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Abstract

Are health care costs increasing for senior citizens? Can seniors avoid making unnecessary visits to health care facilities and save money? How can these unnecessary health care visits be avoided? Questions like these have fueled researchers to develop new means of connecting senior citizens to the care that they need. The following report will discuss our design of a two-way, non-contact video link, which communicates effectively between a home-based senior patient and a nurse practitioner, doctor, or even family member. The purpose of this device is to provide reliable, in-home medical assistance that will lower health care costs and help avoid unnecessary emergency room visits. The monitoring system has been designed to be both simple and user friendly to minimize actions required by the senior. The design includes an infrared motion sensor to determine gestures made by the senior. A detailed description of our design methodology and project management will follow.

Introduction

In today's society, the population of seniors is growing at a fast rate, leading to increased hospital visits and medical costs. The device, labeled the NOVAScreen, will help minimize health care costs and limit frequent visits to the hospital. The NOVAScreen provides senior patients with the opportunity to have basic care at the comfort of their home while being able to have a face-to-face human connection with a nurse practitioner through a two-way, non-contact video link. Monitoring and follow-up appointments at a facility will be drastically reduced due to the convenience of the NOVAScreen.

The NOVAScreen is a 15,6" LCD screen that is capable of making and receiving video calls without absolutely no contact. It is a two-way gesture controlled video link that communicates through Wi-Fi effectively between a home-based senior and remote nurse practitioner. The senior will have the NOVAScreen at their home while the nurse practitioner will be able to communicate via a PC, notepad, smart phone, or similar device. The video communication assists the nurse practitioner in monitoring the senior's health while providing a personal connection. The senior has the option to call four different nurse practitioners, caregivers, doctors, friends or relatives. When the gesture sensor picks up a signal or is plugged in, the application boots automatically and displays the pictures of each contact. The NOVAScreen is gesture based, requiring the senior to make left or right hand gestures to select which nurse to call. An upward hand gesture movement will be made in order to make the call to the selected nurse.

The screen shows instructions on what hand gestures need to be made to perform a certain task. Incoming calls can also be received or rejected using these gestures.

A common question one may have when viewing our product, is “why is it gesture controlled? Why not touch screen?” Our answer is simple and addresses the limited hand mobility of many seniors as well as the ability to maintain a more comfortable distance from the screen. The following report will discuss the design methodology and engineering process of the NOVAScreen.

System Design - Software

1.1 Video Protocol

In the design of the NOVAscreen, we first needed to find a way to create a video protocol and make a communication between the home based senior and nurse. After spending some time on research, we found an application called Linphone. Linphone is an open source voice over IP application that gives users the ability to communicate via the Internet. Linphone uses SIP protocol, which is an open standard for internet telephony and can be used with any SIP voice over IP operator, including the SIP service that Linphone provides. This means that users of Linphone must create an SIP account to register and be able to use Linphone services. They will be able call other people that have SIP accounts whether they have Linphone, or another application that uses SIP protocol. This application is the perfect fit for our design not only because it makes calls through WIFI, but also because it is available on Android, IOS, and can be accessed

through the web. In order to incorporate gesture sensors and simplify our design, we modified the Android version of the source code to make it receive data from the sensor and changed the user interface.

Linphone source code has a very large number of activities and functions. We looked through them all and singled out the ones that were necessary for the NOVAScreen. These functions are main activity, incoming call activity, reject call function, hang up function, and volume function. By switching between these and functions in an organized algorithm, we were able to control the software of the NOVAScreen the way we wanted.

1.2 Android ADK

Android alone does not support any kind of inputs or outputs, so we chose to use the UDOO Quad microcontroller which consists of two connected processors, the i.MX 6 ARM Cortex-A9 and Atmel SAM3X8E ARM Cortex-M3. UDOO Quad board is basically two boards in one, the other being the Arduino Due. In 2012, Google released Android Accessory Development Kit (ADK) 2012 which allows the connectivity of USB accessories to Android powered devices, therefore extending the devices capabilities. Android defines the Android Open Accessory Protocol (AOA) used in accessories to create a communication channel between the Android application and the ADK compatible device. Google ADK 2012 is supported by three boards only, Arduino Mega ADK, Arduino Due, and UDOO Quad. UDOO runs Android 4.4.2 including all the features of an Android device. With Arduino-compatible Embedded we had the possibility to use the ADK 2012

and connect digital and analog sensors and actuators to Android. Since there is an internal connection between i.MX 6 and SAM3X, we do not need to connect the board with an external ADK enabled device. Figure 1.1 below illustrates the connection between the two processors. After installing the application into the i.MX 6 processor in UDOO that runs Android, we wrote a script that opens the application whenever the sensor was connected. Software requirements played a major role in our selection of the UDOO quad.

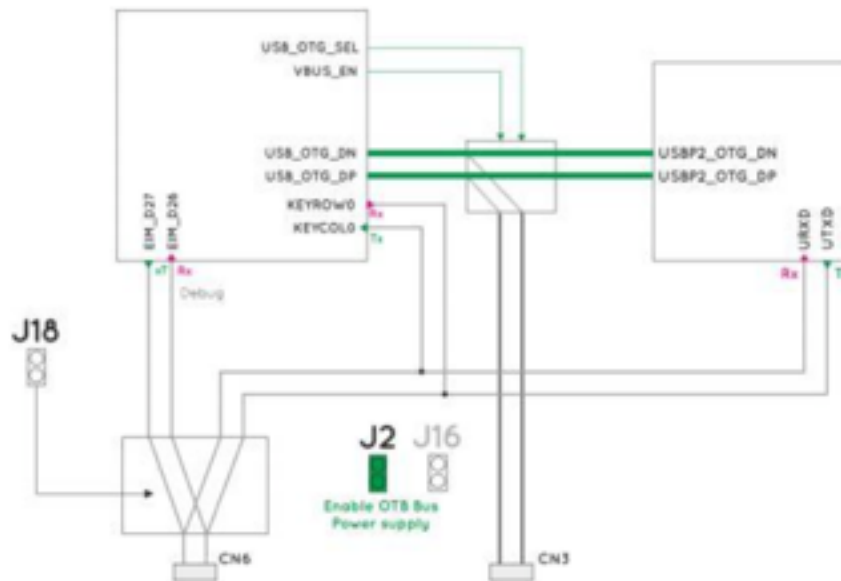


Figure 1.1

1.3 NOVAS Application

Since the NOVAScreen is controlled by hand gestures only, we needed to connect a gesture sensor to the Android application. To do that, we used i2c communication

between the sensor and SAM3X processor (Arduino Due). The gesture sensor can sense specific motions like left, right, up, down, and works as an input for the software. The sensor is going to be working all the time in the background of the application waiting for the user to waive at it. When the sensor detects a motion on its range, it will send a specific data that indicates the type of motion to the Android app using the ADK 2012 library. Depending on the data that was received by the sensor, the application will make or receive calls or will change the user interface accordingly.

One of the modifications that we did to the source code was on the user interface. We wanted to make the user interface as user-friendly as possible. We did this by minimizing text and utilizing mainly visuals. We developed the background of the application using Adobe Photoshop. Every time the sensor senses a motion and sends data that requires a change, the application will simply change the contacts picture accordingly. The previous and next contact in the list are showed on the main contact menu to help the senior with making a selection.

The idea behind the NOVAScreen was to be able to choose between four different contacts to call. So we put a face picture of each of the four contacts in the user interface with the selected one on the center of the screen. We also linked each picture with the Linphone account that belongs to the user that his/her face shown on selected picture. So when the user of NOVAScreen selects one picture to call, the application will use the Linphone account linked with that picture and call it. To do that, the application will use the outgoing call function when receiving that data from the sensor. To make everything clear for the user, we needed to add some texts to indicate the sensor range, and to let them

know that the NOVAScreen is controlled by hand gesture only. Figure 1.2 shows a screenshot of the main contacts menu.



Figure 1.2

After developing the software application and letting other people test it, we realized that many people could make mistakes when using the device for the first time. We found that a lot of first time users had the error of making a call accidentally. They wanted to change the contact and instead made a phone call because of the way they moved their hand in front of the sensor. Therefore, to reduce the error, we developed a confirmation screen and implemented it before making a call. Even if the user tries to change the contact and mistakenly makes a call, the application will ask the user to confirm the call or go back to select another contact. Figure 1.3 shows a screen shot of the confirmation page.



Figure 1.3

For incoming calls, the user will be able to accept or reject the calls by waving up or down, respectively. To make this process user friendly, the incoming call screen shows a green arrow moving from down to up and a red arrow moving from up to down, indicating the motion needed to accept and reject calls. Since Android does not support gif photo format, we used Photoshop to develop 30 photo frames with different locations and animated them using some android coding tweaks so that the arrows look like they are moving. Figure 1.4 shows the first frame of an incoming call.



Figure 1.4

NOVAScreen will be mostly used by seniors for medical purposes, so we wanted them to have minimal control of the device and features to avoid confusion. One feature that we thought could be useful for them is volume control. Only during calls, the user of the NOVAScreen will be able to adjust the volume by moving their hand from right to left or left to right. Listed below are basic instructions for using the NOVAS application.

Software Instructions:

1. Waive right to left or left to right to choose between contacts.
2. Waive up to select a contact.
3. Waive up again to confirm and make the call or left to go back to the contacts menu.
4. While calling, waive down to cancel the call.
5. During a call, waive right or left to adjust the volume.

6. During a call, waive down to hang up.
7. When receiving calls, waive up to accept the call or down to reject it.

System Design - Hardware

The NOVAScreen utilizes a variety of hardware components in order to perform its various functions. A diagram of the NOVAScreen is shown in the figure below. All inputs to the UDOO Quad microcontroller are in green and the outputs are in brown. A brief description of each component in the diagram follows.

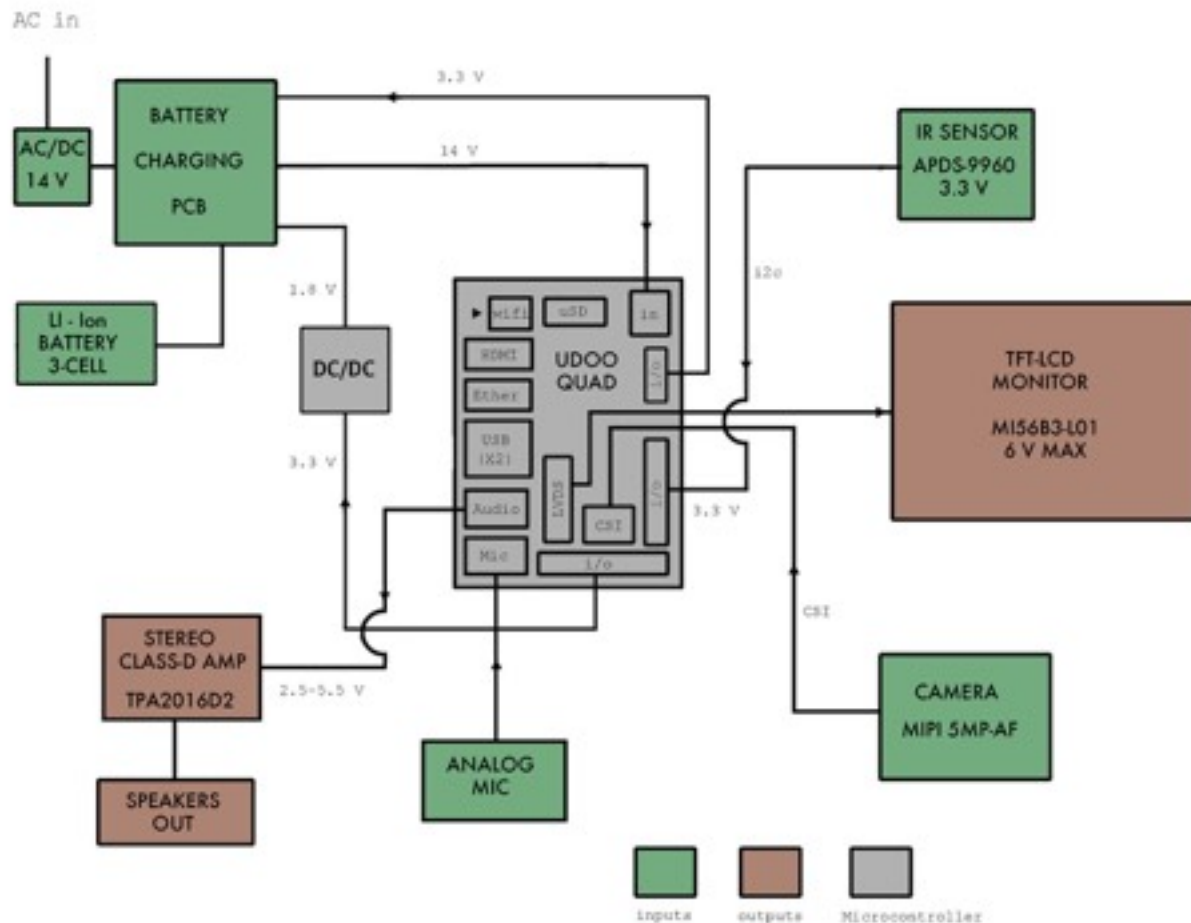


Figure 2.1

UDOO Quad:

The UDOO microcontroller links and processes the outputs and inputs of the other hardware components. It does this with the help of its two processors: CPU Freescale i.MX 6 ARM Cortex-A9 Quad core 1GHz, and Atmel SAM3X8E ARM Cortex-M3 CPU. The UDOO Quad receive inputs through its I2C, CSI, WIFI and analog mic connection and outputs through WIFI, speakers and LVDS.

Battery Charging PCB: LI-ION CHARGER

The bq24610 is a highly integrated Li-ion or Li-polymer switched-mode battery charge controller from Texas Instruments. The device offers a constant-frequency synchronous switching PWM controller with high-accuracy charge current and voltage regulation, charge preconditioning, termination, adapter current regulation, and charge status monitoring. It connects to the power input of the UDOO Quad providing 12V.

Lithium Ion Battery:

This Lithium Ion Battery is made up of three cells in series. It has a nominal rating of 12 V and a capacity of 2600 mAh. Its sleek and compact profile makes this battery ideal for use in laptops and tablets. The Battery connects to the charging circuitry and to the system load.

Stereo Class-D amp: TPA2005D Power Amps

The TPA2005D1 is a 1.4-W high efficiency filter-free class-D audio power amplifier. Features like 84% efficiency, -71-dB PSRR at 217 Hz, improved RF-rectification immunity and a fast start-up time of 9 ms with minimal pop makes the TPA2005D1 ideal for the NOVAScreen audio board. This board connects to the analog audio out port of the UDOO Quad.

Speakers: Railmaster 8 ohm 2 Watt

The 2 Railmaster speakers used are rated to output sound at a frequency range of 200-20,000 Hz. They are connected to the output of the audio board.

Analog Mic: ADMP401 MEMS Technology

This microphone has a rated flat frequency response from 100 to 15kHz. It also has a high SNR of 62 dBA. The INMP401 breakout board provides a rated gain of 67 before going back to the UDOO. The mic connects UDOO Quad's analog mic port.

LCD Monitor: M156B3-L01

M156B3-L01 is a 15.6" wide TFT Liquid Crystal Display module with white LED Backlight unit and 30 pins 1ch-LVDS interface. This module supports 1366 x 768 WXGA mode and can display 16.7M colors. It's connected to the UDOO's LVDS port.

Camera: MIPXI 5MP

This camera can capture 1080p resolution at 30 frames a second. It come with features like Auto Focus Control (AFC) and video capture in full frame of View (FOV). The Camera is connected to the UDOO's CIS connection.

Gesture Sensor

The sensor is the cornerstone of our device, where the concept of hands-free user interface is built. The APDS 9960 detects left, right, up, and down gesture commands with the use of one IR LED and four internal IR photodiodes. When the user swipes their hand over the sensor, IR light from the IR LED reflects of their hand back to the photodiodes, eliciting an electrical response. Since the photodiodes differ in orientation and placement, their amplitude and phase differences can be used to determine the gesture.

The detection is best from 2-6 inches away from the sensor but the maximum range is 8 inches. This sensor connects to the UDOO via an I2C connection. A chart of the photodiodes' responses are shown in figure 2.2 below.

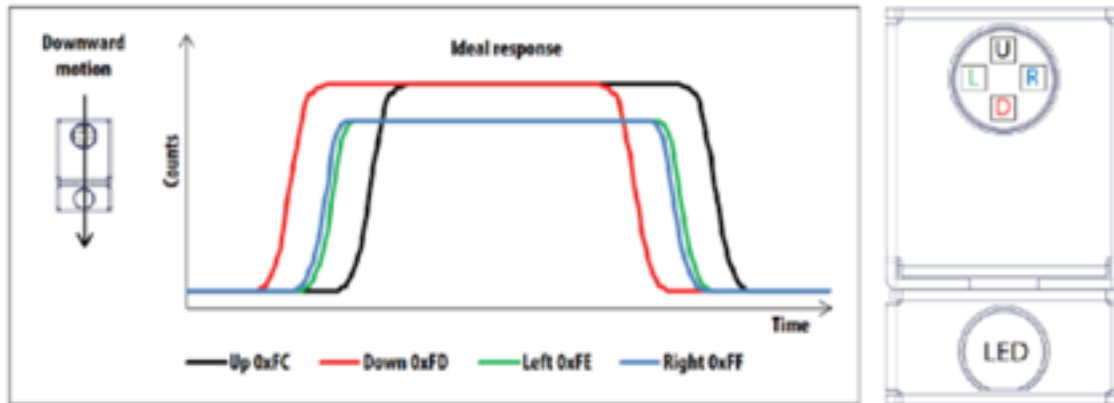


Figure 2.2 : APDS-9960 Photodiode response

The APDS-9960 uses I2C connection to relay the interperated gestures signals back to the UDOO Quad. I2C uses only two bidirectional open-drain lines, Serial Data Line (SDA) and Serial Clock Line (SCL). The voltage that the Udoo I2C connection uses is +5V. The connection has the ability to communicate with multiple slave devices. In the design of the NOVAScreen, only one was used, however using multiple sensors shows a possible improvement in the design concept.

Audio Design

In order for the device to meet specifications, a method for audio receiving and output was needed. To this end we implemented a MEMS technology microphone and driver circuit, as well as a stereo power amp circuit feeding two speakers.

3.1 Microphone

The microphone used was an ADMP401 analog MEMS microphone in a sparkfun package. The analog version of this unit was selected over the digital counterpart due to the incorporation of an analog microphone input on the UDOO main board. This simplified the design and allowed use to use the existing jack for ease of connection and to utilize the UDOO's analog to digital converter. The ADMP401 has a bandwidth of 20Hz to 20KHz, covering the complete range of frequencies and providing ideal pickup of the senior's voice. The driver circuit consists of a single inverting op amp supplied by the 3.3v rail from the UDOO as seen in Figure 3.1 in the appendix. The gain is controlled by selecting an appropriate feedback resistor to allow balancing of good gain but without feedback.

3.2 Power Amp

The power amp stage consists of two TPA20051D class-D power amp chips. the class-D topology was selected as it requires little power, dissipating less of the supplied power as heat. It also provides a very small footprint, making the final PCB smaller.

3.3 Class-D Topology

Class-D operation differs from linear amplifiers because its output devices operate as switches instead of amplifiers. Amplification is accomplished via converting an input signal into a pulse-width-modulated (PWM) representation of the signal, then using those pulses to rapidly trigger the output devices. Transistors dissipate no energy when they are in their saturated or cut-off states, only generating heat when transitioning between the two, which occurs very quickly. This amplified pulsing signal is then demodulated back

into smooth waves via an output LC filter. A linear amplification design is in a constant state of transitioning between the two states, and as such dissipates a significant amount of energy as heat. The efficiency of this chip can reach beyond 84% which is what we were looking for when designing a device that will be battery powered.

3.4 Circuit Design

These particular chips were selected as they do not need an external LC filter, making design of the circuit much simpler. The circuit consists of two power amp chips with input resistors that set the overall gain of the circuit. Coupling capacitors also had to be placed before the inputs, as these chips have a slight dc bias on the inputs and referencing these chips to ground causes them to dissipate considerable power and overheat quickly. With the coupling capacitors, DC voltage is blocked and the chips can operate normally. The gain-setting input resistors were set for 24K Ohms, to provide a gain of 14dB. This value was selected based on the measurement of the maximum signal output from the UDOO at 600mV, thus the sensitivity of the circuit was selected accordingly. When the board was printed and soldered, the sensitivity was measured to be 628mV right where we wanted it, within resistor tolerance. The measured specifications of the circuit by itself are shown in the table below, with the Frequency response bode plot in the appendix. The outputs of these chips powered two Railmaster 2 Watt speakers. These speakers were chosen as the frequency response and power handling capacity were excellent for the size we were looking for to fit in the case. The complete circuit with speakers is shown in Figure 3.2 in the appendix.

Circuit Design

| Table 1 | Specifications | | |
|----------------|----------------|------|--|
| Max Current | 0.200 | A | |
| Gain | 14 +-1 | dB | |
| Sensitivity | 628 | mV | |
| Max P/Ch | 1.64 | W | |
| THD | <5% @1.6W | - | |
| V swing @1.64W | 3.14 | Vrms | |

3.5 Audio PCB Design

The Audio PCB was designed to be a surface mount topology using as little space as possible. The layout had to be design to accommodate the power dissipating chips; they use a package type called “Power Pad” from TI which consists of a DIP package with a metal underside. This underside is used to dissipate heat from the device, and it was crucial that it be soldered directly to a large ground plane. To that end the layout allowed for a large enough area of ground plane on the underside and surrounding the chip to dissipate the heat. The PCB design is shown in Figure 3.4 in the appendix.

Power

In the design of the NOVAScreen we had to take into consideration patient safety as well as emergency situations. Situations such as a power outage or disconnected chord can leave the home based senior with no contact, resulting in avoidable emergencies and unnecessary cost. In order to avoid a scenario like this, an intelligent power supply and battery management system is an important aspect of the design.

4.1 Battery Management System

On a day to day basis, the screen is to be powered with a 14 volt AC wall adaptor. The UDOO quad and all of its peripherals can be powered by this 14 V at all times but need a back up battery pack to supply power when mains fails. The backup battery system is made up of 3 Lithium Ion cells and a switch-mode battery charging IC. After testing and confirming that the device will take no more than 1.7 amps, we decided on a battery that will last at minimum one hour upon disconnection. The peak power consumption of the device occurs at start up and during video calls due to inrush current, and on average is closer to 1.3 A at 14 V. We chose to use Lithium Ion technology because of the high capacity to weight ratio or energy density of the cells. One of the drawbacks of Li-ion is complicated charge characteristics, and the complexity and caution needed for a safe charge. We implemented a 3 cell Lithium Ion battery with a capacity of 2600 mAh and used the following equation to determine battery life.

$$\begin{aligned}\text{Battery Life} &= (\text{Capacity}) * (1/A) \\ &= (2.6\text{Ah}) * (1/1.7\text{A}) = 1.53 \text{ hours}\end{aligned}$$

The most difficult part in designing the power supply for the NOVAScreen was finding an intelligent IC that could handle the current consumption of the device. Some operational requirements that we determined necessary were a separate path for power, charge termination, and high current handling greater than 2 A. After testing a couple of linear chargers, we found that a switch-mode charger with inductive properties would be needed to handle more than 1.5 A. We chose to use the BQ24610 switched-mode

synchronous battery charger from Texas Instruments. This IC charges 3 Li-Ion cells to a user programmable voltage. When the current being drawn by the battery drops below a threshold, the IC terminates charging. When main power is disconnected, the IC switches to battery supplement mode to supply the load without interruption. The typical application of this IC calls for over 20 resistors, including a 0.01 Ohm sense resistor, nearly 20 ceramic capacitors, a large inductor, 5 Mosfets, and a two layer PCB with separate grounds. This schematic can be seen in figure 4.1 in the appendix. Due to time and PCB manufacturing constraints we decided to purchase an evaluation module (EVM) for this IC.

The BQ24610 comes in a 24 pin QFN package and has intelligent pin functions that allow the user to program charge current, charge termination, safety timers, temperature sensing, and charge status monitoring amongst other functions. Because the BQ24610 is capable of charging between 1 and 6 cells, modifications had to be done to the EVM to satisfy our desired operation. Specifically, two surface mount resistors had to be changed to satisfy the following equation:

$$V_{BAT} = 2.1V \times [1 + R_{25}/R_{28}]$$

After measuring resistance, we determined that R28 was 100 kohms. Because we are using 3 cells with 4.2 Volts each, we chose Vbat to be 12 Volts. Following the equation above we switched out R25 with the closest 464K resistor we could find. After completing the EVM's test procedure and making the required changes, we determined proper operation. After fully charging the battery, we disconnected the device from main

power while running the NOVAS application, and recorded a battery life exceeding one hour.

4.2 Shield Connector Board

In order to facilitate easier assembly, a shield board was designed to sit on top of the UDOO board and route all the UDOO connections to a single header. This board also incorporated two diodes in series from the 3.3v rail to provide the ~1.8 V needed by the switched mode power supply board. This board was also implemented using surface mount design, but with through hole vias for the header pins to attach. Additionally, the board provides labels for each pin to allow quicker troubleshooting and wire identification. The completed board design can be seen in Figure 4.2 in the appendix.

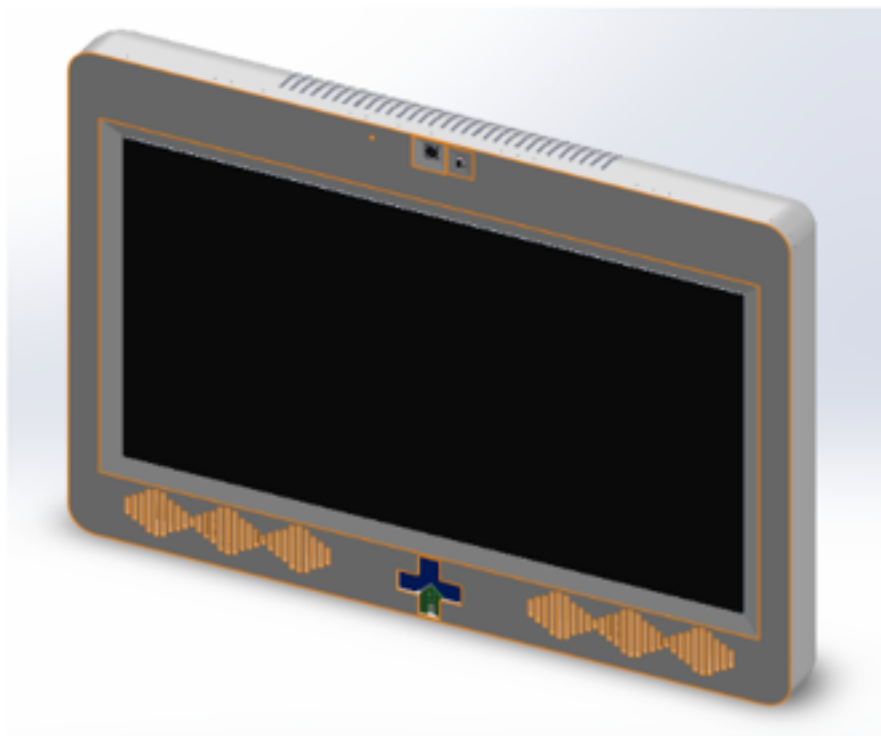
4.3 Power Consumption

With a fully functional power supply and battery management system, we were finally able to test the total power consumption of the device. The following table lists power consumption at 14 V through main power. When the power chord is disconnected, the device switches to battery power at 12 V. As the voltage switches from 14 V to 12 V there is a small spike in current consumption between 200 and 300 mA. On average, total power consumption equals approximately 24 Watts. Total power consumption can be seen in the table below.

| COMPONENT | CURRENT DRAW |
|-----------------|--------------|
| UDOO QUAD | 500 mA max |
| BATTERY CHARGER | 350 mA max |
| LCD SCREEN | 810 mA max |
| CLASS D AMP | < 10 mA |
| IR SENSORS | < 10 mA |
| MICROPHONE | < 10 mA |
| CAMERA | < 10 mA |
| TOTAL | 1.7 A |

3D CAD

Using Solidworks, we have designed and printed an appropriate housing for our product. Figure 5.1 below shows our final case that is housing a camera, gesture sensor, microphone, two speakers, and a 15.6 inch LCD monitor.



The total dimensions of this case are 404 mm in length, 298 mm in height, and 50mm in width. In the front cover, we have included holes for the essential electronic components we are using. These include the microphone, camera, sensor, and speakers. On the top rear of this case, we have designed holes for cooling purposes.

The backside of this case includes two wall mounts to place the device on any vertical object. We have also designed holes to attach the front cover of this case with the back cover. Finally, we have included a hole on the left side of this case for the external main power input. Figure 5.2 below shows the backside of our device.



Figure 5.2

Inside this case we have designed and cut an acrylic sheet to mount electronic components. This sheet mounts the UDOO microcontroller, 3-cell battery, the battery management system, and an audio PCB as can be seen in Figure 5.3 below. We also included some mounts on the front cover to attach the camera, gesture sensor, speakers and the microphone as well as mounts to attach the front cover to the back cover. After confirming the specs of our casing, we 3D printed the case and were able to test the NOVAScreen in its entirety.

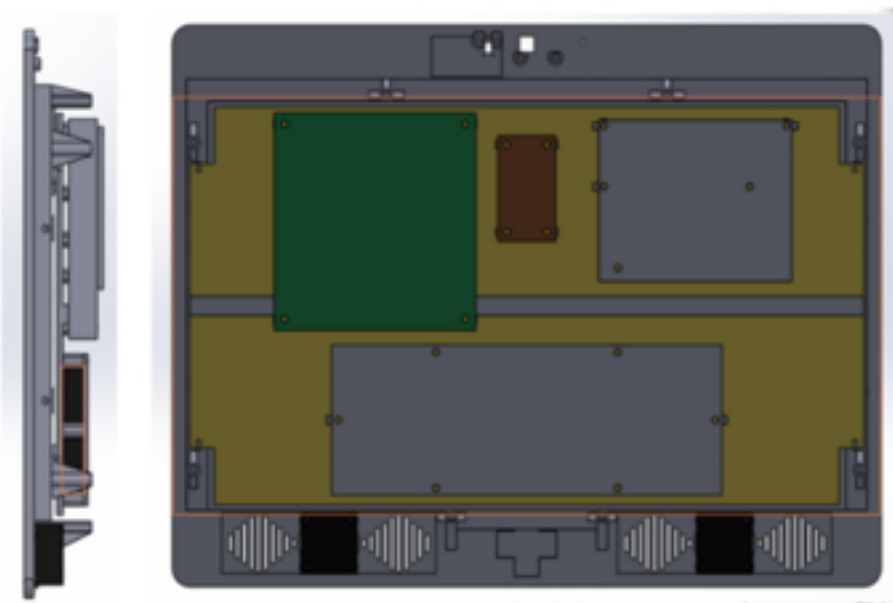


Figure 5.3

Schedule

The three phases of our project (develop, build, and test) were all completed on time. The deliverables were in working order by the scheduled time. The challenges experienced delayed our project's progress, but enough margin was baked into the schedule to allow for these errors. The team was able to overcome any problems within our scheduled time. The only thing that would have helped improve our schedule would have been to allow for more testing time. We tested the hardware several times as individual components and connected. We tested the software several times. However, we only did not test the complete system enough times. Doing more research on how users interact with the system could have resulted in a more polished product. Adding this into the schedule could have helped. Please see the Appendix for the details of the project plan.

Considerations for Production

If the NOVAScreen was to go into production, there would be several things done differently. Some things that would be addressed would be the pre-fabricated sensor boards, the development boards, the case material, temperature control, the wiring, the sensor mechanism, and the user interface. Basically, everything could be improved upon for a streamlined production process. Custom PCB designs would be used for all the peripherals instead of using the pre-fabricated sensor, camera, and microphone boards. This would allow for greater control in the circuitry and would be much cheaper. Also, instead of mounting each board individually, a single board could

be made that contains all three of these components. The sensor breakout board cost around \$20, but the sensor itself costs only \$2 in bulk. Similar savings can be found when ordering the microphone IC in bulk. The board used in our power management system was a development board intended for testing, in production we would use only the IC from Texas Instruments. These changes would save significant space inside the NOVAScreen and drastically reduce the cost.

Some of the parts used were not necessarily production ready. For example, the speakers were taken from an old sound bar that we opened and the battery was a replacement laptop battery. The speakers and the battery would have to be sourced from a distributor when mass producing the device. The battery would also need a more secure mechanism to hold it in place. The case was made using 3D printing which is fine for prototyping, but is obviously not viable for mass production. In production the case would likely be injection molded plastic.

The UDOO board was very convenient for our prototype, but would not be feasible for the production device. The UDOO board is an i.MX6 processor with an Atmel microcontroller on a single board. These two components or similar components could be put onto a custom designed board. The board could also incorporate the audio PCB, the power PCB, and all connectors. This would bring the cost down significantly, as the Udoo was the most expensive piece.

Conclusion and Recommendations

During the development stage of the NOVAScreen our team faced some challenges. Most of these were minor and did not affect the goal of making a working prototype. The problems would have to be addressed, however, before bringing the device to a production-ready state. Some of the problems involved the use of a single gesture sensor, thermal management, and burning up our Udoo boards. All of these problems were handled during the development of our prototype, so they were not critical issues.

The team decided to use one gesture sensor as the point of interface for the user. This decision was made due to time constraints, and our ability to integrate the sensor into our Android application. One sensor works just fine, but it creates a very limited range of interaction. The user is confined to making gestures 4-8 inches away from the screen. The user must make their gesture directly above the sensor. Two simple solutions to this would be to use more sensors or to incorporate voice control.. Voice control could be implemented using Android's voice engine. This method would keep the user from having to be close to the screen, so wheelchair bound seniors would probably find voice control the easiest method to use. With either method, there is no need to memorize gestures or execute them correctly which is an improvement for the general public.

Two-way video and audio communication is heavy work for our processor. This plus the screen size and power creates a lot of heat when the device is running. We managed this by creating ample airflow via holes in the case. If the power consumption

remains the same, then a fan should be added if the NOVAScreen is mass produced. Much like a laptop, the amount of heat is significant enough to necessitate forced air circulation. A small fan would definitely help reduce any thermal issues, but reducing the power consumption would be a better option. This could be achieved by using a smaller screen, enabling a sleep mode, or using a less powerful processor combination.

During testing, several of the UDOO boards experienced problems. Much of our budget was used in buying replacement boards. This could have been avoided by using better ESD precautions. The UDOO board was originally mounted on plastic which could have developed a charge. A short circuit happened when closing the case due to a metal switch coming in contact with leads on our battery charging board. Simple precautions could have prevented these, but we were able to replace or fix the issues promptly.

Although, there could have been some improvements as mentioned previously, ultimately our finished design of the NOVAScreen successfully fulfilled the requirement of being a two-way, non-contact video link, which communicates effectively between a home-based senior patient and a nurse practitioner. The user is successfully able to select which nurse to call and able to answer and receive calls. All the peripherals implemented in the design work the way we have envisioned them to work. Given all the points in this report, the development of the NOVAScreen was created to help provide reliable, in-home medical assistance that will lower health care costs and help avoid unnecessary emergency room visits.

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Appendix A: Schematics and Simulations

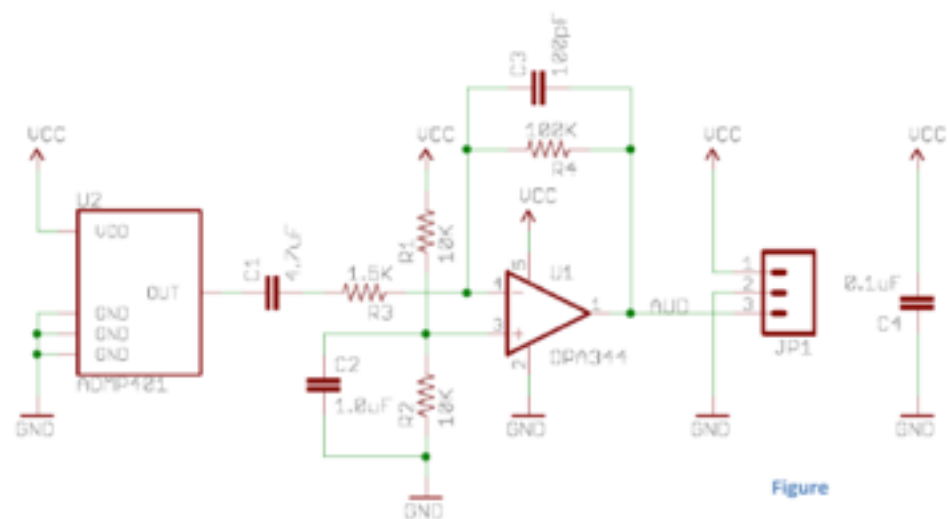


Figure 3.1

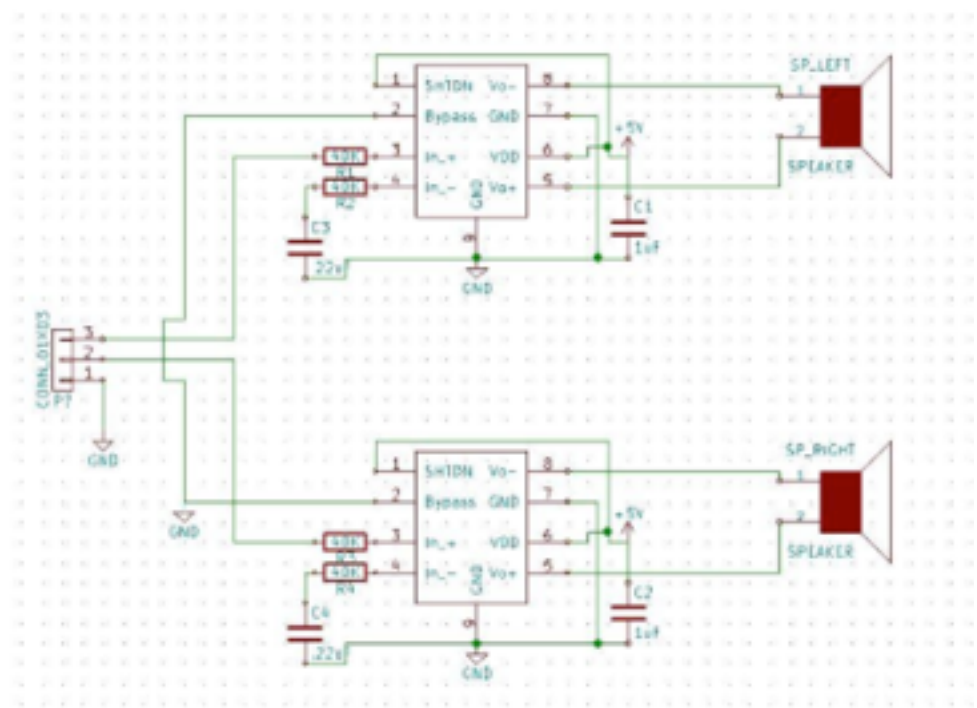


Figure 3.2

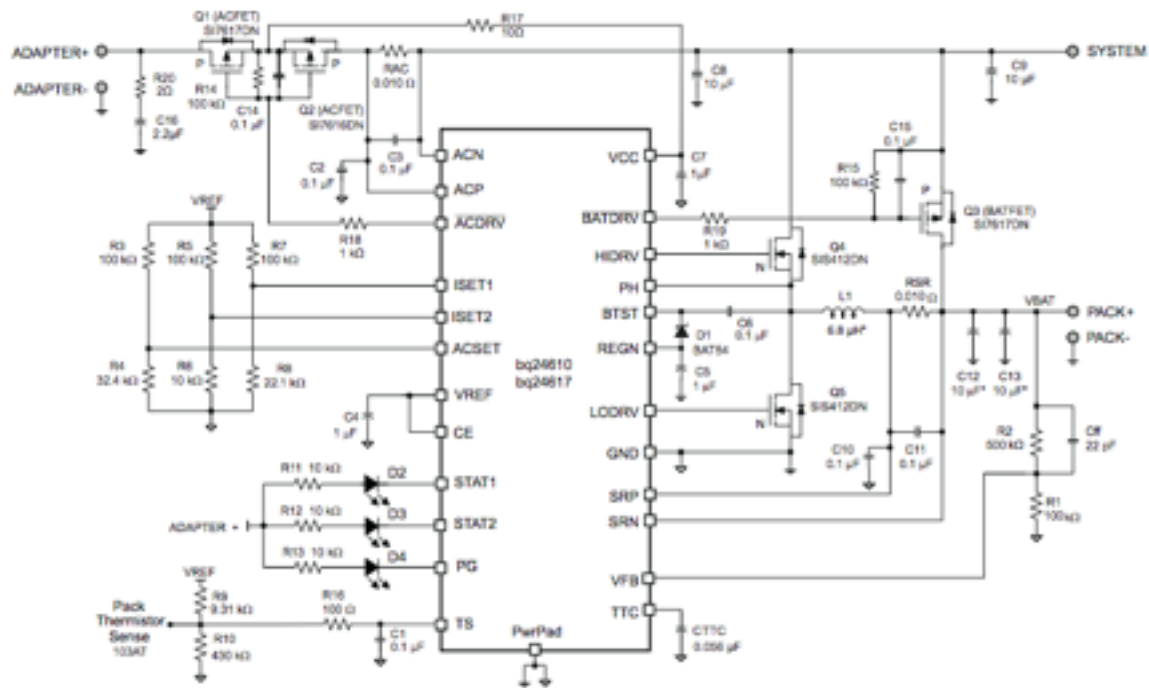
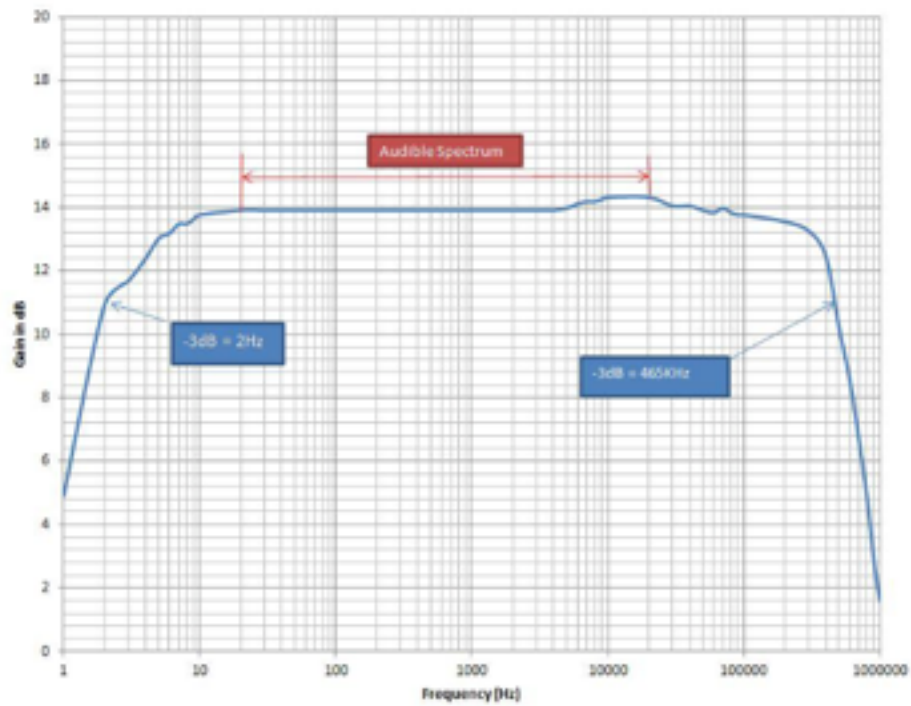


Figure 4.1



Appendix B - PCB Layout

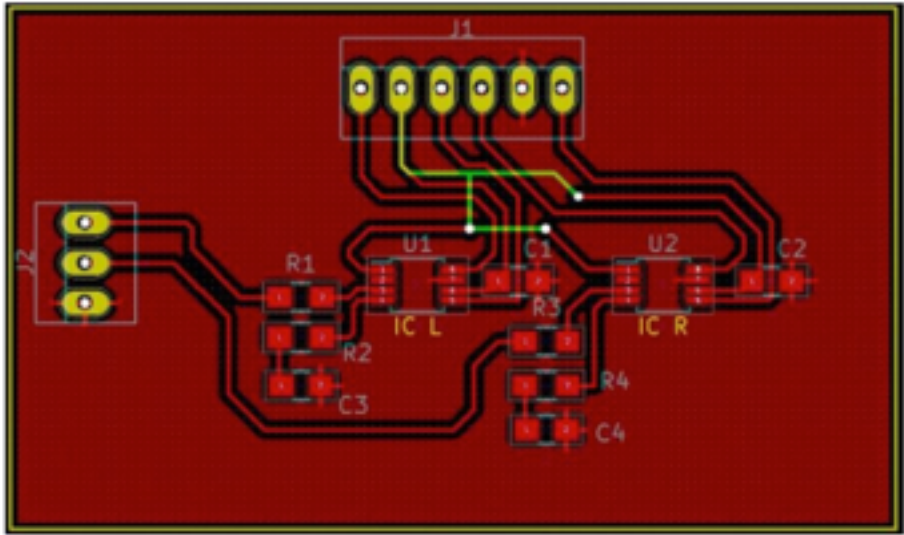


Figure 3.4 - Audio PCB

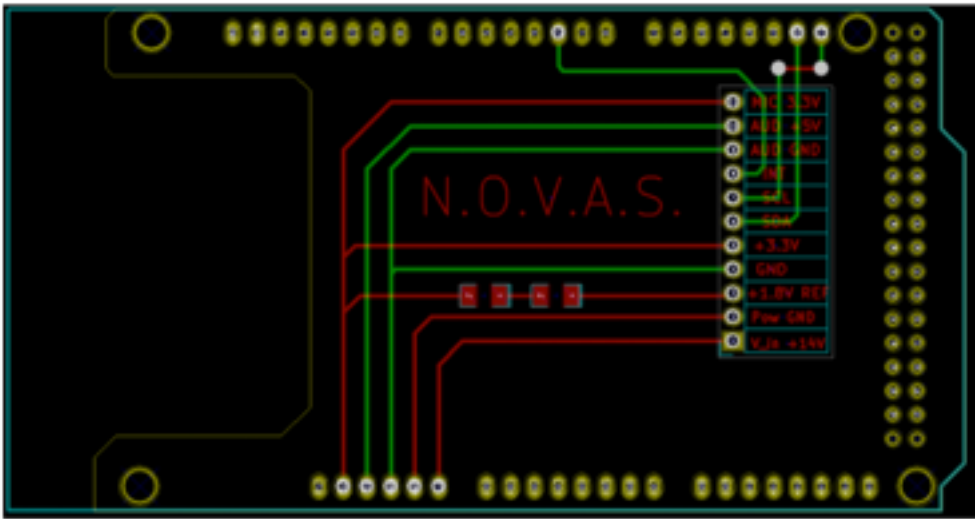


Figure 4.2 - Shield PCB

Appendix C - Bill of Materials

Bill of Materials

| Part | Quantity | Cost Per Unit | Total Cost |
|------------------------|----------------------|---------------|------------|
| UDOO Quad | 3 | \$135 | \$405 |
| 8Gb SD Card | 1 | \$5 | |
| UDOO Screen | 1 | \$150 | |
| Railmaster Speaker | 2 | \$0 | |
| TPA20051D | 2 | \$0 | |
| Gesture Sensor | 3 | \$14.95 | 44.85 |
| ADMP401 Breakout | 1 | \$9.95 | |
| UDOO Camera | 2 | \$39 | \$78 |
| Ti Battery Charge Eval | 1 | \$99 | |
| 10.8V Lithium Battery | 2 | \$49.70 | \$99.40 |
| Shield Board | 1 | \$0 | |
| Power amp Board | 1 | \$0 | |
| Case-Front | | \$0 | |
| Case-Back | | \$0 | |
| | | | |
| | Shipping/Handling | \$48.86 | TOTAL |
| | Parts Per unit Total | \$891.2 | \$940.06 |