

Efficient HVAC System

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Abstract — The Efficient HVAC System is a modern interpretation of a digital HVAC Controller that uses modern technology to save business and home owners money on Heating, Ventilation and Cooling of their workplace or home. With this system, users can improve the economy of their electricity consumption by increasing their awareness and control over humidity, and carbon dioxide levels. This system contains four interdependent components. A hardware unit simulating a touch screen HVAC control panel, an external temperature sensor sending data to the main system wirelessly, a web site allowing users to log in and control their HVAC system from a remote desktop with a browser and Internet connection, and a mobile phone application that lets users control the HVAC system from their smart phone. The main control system is a touch screen that allows users to increase and decrease their temperature, read current temperature and humidity settings, read whether or not CO2 levels are safe indoors, and allow administrators to log in and adjust the hardware based on what components the owner's HVAC hardware currently contains. It also uses Natural Air's patented ability to adjust the system to one of five different tolerance levels to make the system give more leeway past set temperatures and humidities, saving electricity. At the same time, the web application, and mobile web application, allow users to have those same features from a desktop, laptop or mobile phone. The wireless temperature sensor is installed in a home's attic, or a business's utility area, where it will feel outdoor temperatures and send that temperature to the main control unit. All these components combine to form a new, unique means of controlling the air quality in a user's workplace or home.

Index Terms — HVAC, LCD touch screen, CO2 sensor, temperature sensor, humidity sensor, microcontroller, Databases, query processing, web page design, web services

I. INTRODUCTION

HVAC is short for Heating, Ventilation and Air Conditioning. It encompasses the majority of indoor environment control in buildings. Every time you use your air conditioner, you are using an HVAC system. What an HVAC system consists of can vary depending on the components installed. When a typical homeowner thinks of their HVAC system, they think of an Air Conditioner, a Heater, a Fan, and a Thermostat to control

it all. Meanwhile a business owner will take more consideration into the ventilation of the building, as well as Heating and Cooling. Ventilation becomes a greater concern for a business owner when safety is on the line, because a poorly ventilated, highly populated indoor area can become filled with odorless. It is a subject of great study for engineers and home designers, because HVAC systems are one of the largest sources of energy consumption in residential and commercial businesses. Our mentors, William Carson Sr. and William Carson Jr., are heavily invested in creating a modern, easy to use programmable HVAC control system that can be tailored to meet the needs of all buildings, whether they be residential, commercial or industrial, and have asked numerous senior design teams in the College of Engineering and Computer Science to be a part of this industry. And now in Fall 2011 and Spring 2012, Group 16 has the opportunity to be a part of such a design.

Our project is to perform a redesign of the work of a previous group before us, designing an energy efficient HVAC controller that can be controlled from a touch screen interface, an independent website, and a mobile application for smart phones. From all three different methods of accessing the controls to the HVAC system, a user will be able to have the same amount of control over their HVAC system. A user can select modes of cooling and heating, or turning the HVAC system off. After that, they can select the ideal temperature and humidity they want, which is ideal in modern HVAC systems that control both temperature and humidity. In fact, Natural Air Energy wants the control system to be expandable based on the numerous hardware components that could potentially be installed in a building, many of which are designed to save home or business owner money. Administration login is available so that Natural Air can add or remove hardware components based on what a customer has installed in their building. If a homeowner has a basic HVAC system that has just an air conditioner and a fan, an administrator can log in and deactivate all modern hardware options except the air conditioner and fan. If a modern residential or commercial building has more modern hardware available, an administrator can add the wide variety of hardware components that are in the market, such as a second air conditioning pump, a dehumidifier, air filter scrubbers, dehumidifiers, and chemical air fresheners.

Unique to Natural Air Energy, and this project, and the project before us, is a system called "Emax," which allows users to choose energy saving "tolerance levels" which cause the HVAC system to provide greater or lesser leeway beyond the user's temperature and humidity allowance. This is one of Natural Air Energy's most

important features requested by the group. The greatest energy saving feature of this HVAC system is this feature, because when a user has control over both their humidity and temperature in their building, a user can save more electricity and money with an HVAC system than with a system that is merely a thermostat, air conditioner and fan.

The human body, at one's own preferred humidity levels, can feel just as comfortable in a warmer area as an area with an air conditioner that will work alone to make an area as cool as possible. This means that in an area with controlled humidity, the HVAC system consumes less overall electricity because it is not working as hard to maintain a less intense temperature. This tolerance system has five different levels, labeled 1 through 5. Level 1 is called the "Maximum Comfort" level, which is the lowest tolerance level. By default this level behaves like an ordinary thermostat, immediately responding when the ideal temperature and humidity is lost. Level 1 is intended for buildings in which there is a lot of people, such as a home with a lot of guests. The opposite level is Level 5, the "Maximum Savings" level, which provides the most leeway beyond a user's desired humidity and temperature. Such a setting would be ideal for a user in his or her home, alone, requiring the minimal amount of adjustments to their building's temperature and humidity. All the levels in between provide moderate levels between 1 and 5, however there is one more additional feature. An administrator has the ability to log in and fine tune the amount of tolerance for the five levels. The administrator also has the ability to adjust the amount of time the HVAC system is permitted to turn on in response to adjusting the temperature and humidity. In the previous version of the project, the administrator only had the ability to adjust tolerance levels 1 through 5 for the temperature, exclusively. At Natural Air Energy's request, administrators now have the ability to adjust both the temperature and humidity responses and durations, providing additional advanced control over a user's HVAC system.

This part is key to conserving electricity and money because the human body is capable of being comfortable with less need for air conditioning (in terms of temperature) if measures are taken to adjust humidity. In terms of energy consumption, air cooling and heating is always a greater energy consumer than a dehumidifier. By increasing the tolerance level of a temperature while leaving humidity adjustments intact, a user is capable of being comfortable in his or her home with less cooling.

This system can be controlled by three different ways. First, there is a touch screen simulating the plain, basic user thermostat a user would have in their home. New to

this version is the project, is a website and mobile application. Natural Air Energy's most important specification was for the system to be accessible by any web browser as well as a mobile phone.

II. COMPONENTS

Late into the semester, a wide variety of hardware was added to the project. The following hardware additions are based on the direction Tim VanderMey of Proton Design Inc. was, and is, taking with the redesign of the hardware. At the core of the project's needs is the PIC32 Microprocessor (We chose PIC32 starter kit which is \$55.00), which serves as a significantly cheaper alternative to the previous processor, the Panda Board, which was \$275.00.

The PandaBoard is a really powerful board using an OMAP4430 platform for any design. The OMAP4430 is a 1GHz Dual-Core ARM processor also has onboard connectors which can supports development of additional capabilities. It has a good advantage because PandaBoard don't need to buy an extra external board expansion. By using PIC32, we needed to have an expansion board to get the same results. It can stream video up to full high definition (HD) 1920*1080 pixels with two HDMI display and support 2D/3D mobile gaming with the help from 1GB DDR2 RAM. However, all these functions are too powerful for us so we decide to go with PIC32 as our development platform. PIC32 contains 32-bit MIPS M4K core that has 80MHz which can handle up to 1.56 Dhrystone million instructions per second (DMIPS). It also contains 512K flash with pre-fetch cache and 128KB Ram for data and program execution. It has 16 analog pins that we can use for our project because I choose to use some analog device for our indoor temperature and humidity sensors and also the CO2 sensor.

A. Temperature Sensor

In order to detect the temperature indoor and outdoor, we choose the LM34 (Precision Fahrenheit Temperature Sensors). The LM34 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Fahrenheit temperature. The LM34 thus has an advantage over linear temperature sensor calibrated in degrees Kelvin, because the user did not require subtracting a large, constant voltage from its output to obtain the convenient Fahrenheit scaling. Following in Figure 1 is the representation of the basic usage of the LM34.

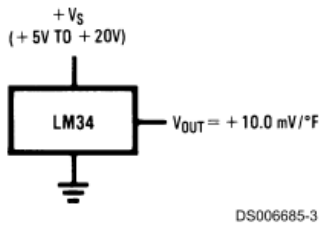


FIGURE 1. Basic Fahrenheit Temperature Sensor

For demonstration purposes, +5 °F to 300 °F is good for our design, especially in Florida. And Vs here we give them 5V in our design. The other advantage for LM34 is that it does not need any external calibration to provide typical accuracy of $\pm 1/2$ °F at room temperature and $\pm 1 1/2$ °F over a full -50 to +300°F temperature range. The LM34's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It has very low self-heating, less than 0.2 Fahrenheit in still air and is rated to operate over a -50° to +300°F temperature range. Below is the bottom view of the LM34 temperature sensor.



Figure 2. LM34 temperature sensor (Bottom view)

Many electrical signals around us are analog in nature. This means a quantity varies directly with some other quantity and the first quantity is mostly voltage while that second quantity can be anything like temperature, pressure, light...etc. In our design, LM34 temperature sensor will output voltage varies according to the temperature it measured, so if we could measure the voltage, we should be able to measure temperature also.

But most of our microcontrollers are digital in nature not in analog signal that we want to use like voltage. It means they can only differentiate between High and Low level on input pins. For instance, if input is more than 2.5V it will be read as 1 (High) and if it is below 2.5 them it will be read as 0 (in the case of 5V system). So we can not measure voltage in that way directly. In order to solve the problem, I use ADC unit (Analog to digital Converter). It will convert a voltage to a number so that can be processed easily by digital system like MCU.

Most important specification of ADCs is the resolution. This specifies how accurately the ADC measures the analog input signals. In the PIC32 we use, it has 10 bits

but normally ADCs can be 8 bit, 10 bit and 12 bit. In order to calculate the right factor for our input and get right temperature output. The step by step processes is as follows.

For example, if the reference voltage of ADC is 0 to 3.3v (with the PIC32 as an example) then a 10 bits ADC resolution will break it in 1024 divisions so it can measure it with accuracy up to $3.3/1024=3.2$ mV, so you can see that the 10 bit ADC can't distinguish a difference between 1mV to 3.2 mV, but it is good enough for our design because 1 °F is a 10mV difference. The value we read from ADC on PIC32 indicates we needed to get "real voltage = ((ADC reading)/1024.0 *3.3*1000);//Voltage in mV" since 10mV = 1 degree from figure 1, to get temperature we must divide it by 10 from previous equation. "t= ((ADC reading)/1024.0)*3.3*100); //It is in degree Fahrenheit. " After simplification, it then becomes "t= (ADC reading*0.33)."

B. Humidity Sensor

In order to detect the humidity indoor and outdoor, we choose the CHS-MSS from TDK Corporation. It has a compact size so we can reduce the size of the total sensor and it has low current consumption. If the output DC is 1 V, it means at 100% RH. Voltage and the humidity have linear relationship so the relative humidity can be read directly with a voltmeter. Figure 3 is the detailed schematic of the CHS-MSS humidity sensor.

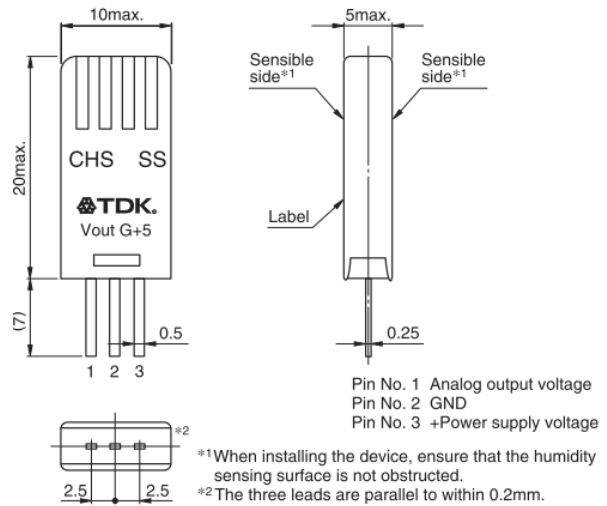


Figure 3 CHS-MSS humidity sensor

CO2 Sensor

This part was added by Natural Air Energy recently because it can increase the potential customer for this particular function. In order to detect whether the CO2 concentration is over normal range, we choose to use

CO2 gas sensor module 27929 from the Parallax Incorporation lineup. It is interfaced with through 4-pin header and only requires 2 I/O pins from MCU. The sensor is used to provide a means of comparing gas sources and being able to set an alarm when the CO2 source become excessive. Below in Figure 4 is the CO2 sensor schematic.

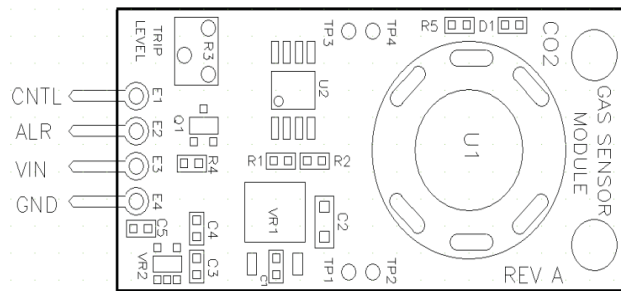


Figure 4 – CO2 Sensor

C. The PICtail Touch Screen

To test the connection between that of the eventual hardware and the software components, a rough simulator of the potential touch screen will be designed. Due to time constraints, a full version of the HVAC system will not be possible to implement, but the simulator will focus on the most important part of the design: the establishment of communication between a hardware and the database, website, and mobile website.

Several touch screens were researched to determine which would be the best fit for the project. The first generation of the HVAC system project used the Evervision LCD touch screen for their project. It was a good touch screen with no significant problems, but it proved to be a very expensive part in a otherwise economically efficient project, so other options were researched. The second generation used the XENARC 706TSA touch screen for their version of the project. In terms of all the touch screens researched, the XENARC has the most features and the best attributes such as lifetime and resolution. Likewise it was high in price as well. The third product researched was the NHD touch screen.

Overall, its capabilities were comparable to the Evervision LCD touch screen. However, its main advantage over the Evervision is its price. So it was decided to use the NHD touch screen for the HVAC system project. However, a major complication arose during the initial designs of the simulator. It was revealed that the NHD touch screen was incompatible with the current processor, the PIC32 processor. While this caused a significant setback, an alternative touch screen was

eventually found. The PICtail touch screen, a touch screen from the same company that the PIC32 product is from would be used in the final design of the simulator.

The touch screen to be used for this simulator was the PICtail from Microchip. Designed to be an extension for system development, it is capable with most of the Microchip family of processors including the PIC 32 processor. The PICtail comes with an extensive software library and toolset to design graphical unit interfaces. The simulator will be constructed using these tools such as the Graphics Display Designer. The Graphics Display Designer is a tool that allows one to easily design a base outlook of the touch screen interface, automatically generating the code which can then be modified as needed.

One of the primary goals of the simulator is to show that the database is able to read data from the PIC32 microprocessor components. This starts by reading from the temperature, humidity, and CO2 sensors into the PICtail touch screen, which will display the information obtained from them. The PIC32 will wirelessly upload this information into the database and website. The PICtail touch screen will display the information from the sensors. It will be displayed in a format similar to what the potential final version of the display unit could be. The style will focus more on displaying the information rather than having a more professional and sophisticated design for clients in the actual market.

The touch screen interface will first consist of options to switch between heating and cooling for either the temperature or the humidity. After choosing one or the other, a user can choose which setting to modify, temperature or cooling. After modifying the settings, the simulator will send the new data to the database and send the new information to the websites as well.

D. The Remote Sensor

To enable our hardware simulator to function like an efficient HVAC system, we need to have a remote temperature and humidity sensor responsible for measuring the outdoor temperature and humidity. We will have a secondary remote unit with a LM34 Temperature Sensor and CHS-MSS Humidity sensor.

The LM34 Temperature sensor and CHS-MSS Humidity sensor was the selection made based off the ability to be able to simply provide the temperature and humidity to our hardware so it could be provided to our database on our internet and allowing our website be able to function off of these readings. The LM34 Temperature sensor and CHS-MSS Humidity sensor also displayed the qualities that we needed for our remote sensor by being small in size, even though it consumes more power than

other temperature and humidity sensors available, the process of programming these sensors with our microcontroller outweighed all other factors. The LM34 Temperature sensor is made for outdoor conditions with a temperature range from -50 to 300 degrees Fahrenheit. The CHS-MSS Humidity sensor has a range from 20 – 85% relative humidity suitable for the conditions our sensor will be in for simulation purposes.

III. DESIGN AND IMPLEMENTATION

A. Software

The first software formed was the basic website for the HVAC Controller, to be accessed by any web browsers that users could use to control all the settings of their HVAC Control System. To achieve this, first a basic HTML and CSS based website was formed based off of the work of the previous group. After that, at Dr. Richie’s suggestion, a mobile website was developed. A second website was deemed a reliable “third option” as opposed to developing a legitimate Android or iPhone application. The issue with developing a traditional application would be that it would only work for one of those platforms and be harder to program. Also, the price to develop applications on iPhone is one hundred dollars per year. By using a website, any phone by any developer could access our application. At first, Group 16’s intention was to restyle the first website if a mobile browser was detected. A superior alternative was introduced to Group 16, and jQuery was used instead. Below in Figure 5 is a sample of the desktop and laptop browser application’s main screen.

inside air comfort

	Indoor	Outdoor
Temperature	80	82
Humidity	42	
CO2	42	
Cool - Select Mode		
Cooling		
Temp	80	
Hum	42	
emax level		
Level	5	
Fresh Air Exchange		
OFF		
Air Quality		
OFF		
Mood Scents		
Scent 1	<input type="radio"/> On	<input type="radio"/> Off
Scent 2	<input type="radio"/> On	<input type="radio"/> Off
Scent 3	<input type="radio"/> On	<input type="radio"/> Off
Mood Scent Duration		
OFF		

Figure 5: Main Screen (for desktop and laptops)

A user can select a mode of Cooling, Heating, or turning their system off, like a regular thermostat. Like an advanced thermostat, a user can specify both the temperature and humidity they want. However, Natural Air Requested the specification of allowing administration login to allow theoretical technicians (such as themselves) to access customer HVAC control systems and fine tune customer settings based on their needs. Natural Air wanted something technicians could access from a distance, such as at Natural Air Energy’s offices or a service truck. For example, one setting that customers must not touch is listing out the hardware components that a customer might had installed. Different buildings have different needs and hardware installed. The first thing administrators can do is specify what a user has installed in their home, such as a second air conditioner, a fan, a dehumidifier, a natural air system, filtration system, or air freshener (called Mood Scents.)

The second major function of administration login is to allow technicians to fine tune the “emax” tolerance levels. In the previous edition of this project, an administrator could adjust the temperature tolerance levels 1 through 5, specifying the range of tolerance between degrees. In this edition of the project, Natural Air requested that administrators be able to adjust both temperature and humidity, so now the administration section can adjust the humidifier and thermostat behavior independently. For both temperature and humidity, administrators can select the amount of time the HVAC system is supposed to react to changes in temperature and humidity, ranging from five minutes to four hours. This dynamic functionality is something that not even Bayweb.com uses. The two system user groups using for the software The user case diagram is pictured below in Figure 6.

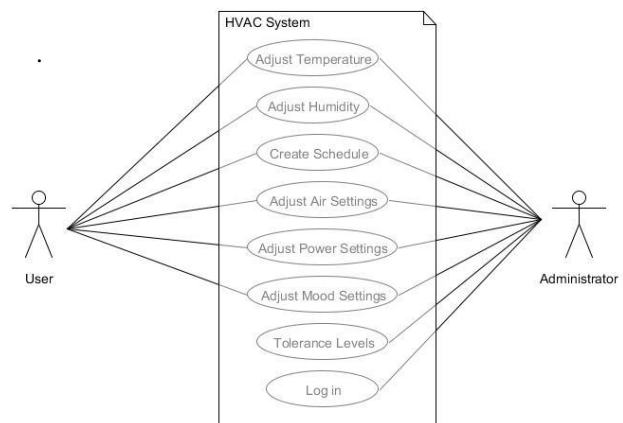


Figure 6 – User/Administrator Use Case Diagram

A user can go into a seven day HVAC scheduler that allows users to enter specific commands for setting the mode of the HVAC system, the time the system should activate, the duration, and one of the individual emax tolerance levels for that time period. A user can also view previously entered scheduling “jobs” and see what the scheduling agenda currently is for their home or business.

In addition to the previous stated features, users can also select between five levels of comfort settings ranging from Maximum Savings (Level 1) to Maximum Comfort (Level 5). Each of the levels retains its own temperature range and AC elapsed time for triggering additional components to turn ON or OFF. Additional selection options are available to the users for immediate system actions instead of allowing the system to determine the ideal settings. The Selection Menu buttons such as the Fresh Air, Air Quality, Times/Zones, Power Costs, and Mood Scents allows this to be possible.

What makes this project very unique from the previous edition is the inclusion of a mobile phone application that gives users and administrators those same capabilities. First, developing for Android and iPhone was considered, but a third option of making a mobile website turned out to be the best option. First, a mobile website is free and easy to implement, as our project requires a MySQL database, second, it is free, because we did not have to purchase a development license from Apple, which goes at 100 dollars a year. Finally, a mobile website provides the opportunity to produce an application that will work on any phone, and any browser, which is something not even Google’s Android development can provide. Below in Figure 7 is a sample picture of the mobile main screen.

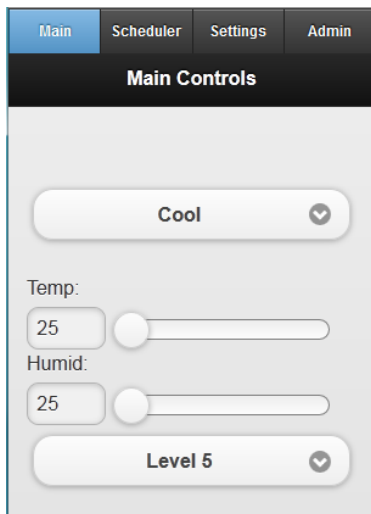


Figure 7 – Mobile Touch Screen Application

The original plan was to build a website with the exact same code as the standard desktop/laptop browser based code for the first web site. Instead, a popular library called jQuery Mobile, of the jQuery series of libraries, was investigated. jQuery Mobile allows the production of websites for mobile phone web browsers that are touch-screen ready, to the point that they look and feel like real Android and iPhone applications coded for their specific phone models.

This jQuery Mobile application produced a unique application that allows users to do all the same things that they could do on the regular browser. A main menu allows users to set temperature, humidity and tolerance levels, the scheduler remained intact, basic user settings were included, and even all the administration settings remained. All the links and buttons behaved like traditional mobile phone applications as if they were coded in C or Java. This technology allows mobile application programmers to save time and hundreds of dollars in development costs.

At the core of both the website and mobile application is the server containing both sites and a MySQL Database. Natural Air Energy provided Group 16 with access to their own web hosting services with Host Gator. All of the web programming work required remains hidden and live at <http://www.naturalairenergy.com>. The folders “hvac” and “m” store the desktop and mobile web applications, respectively. Both websites communicate with a MySQL database that stores and retrieves user inputs for use within the HVAC system. The database contains six different tables for storing variables. First, a customer data sheet called cust_info is the first table used first. It stores a user’s first and last name, and a username and password. This database currently stores seven different users, consisting of Group 16’s members, Dr. Samuel Richie, William Carson, and one sample user for any third parties who wish to try logging in. When a user logs into the application, their username and password is checked with this database.

The main screen’s table, called main_screen in the database, stores the most fundamental values, including indoor and outdoor temperature and humidity, the status of indoor CO2 levels, and user settings for adjusting the temperature, humidity and tolerance levels. It can also store commands for natural air ventilation and for how long it should be turned on. A user with Mood Scents installation is also able to turn on and specify Mood Scents spraying during ventilation.

For administration use, there are two different tables. One is called “admin_login”, which stores administrator usernames and passwords, and the other is called

administration. The administration features are Natural Air Energy's most requested specifications for the project. First, it was absolutely required that administration capabilities be locked behind a login for administrators, theoretically working at a service truck, office, or some distance away from the actual hardware. After a successful log in, the administration table is used. An administrator can post new values to the database setting each individual tolerance level. Tolerance levels 1 through 5 can have their temperature tolerance, humidity tolerance, and amount of response time tweaked and adjusted. Furthermore, all the potential hardware a building may or may not have installed are represented in the administration table. And as the administrator fills out the form and submits, those hardware components are represented as 1 for ON or 2 for OFF within the database. The administration database tables are easily the most unique part of the project, and are something that not even BAYweb has included in their HVAC internet software.

The most complex table in the database is for the scheduler. Simply called "scheduler" in the database, it stores user entries representing requested changes in the hardware settings. A user can specify one of seven days of the week, an hour (or half hour) within that day, the mode, the ideal temperature, humidity and tolerance level they want, as well as ventilation and filtration system duration time. When a user submits this information, a new row in the scheduler database table is created. All adjustments to the database are stored and there is no limit to the number of scheduling changes a user can make, so the scheduler is the most dynamic table in the database.

A more basic table for the project is the basic_settings table, which contains whether or not to reboot or deactivate the hardware, which is represented by ones and zeroes like the administration hardware. A user can enter their state and zip code for administration purposes.

B. Hardware

It was really important for us to test our hardware especially indoor sensor like humidity, CO₂, and temperature sensor. In order for us to test the temperature sensor, we first needed to decide how we wanted to test it. First, we used something with a warmer temperature than the indoor temperature on the top of LM34 sensor, so we can see the temperature increase on the computer screen and maybe touch screen. In order to let the result print on the computer screen, we need to include the `<stdlib.h>` and `"#define PIC32_STARTER_KIT"` into our codes; otherwise, we could not print any result on the screen. We

simply used our breath to increase the temperature by keeping continuing expire the hot air on the top of temperature sensor so you can see the changes of the temperature easily on the screen. On the other hand, we will also do some testing on decreasing the temperature by putting the cold drinks close to the surface of the temperature sensor. But when we are doing it, we should be extremely careful not to let the water drop on the circuits which may cause some problems.

Other than testing temperature sensor, we tested the indoor temperature also. But it is hard to control the humidity inside the building to test it. So again, we just use breath to increase the humidity temporarily by expelling the humid air from mouth to the sensor. And then we were able to see the change on the screen. When performing the testing, the indoor humid sensor should increase significantly. Normally, indoor humidity is roughly 46% RH so when you breath the humid air on it, it should increase to roughly 75% RH (As were the results discovered in the senior design laboratory). We could not do the testing for decreasing the humidity because we do not have access to the AC on the school. It will be hard for us to do the testing for that but if the testing for increasing humidity is working, the results should be suitable.

After the calibration, we could do the testing for CO₂ sensor. First, we were concerned on how we can get the CO₂ gas, but we learned of a simply solution from another senior design team. We used a household cleaning air duster which uses CO₂ to clean homes and electronic devices and we will use that as our CO₂ source. Before we supplied the CO₂ to the sensor, the light on the module should be off (which indicate the CO₂ level is normal) and the computer screen should show the CO₂ concentration in Normal indication. After the CO₂ gas adds close to the sensor, the light on the sensor should be on and the screen showed "Warning! Warning! Warning! The CO₂ concentration is too high" on the screen to indicate the excessive CO₂ exist in the environment. And after around one to two minutes, the CO₂ level returns to normal.

C. Communications

Main Control Unit to Database

The main control unit has Wi-Fi capabilities and is able to access the internet. The main responsibility of the main control unit is to be able to communicate with the online database. In regards to the hardware sending information to the database it is responsible for sending the indoor

and outdoor temperature and humidity readings in addition to the CO2 reading to the database online to be accessible by users and administrators via the internet. With reference to receiving data from the database the hardware will record any values on the database that have been provided from the user or administrator via the internet and make the appropriate responses to this information. The hardware will receive and send data to the database in minute intervals allowing consistent updates and accuracy to the information that is stored on the database.

We would like to conclude that our project is a unique and robust means of taking control of household and commercial energy consumption. This project uses a wide variety of technologies including microprocessor study, web programming, database analysis and electronics, and was a challenging but rewarding project to be a part of. Below in Figure 8 is the project's hardware, assembled.

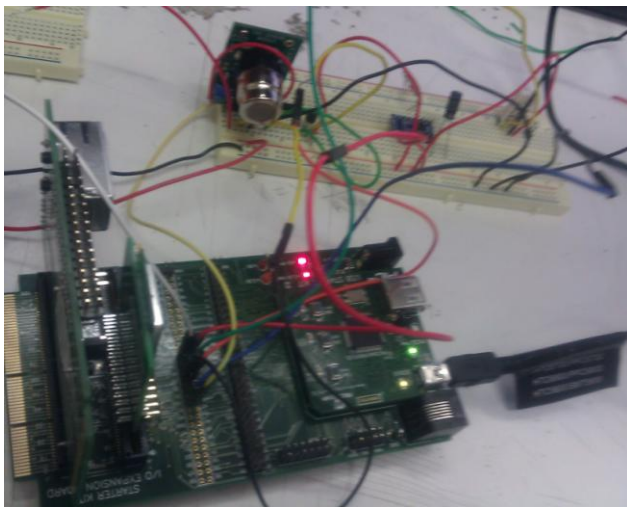


Figure 8 – Hardware Assembled

IV. ACKNOWLEDGEMENT

We would like to thank William Carson Sr. and William Carson Jr. They are our mentors and heads of Natural Air Energy, and as our mentors, they were the reason this project was chosen. Daniel thanks Workforce Central Florida for the initial financing. Chung also thanks Workforce Central Florida for additional financial support in the spring. Marvin thanks Workforce Central Florida as well for their efforts in additional funding in the spring semester. Finally, we would like to thank Dr. Samuel Richie and all committee faculty members, Dr. Sumit Jha, Dr. Jun Wang, and Dr. Kien Hua.

V. SENIOR DESIGN GROUP 16 MEMBERS



Daniel Galarza is an AFROTC Detachment 159 Cadet in the University of Central Florida, graduating May 2012 with a B.S in Computer Engineering and will commission as a Cyberspace Operations Officer in the United States Air Force. He awaits active duty in Keesler AFB, Mississippi.



Chung Chien Hsia is a senior at the University of Central Florida and will graduate in May 2012 with a B.S. in Electrical Engineering. He was accepted into NOVA, and will study dental medicine. His goal is to develop innovative medical equipment for dentists.



Kevin Ivy is a senior at the University of Central Florida and will graduate in May 2012 with a B.S. in Electrical Engineering. He plans to pursue a career in the engineering field in particular sales or division attributing to his skills sets.



Marvin Fernandez is a senior at the University of Central Florida and will graduate in December 2012 with a B.S. in Computer Engineering. After graduation, he will pursue a career in engineering.