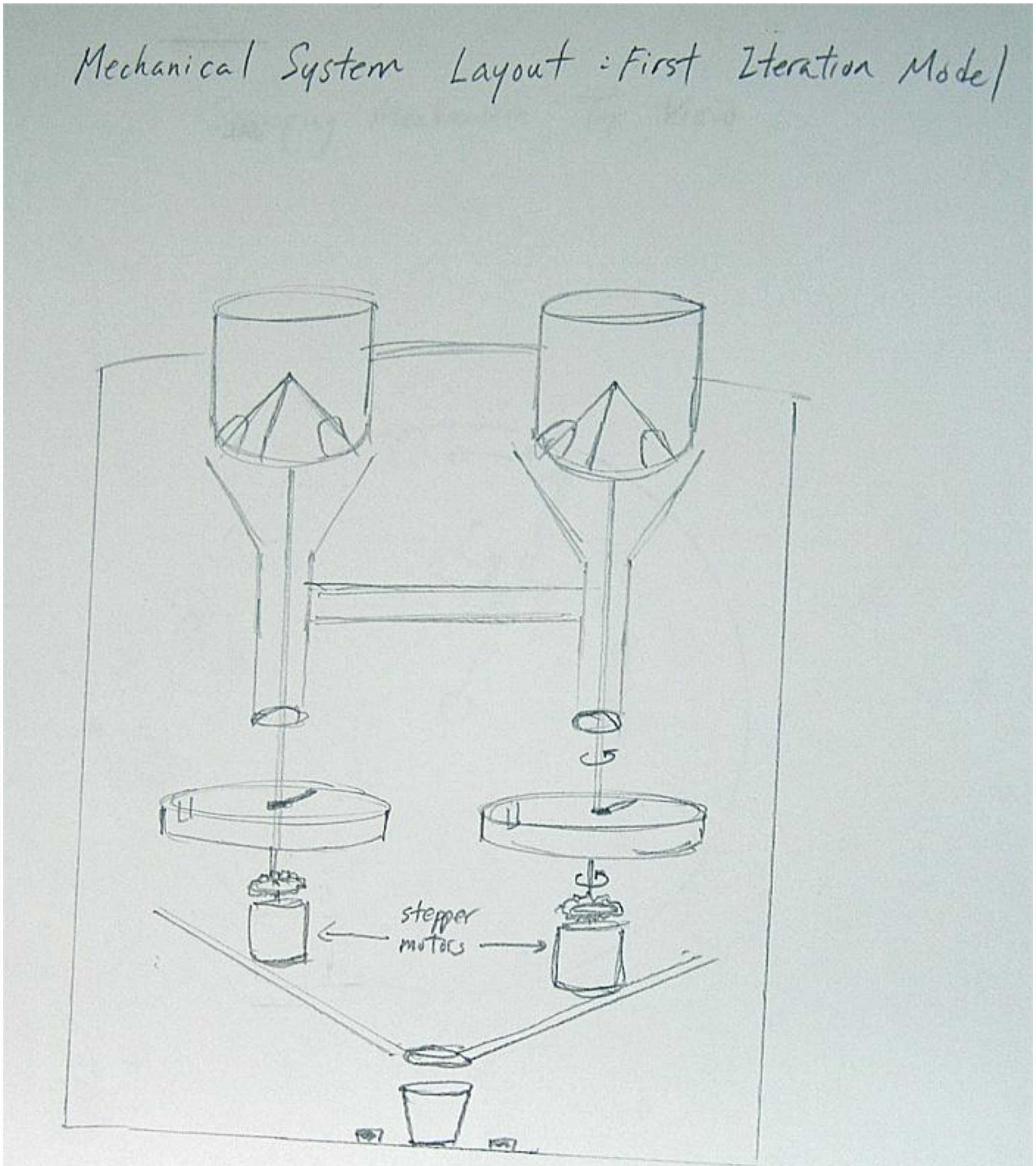


Figure 12: Mechanical System Layout

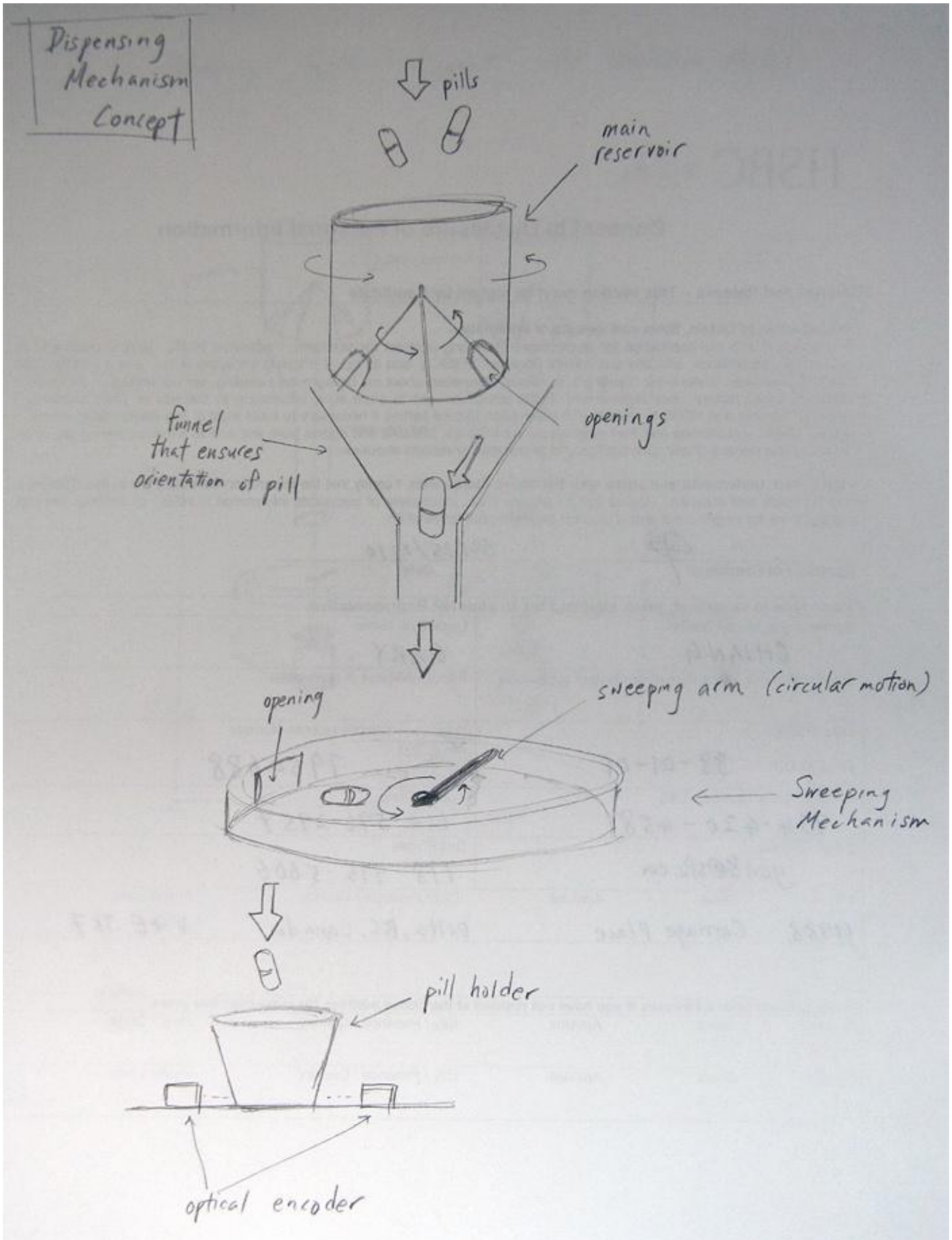


Figure 13: Dispensing Mechanism Concept

Figure 14: Top View of Sweeping Mechanism

As seen from the figure, the reservoir acts as the main storage for the medications and only releases a few pills at specific times to prevent jamming of the sweeping mechanism. The next level, the sweeping mechanism, along with the rules of physics will only allow one pill to drop at a time through the fixed size opening, therefore it is easy for us to control the accurate amount of pills dispensed using this method.

5.6 Wireless Transmitter

A wireless transmitter is required to transmit data from the main unit to the wristband unit. We have chosen the MO-SAWR-A Saw Resonator Transmitter Module due to its excellent performance and ease to use. This component operates at 315 MHz, between 1.5-12 V and can sustain temperature ranges from -20 to +85 degree Celsius.

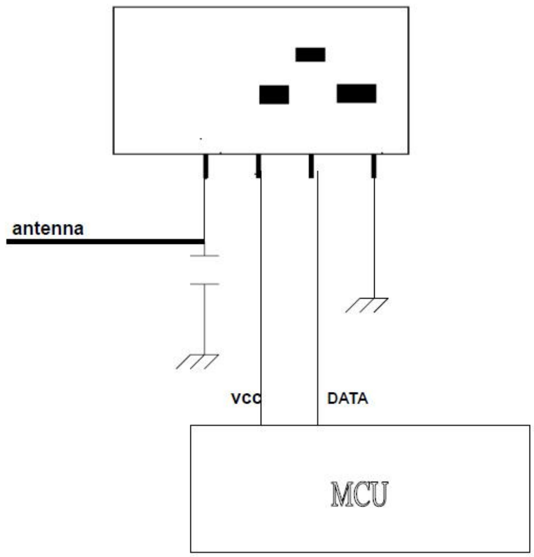


Figure 15: MO-SAWR-A Transmitter Pin Connections

The transmitter can transmit up to 150 m in open space with our receiver pair. This range is well enough for our product as synchronization and updates only occur while the two units are in close proximity.

6.0 SOFTWARE DESIGN - WRISTBAND UNIT

The software design for the wristband unit includes the UI and the communication between the MCU and attached peripherals. The following section details the specific functionality of the software for the wristband unit of the DispensAlert™ system.

6.1 Menu Navigation

The AVR Butterfly development board includes an LCD and a joystick for user input. We will utilize these two components to create a simple user interface where the user can:

- Check the next medication time
- View a list of medication times
- Snooze an alert once it has gone off
- Check the battery life
- Change the contrast of the LCD
- Modify the vibration intensity

The wristband unit will, by default, display a clock of the current time. By pressing 'Up' on the joystick, the user may navigate through the menu tree depicted below in Figure 6:

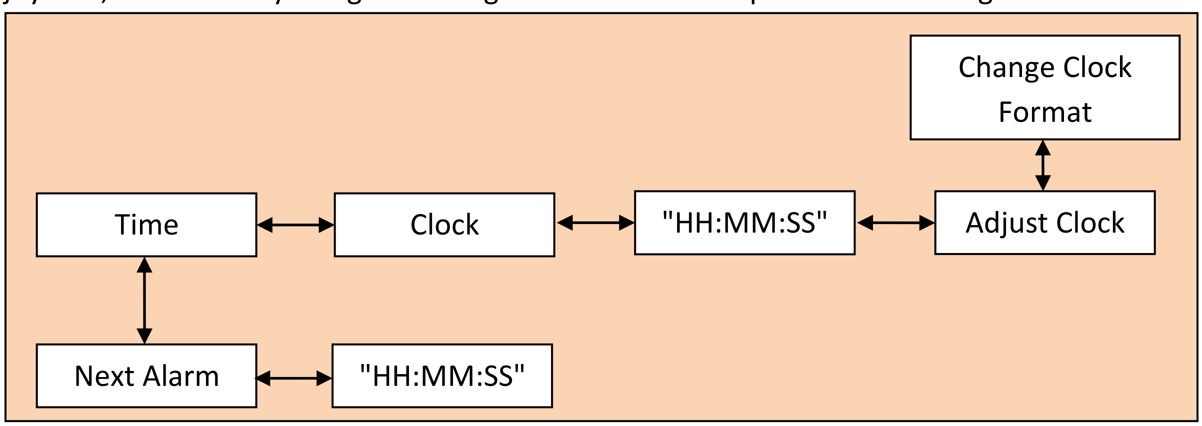


Figure 16: Menu Tree for Wristband Unit

6.2 Firmware Design

In order to develop applications that run on the wristband's MCU (ATmega169), we decided to use AVR Studio 4. AVR Studio is a complete development suite, it contains an editor and simulator that we will use to write our code and then see how it will behave when loaded onto the device. The code will be written in the C programming language (via the WinAVR GCC C compiler toolset), and it will dictate the complete functionality of the wristband unit.

7.0 HARDWARE DESIGN - WRISTBAND UNIT

The hardware design for the wristband unit consists of the implementation of an ATmega169 MCU on an AVR Butterfly development board in conjunction with VPM2 vibrating disk motor and a MO-RX3400 wireless receiver. The following section details the functionality and operation requirements of the hardware for the wristband unit of the DispensAlert™ system.

7.1 ATmega169 MCU

The ATmega169 MCU, implemented on an AVR Butterfly development board seen in figure 6, will be used to control all the operations and functions of the DispensAlert™ wristband unit. The AVR Butterfly development board was selected because of its small size and the accompanying features built into the board like the LCD screen, piezo-electric buzzer, and toggle switch. The LCD screen will be used to display written alerts as well as any UI we implement. The piezo-electric buzzer will be used to provide the auditory alert component of the overall alert system. Additionally, the toggle switch will be used to navigate the menu system and operations to be implemented on the board. Furthermore, the ATmega169 MCU offers 53 programmable I/O ports and 1 kB of memory which is very generous for the wristband unit's demands.

Figure 17: AVR Butterfly Development Board (Atmel Products - Datasheets, 2010)

By making use of a portion of the 53 I/O ports, the MCU will be able to control the VPM2 vibrating disk motor through a sequence of clock pulses while receiving update information from the main unit via the MO-RX3400 Wireless Receiver.

7.2 VPM2 Vibrating Disk Motor

As seen in figure 7, The VPM2 vibrating disk motor is a small, flat, circular device looking similar to a button cell battery. It will provide the vibrating alert which will be implemented in the overall alert system.

Figure 18: VMP2 Vibrating Disk Motors (VPM2 - Vibrating Disk Motor, 2010)

For the prototype, a discrete component VPM2 will be used whereas ideally in the future, for the final product, the VPM2 will be built into the circuitry. The VPM2's operation requirements are summarized below.

Table 1: Operating Characteristics of the VPM2

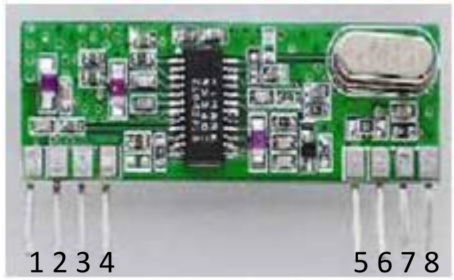
	Start-Up	Standard
Voltage	2.3V	3.0V ± 0.5V
Current	120mA (max)	80mA (max)

The main reasons the VPM2 was selected for this application was because of its small size and the fact that there are no exposed component.

7.3 MO-RX3400 Wireless Receiver

The MO-RX3400 wireless receiver (Figure 10) is the only data transfer connection between the main unit and the wristband unit. It will be implemented to receive information at the frequency of 315MHz with a maximum data rate of 8kbps (1kBps).

1	Antenna
2	GND
3	GND
4	Vcc



5	Vcc
6	Data
7	Data
8	GND

Figure 19: MO-RX3400 Wireless Reciever (RF Link 4800bps Reciever - 315MHz, 2010)

The MO-RX3400 wireless receiver was selected for its low power consumption. The operation requirements of this component are summarized in the table below:

Table 2: Operating Characteristics of the MO-RX3400

	Standard
Voltage	5.0V ± 0.5V
Current	2.3mA – 3.0mA

8.0 SYSTEM TEST PLAN

The DispensAlert^{TM} proof-of-concept prototype will undergo four stages of development testing. The initial stage will involve testing of individual components to ensure their good working order as well as to gather operational knowledge of each component. Each unit will then be assembled and tested separately as individual systems. Next, the entire device will be integrated and we will test the ability of the units to work with each other. After, we will conduct qualitative testing, employing a holistic method involving typical use scenarios. Finally, we will conduct failure testing, to ensure that when the end-user performs an illegal action an appropriate error message will be given.

8.1 Component Testing

MCU: Power

Condition: Ability to function on wall socket power for extended periods of time.

Procedure: Attach the main unit to a wall socket supply and run a primitive program for several hours.

MCU: Connectivity

Condition: Ability to output signals to peripherals.

Procedure: Attach peripherals to GPIO ports and use MCU to actuate / turn them on and off.

MCU: Functionality

Condition: Ability to contain and run programs.

Procedure: Construct a "Hello World" program capable of testing all data paths.

Touch Screen Unit: Functionality

Condition: Ability to detect human digits and interface with a primitive GUI.

Procedure: Create a program capable of detecting human digits and interface it with multiple buttons on a GUI displayed on the touch screen.

Wireless Module: Power

Condition: Ability to power unit using battery power.

Procedure: Verify that batteries (Wristband) / supply power (Main) can supply the 5V needed to power the receiver/transmitter.

Wireless Module: Functionality

Condition: Ability to transfer data between units.

Procedure: Send a test time from the main unit's MCU memory to the wristband's MCU memory.

Barcode Scanner: Functionality

Condition: Ability to scan barcodes and output data.

Procedure: Use the main unit to scan a barcode and save the data to memory.

Wristband Circuitry: Power

Condition: Ability to power Wristband MCU via battery power.

Procedure: Connect battery cells to the Wristband and run the included sample software.

Wristband Circuitry: Functionality

Condition: Ability to run a timer, activate alerts.

Procedure: Create a "Hello World" program that will run a countdown timer from a number stored in memory and activate audible and tactile alerts when the counter reaches zero.

8.2 Module Testing

Main Unit: Set Timer / Add New Medication

Condition: Ability to add new medication and schedule its timed release.

Procedure: Have a team member go through the steps needed to enter a new medication to the DispensAlert™ system and verify its operation.

Main Unit: Manipulate Settings

Condition: Ability to change time schedule and display statistics.

Procedure: Use the main unit to modify an existing dispensing schedule and verify its effect. Also, use the menu system to display statistics on the main screen.

Main Unit: Barcode Functionality

Condition: Ability to read, store, and use data from barcodes.

Procedure: Use a customized barcode to enter the required data for a new medication as tested under "Set Timer / Add New Medication"

Main Unit: Intended Operation

Condition: Ability to know which pills and how many to dispense.

Procedure: Run through multiple pill type and multiple pill quantity scenarios and verify the system dispenses the correct amount of each pill.

Main Unit: Usability

Condition: Ability to provide useful error messages to user.

Procedure: Have a team member go through the parts of the Typical Usage Scenario pertaining to the main unit and verify that it is intuitive.

Main Unit: Power Saver

Condition: Ability to return to a low power state when not in use.

Procedure: Test that once the main unit is idle for one minute, the backlight on the touch screen will turn off and all actuators will power down.

Wristband Unit: No-Touch Setting

Condition: Ability to set alarms wirelessly.

Procedure: Send a timer to the wristband via the wireless module and test whether it works or not.

Wristband Unit: Multiple Alarms

Condition: Ability to keep track of multiple alarms.

Procedure: Add multiple alarms to the wristband. Check in the menu that they are saved and verify that they go off at the specified time.

Wristband Unit: Warnings

Condition: Ability to notify user when batteries should be replaced.

Procedure: Connect the MCU to one of the power supplies in Lab 1 and bring the voltage down to below the operating threshold and verify that the Wristband unit will notify the user that they need to replace the batteries.

8.3 Qualitative Testing

Xypnios Innovations will conduct thorough hardware and software testing to ensure that all modules have been integrated properly. We will confirm that the device complies with our requirements listed in the Functional Specification document. In addition, we will employ a Typical Usage Scenario, outlined below, which emulates the intended use of the device by the end-user. During the test, we will ensure that each step of the usage scenario is functioning as intended.

Typical Usage Scenario:

1. User plugs in the main unit and inserts batteries into the wristband.
2. User loads medication into main unit.
3. User enters pill scheduling information.
4. Wristband alerts user to take medication.
5. User cancels alarms and returns to main unit for medication.
6. Next alarm is sent to the wristband.

8.4 Failure Testing

This phase involves considering any improper usage the device may encounter while being used by the consumer. We will try to avoid any type of improper usage through intelligent programming techniques in an effort to prevent or mitigate the effects of improper use. The typical techniques we will employ will be to produce error messages when an invalid action is performed.

Table 3: Failure Situation Remedies

Situation:	Solution:
Multiple button presses	Do not respond to multiple buttons being pressed at once.
Invalid time entry	Display a prompt for the user to re-enter the offending field.
Alert ignored	Make the alert re-activate every 10mins until dispensing occurs.
Power failure	Data will be saved and the system will be able to recover.

The above situations will be tested to verify that our device produces effective and helpful feedback to the end user while ensuring proper use of the device.

9.0 ENVIRONMENTAL CONSIDERATIONS

DispensAlert™ is composed of common electronic components such as silicon based integrated circuit packages, printed circuit boards, LCD screen and more. Recycling of these components is an expensive process. Metals from printed circuit boards such as gold, silver, tin and lead are currently being extracted and recycled for future use(AzoMaterials.com, 2002). Copper wires from stepper motors and cabling can also be recycled.

Since DispensAlert™ will be encased in a stainless steel enclosure in its final production units, most of the stainless steel can be easily extracted and recycled. The recycled scrap metal can be refinished for the use of other products. Furthermore, metal and plastic structures used to mount subassemblies can be easily re-melted and be re-used.

Moreover, the construction of DispensAlert™ is optimally designed such that the amount of material used is kept to a minimum. Due to the reasons mentioned, we believe DispensAlert™ will impact the environment minimally.

10.0 CONCLUSION

This Design Specification document provides a detailed description and specification of the components incorporated into the proof-of-concept prototype design of the DispensAlert™ device. It also discusses the design choices Xypnios Innovations has made in order to meet the functional requirements outlined in the Functional Specification document. The parts chosen were decided upon keeping, reliability, energy consumption, usability, and budgetary constraints in mind. It is expected that the specifications in the above document will be realized in a prototype by the target date of April 16th, 2010.

11.0 REFERENCES

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