Smart Home Security Module

Rutgers University
Senior Design Project

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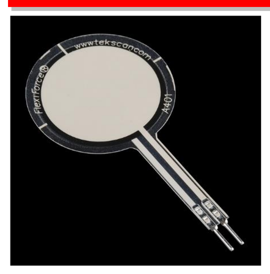
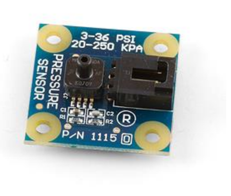
Introduction

The smart home module is a small, efficient and elegant solution to problems that everyday house holds have. It can be customized and outfitted to a variety of designs on the fly.
The device follows a modular approach to achieve a multitude of functions based around analog sensors, which it converts into a digital signal.

The Sensors

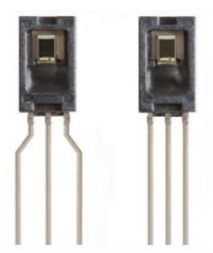


Flexiforce Pressure Sensor

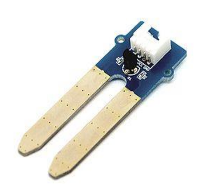


Phidgets Gas Pressure Sensor

LMD35D Temperature Sensor



HIH-4000 Humidity Sensor



Grove Moisture Sensor

MQ-2 Gas and Smoke Sensor

Sensors come in many shapes and sizes and can be used to measure all kinds of things, from barometric pressure to moisture content. Most sensors have an analog output which can be converted into a digital out and the put on a display. The display can be anything from the 7-segment display, which we ended up using, to a Bluetooth output. As soon as the signal was converted into digital, anything with computers was possible.
Typically the analog signal would correspond to a difference in resistance in the sensor, thus a difference in voltage can be observed for incoming signals and interpreted by a small computer and an output can be determined, either by basing it off a the 5 volt standard that comes with the sensor, or by measuring each point manually and referencing those points in a table, which allows for complete accuracy for any dynamic range.

Many of them follow a linear voltage and come pre-calibrated to a 5-volt standard that is usually shown on a graph, much like the ones below.

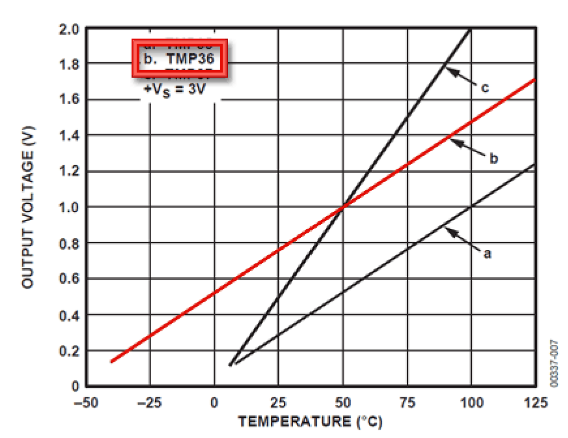
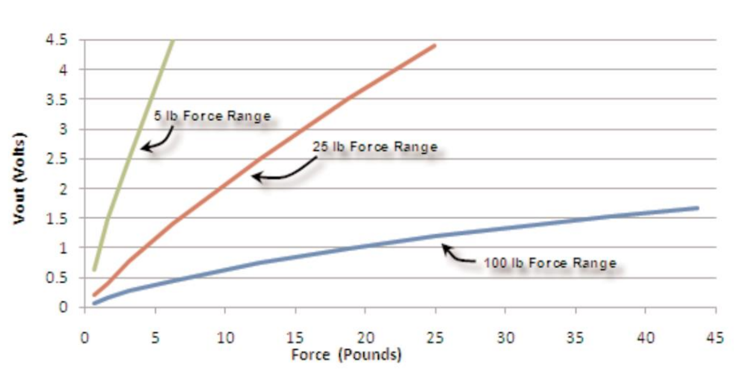
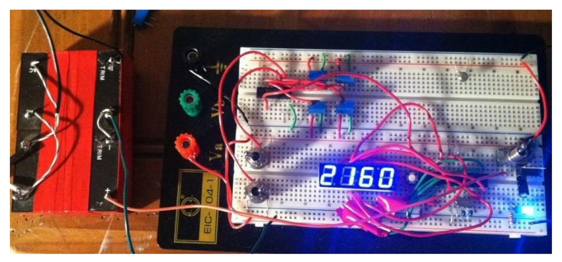


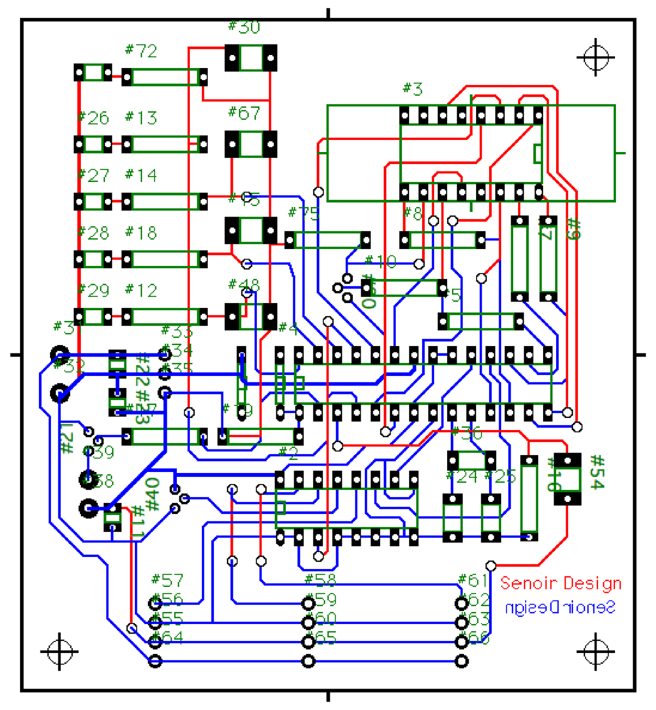
Figure 6. Output Voltage vs. Temperature

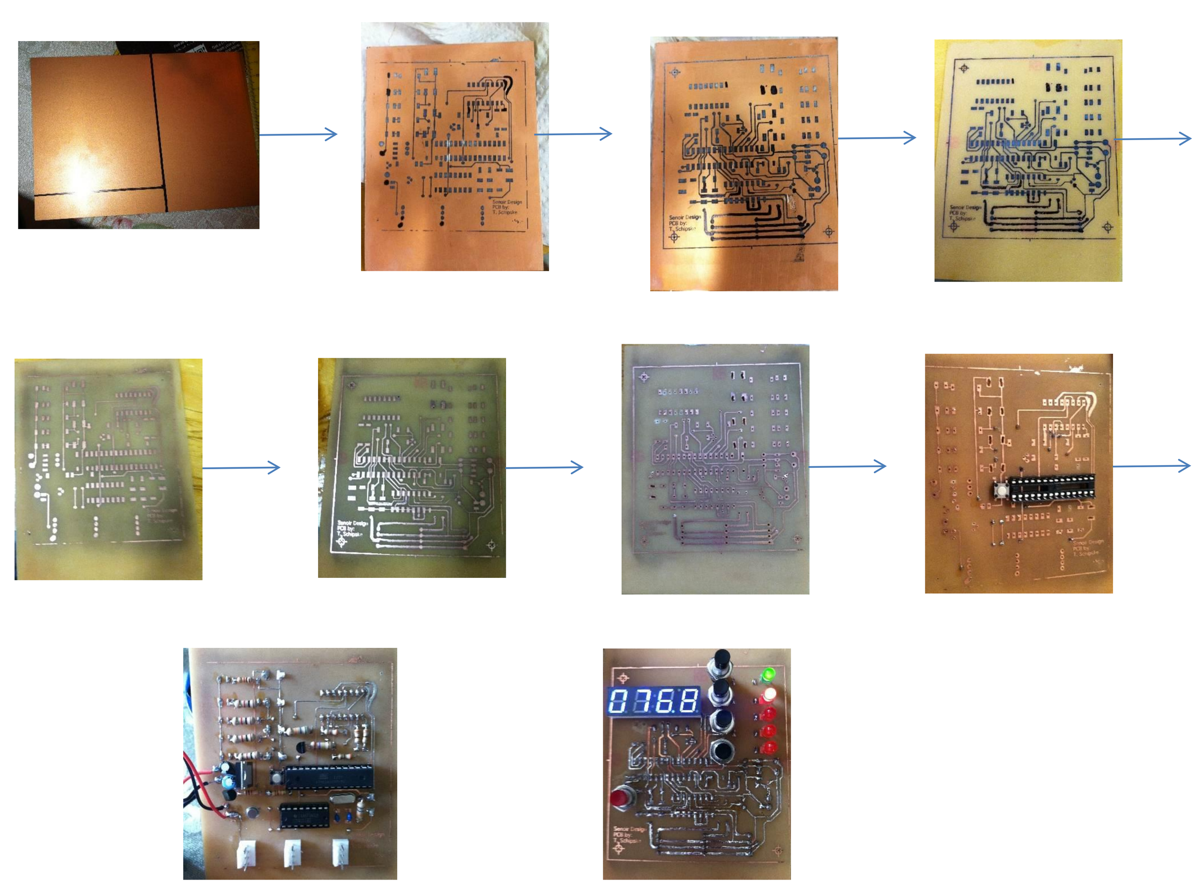


Building the PCB Board

When creating a PCB using a chemical etchant, you want to protect certain areas of copper from the chemical reaction and let the ferric chloride remove all the metal that remains exposed. A sharpie marker will also fulfill this function.
Now what we need is a way to transfer the printer ink to the copper board. PCBs are usually far too brittle and rigid to go through the printer. A simple solution is to print a mirror image of our PCB traces on a material to which the toner will bind only mildly, as it turns out glossy magazine paper works the best, then heat the material to re-melt the toner and get it to stick to the board.
Laser printers were used because the toner is transferred from the cartridge to the paper in a powdery form (inkjet printers use liquid ink, and thus are unusable for this purpose). In order to get the shapes and letters to stay in place on the paper, this powder--which contains plastic--is heated, so that it melts and fuses in place. Essentially the printed circuit is placed on the copper and a hot iron is used to transfer the ink. This is very similar to how most t-shirts are made.
The next step consists in removing unwanted copper from the board. Put the board into a container and the pour etchant on it. Then the solution is gently stirred until the unwanted copper dissolves. The board is then rinsed and the holes are drilled, making it very easy drill in the rest of the holes so that you may solder components into the board.

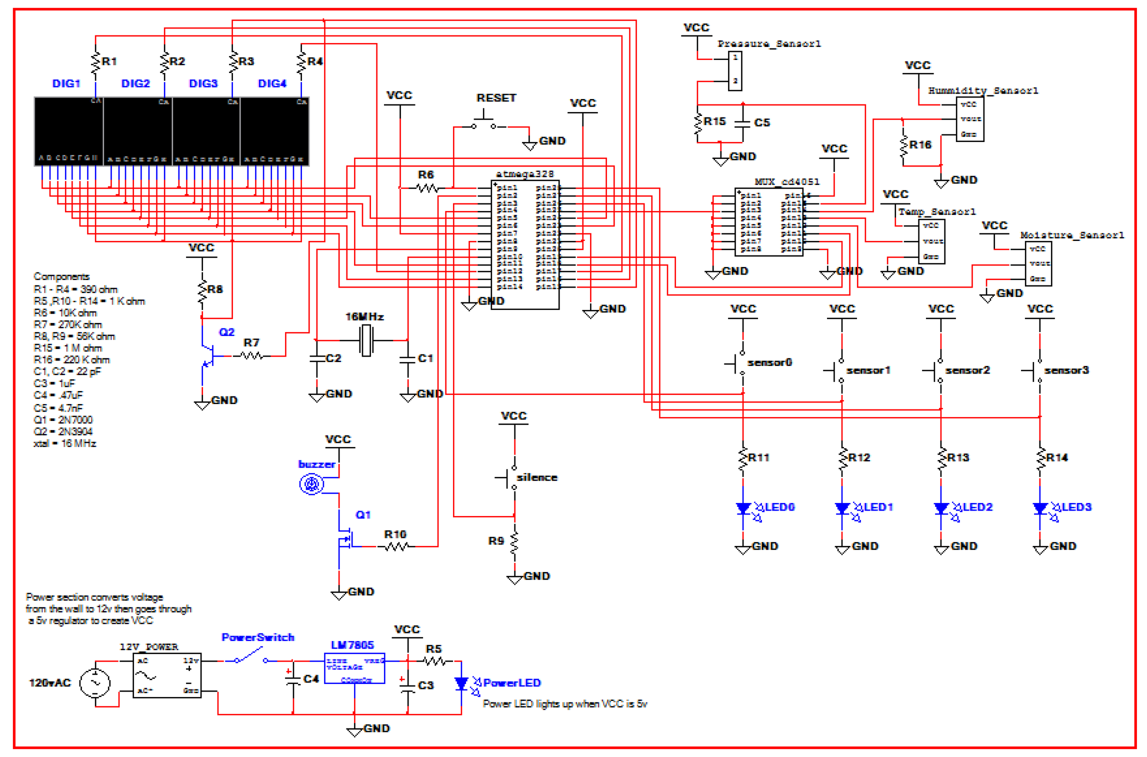


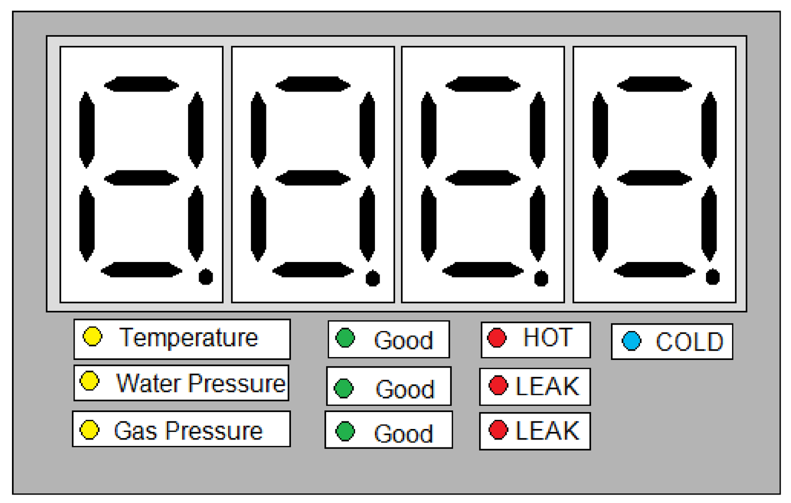




Circuit Design

A home automation and security system needs to be scalable and adjustable to the many different applications that present themselves. The system needs to flexible and adaptable with a simple easy-to-understand user interface. To accomplish flexibility across a wide expanse of applications the systems need to be modular. Additionally the individual components need to be properly packaged and sized to be incorporated into various appliances, outlets, or lighting systems. The power consumption of such devices needs to be minimal to ensure maximum power efficiencies.





A mockup of the final case design

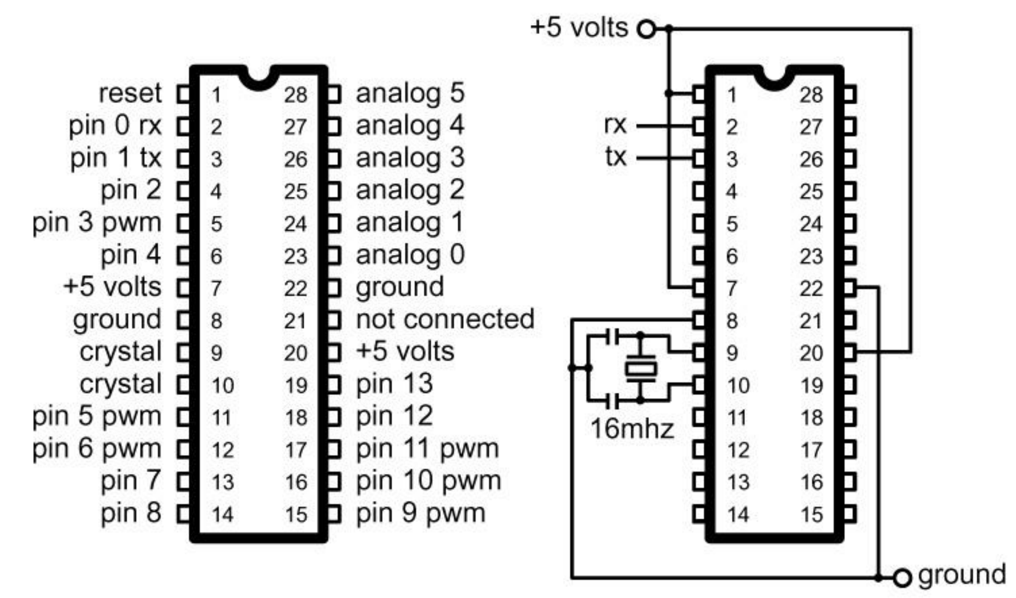
Conclusion

From the very beginning our project was made to be customizable based on needs, useful, modular, efficient and inexpensive. There are solutions to each problem that this devices solves, but they are problem specific, you would need an array of devices to do what this single device does. When we were going through the design process, we focused on how we could use it in our own homes. Thus we tried to solve things that we ran into, and we built something that, not only that we can be proud of, but something that we can use on a day to day basis.
Our smart home security modules fulfills all these goals and has to potential to do so much more. From connecting with cellular networks and your home Wi-Fi, to being able to run off solar power in remote locations, these unexplored avenues have an almost unlimited amount of potential, due to our steadfast hold onto those few ideals that we kept in mind while designing our project.

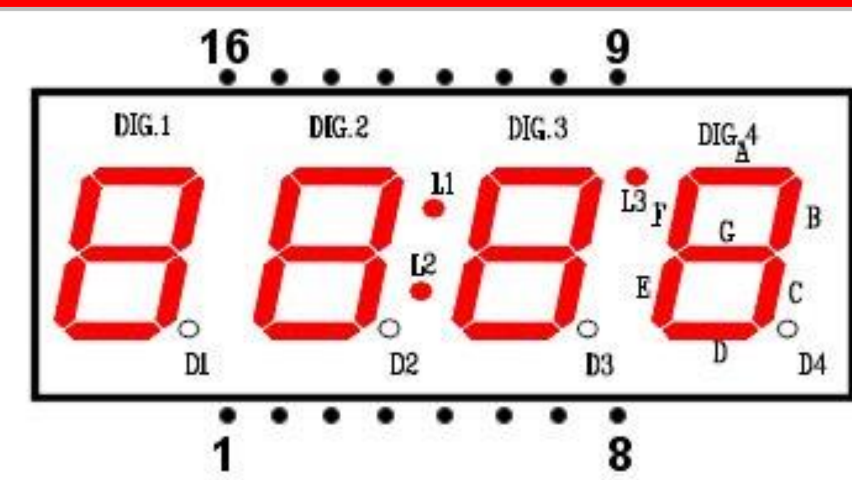
The Microprocessor

Backward compatibility is an important consideration and needs to be incorporated in the system design. This ensures the system will work most devices both existing and future along with being non-proprietary. To accomplish this a programmable microcontroller was used. The microcontroller used in this project is an Atmel chip series. Using this chip allows to the ability to send I/O signals to any device and allows necessary modularity.

The high-performance, low-power Atmel 8-bit AVR RISC-based microcontroller combines 128KB of programmable flash memory, 4KB SRAM, a 4KB EEPROM, an 8-channel 10-bit A/D converter, and a JTAG interface for on-chip debugging. The device supports throughput of 16 MIPS at 16 MHz and operates between 4.5-5.5 volts.
By executing instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.



7 Segment Display



Initially we were going to have the display on something other than an LED screen.
While this was definitely possible, we used this basic and common module to give our
results in a quick, easy to read digital format. Using this display was the best way to prove our concept and design.