Laundry Alarm

Team 8

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1. Introduction:

People often forget about their laundry and in shared laundry rooms this can back up the machines and cause issues. More importantly, clothes may become damaged or get a foul smell that is hard to remove if left sitting damp in the washing machine for long periods of time [1]. This can be a costly mistake, especially for students who already live on a small budget, as one load of laundry can be worth up to $100 or more in clothing [2].

Another issue that can arise, especially in busy laundromats or coin laundry stations, is that if someone doesn't pick up their laundry then the next person can't start their load and that delay is money lost for the business or coin operated unit. Even worse, someone could forcefully remove the clothes to put their own in, which could damage the load or force the user to rewash their clothes. According to the T&L equipment company, "The average wash costs you $2.50 and the average cost to dry is $1.25. This is typically 50% of your washing machine revenue. So, on an average day laundromat, X, has 20 machines at 4 uses a day at $2.50 per use is around $200 and another $100 for the dryers. That equates to $300 of profit for a typical day. [3]" If congestion becomes an issue and the machines get backed up to 3 uses per day for example, then you are looking at of $240 profit on a typical day. That would cause a loss of $60 per day and lowers the more congested the laundromat becomes. Our solution to this issue is to create a device that will notify the user when their laundry has completed its task, preventing congestion and backkup

We believe that our product would be a perfect solution for everyone from students in dorms or apartments to large businesses that run multiple coin operated machines. Dorm and apartment laundry rooms are always busy and people often forget or leave their load in the washer or dryer for long periods of time after the load has been completed. The same issue can arise in busy laundromats. Our product helps eliminate congestion and traffic in laundry rooms and help people save time by notifying them as soon as their laundry is ready for pickup.

A device like this is currently not available on the market, except for brand new washers and dryers that have a feature like that built in, but those solutions can be very expensive, costing upwards of 1000$. Our solution, however, would work on all models by simply plugging your washer or dryer unit into our device and getting notifications on your mobile device for a fraction of a cost.

1.1 Background:

According to Lucinda Ottusch, the lead home economist at the Whirlpool Institute of Fabric Science, "If you let your wet clothes sit long enough, you'll have to deal with not only the mildew smell in your clothes, but also possible stains and patches of rotten fabric. [1]" Depending on the quality of clothes you own, this can cost you up to $100 in clothing that could be ruined [1]. This would be a very costly problem especially for students who are already on a tight budget.

Also, according to Pheena Kenny, who works with the The Asthma Society of Ireland, “The moist environment of your washer encourages mold and mildew to release spores. This can cause problems for people with conditions like asthma. "Normally, when people breathe in these spores, their immune system helps get rid of them by coughing or sneezing. If you aren’t sensitive to mold, you may never even experience a reaction [1]”. According to the center for disease control and prevention about 1 in 12 people in the United States (about 25 million) have asthma, and the numbers are increasing every year [8], so our product has the potential to help millions of people with allergies. By making sure the user of the laundry machines do not let laundry sit and give the potential to collect mold and dust.

One existing (DIY) solution to this problem that we discovered online is a vibration sensor that is mounted on the outside of the machine. That, however, is not a good solution because calibrating the vibration sensor would be very difficult for the wide variety of washing machines on the market. Every machine would vibrate at a different frequency and magnitude, so it would be impossible to make a universal solution using vibration sensors. Vibration from nearby machines would also interfere with measurements. Another thing is that many new washing machines have advanced vibration dampening so newer, more expensive models would not work with vibration sensors at all. Our device, which will measure current draw, is a universal solution that will work with any model, whether it’s 30+ years old or brand new.

1.2 High-level requirements list:

- Our device will have to operate on a wireless network and maintain a data transfer rate as described in the ESP8266 wifi chip of around 11520 baud, the amount needed to maintain a proper server connection between the microcontroller and the android application.
- The device will have to operate within a building and have a range of 150 to 200 feet from the router.
- The device will need a software delay of around 1 minute of zero current (or below threshold current) before sending the alarm to avoid sending a false alarm when the washer or dryer is between cycles or in a cycle that draws little to no current.
- The device will be an affordable solution (less than $50) to the problem we mentioned earlier.

2. PHYSICAL DESIGN

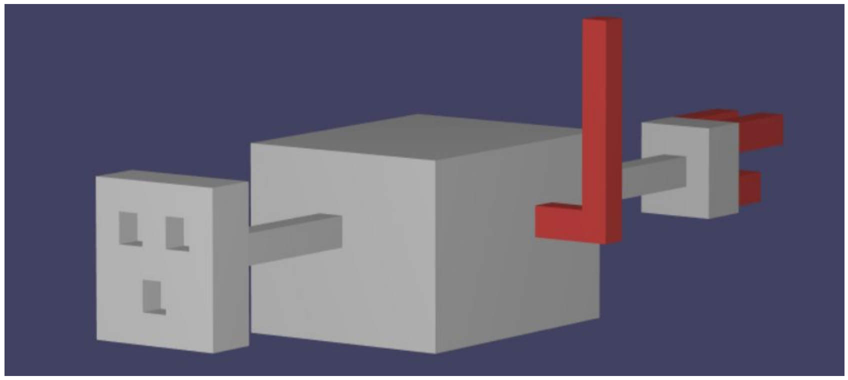

Figure 2.1

The image in Figure 2.1 depicts a rough 3D model of our design. The look is similar to that of a laptop charger with an inlet and outlet on either sides of the box, which will have the following dimensions: 154.94mm x 116.84mm x 60.198 mm.

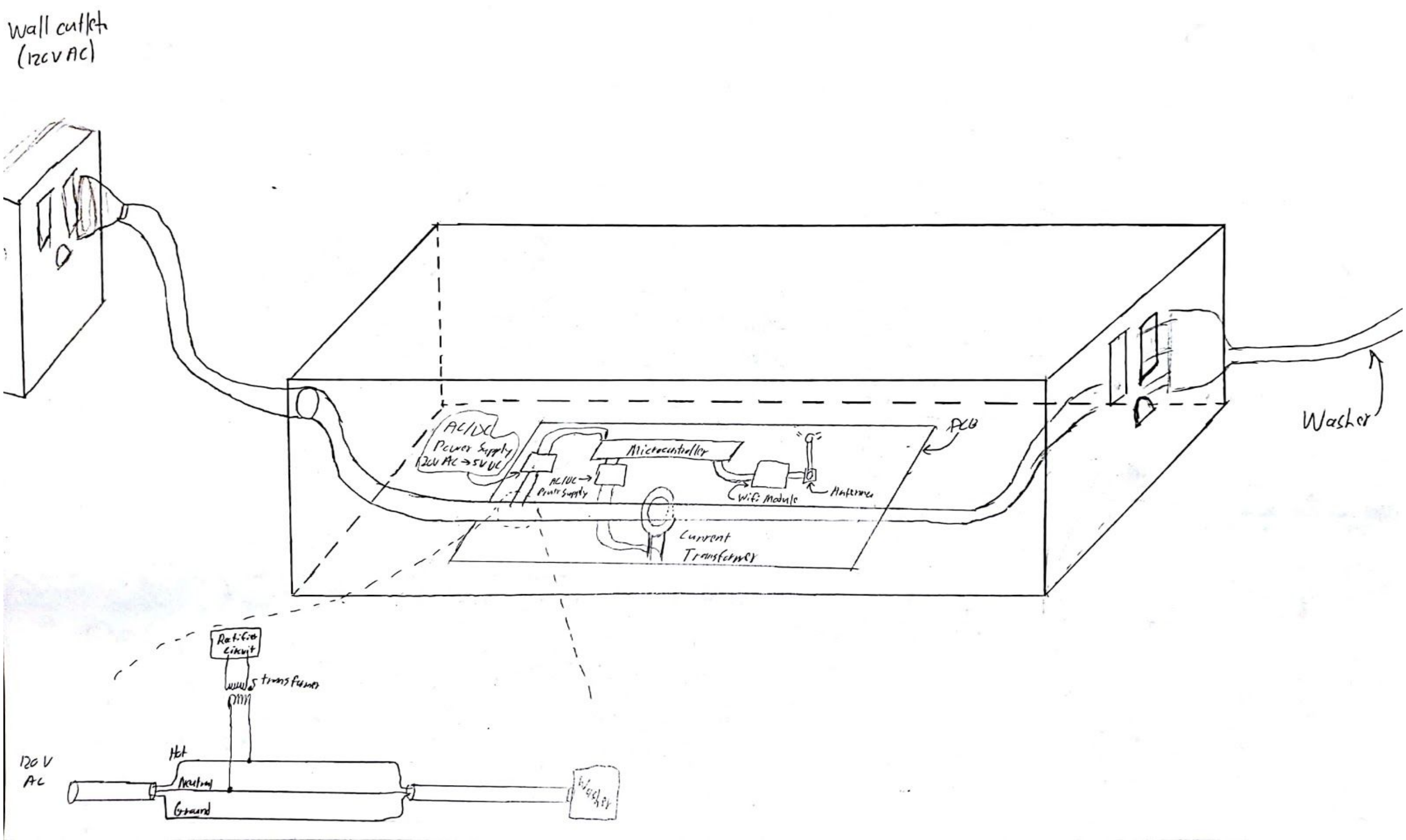

Figure 2.2

Figure 2.2

This figure represents a 3D model of our device. The rectangular enclosure or casing is made of ABS thermoplastic. This enclosure will have an outlet on the right to plug in an appliance and a 120V AC cable from a wall outlet will be led through the casing (through a 21mm cable gland) and to the outlet on the other side. The zoomed in diagram in Figure 2.3 shows where the wire will be tapped to power the low voltage components.
Casing/Enclosure size**:** 6.1" x 4.6" x 2.37" = 154.94mm x 116.84mm x 60.198 mm.
Max PCB size: 100mm x 100mm.

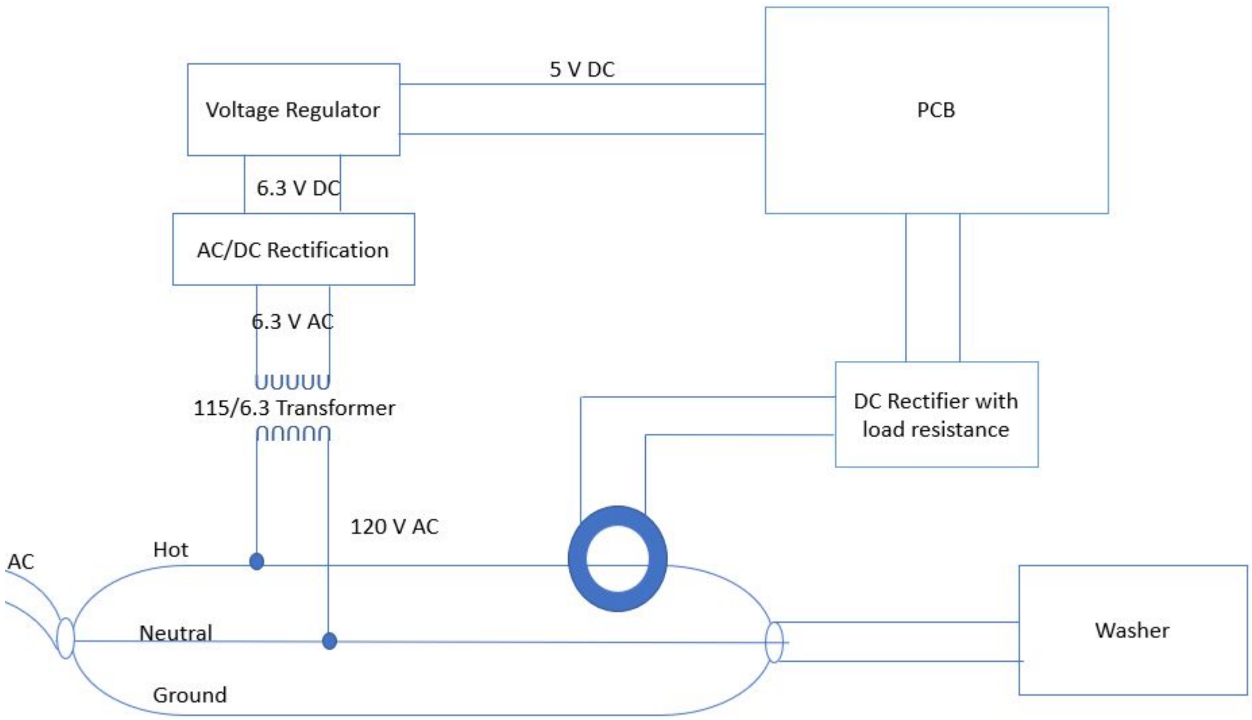

Figure 2.3

Figure 2.3 shows how the low voltage components of the device will be powered. The wire will be stripped and we will tap the HOT and NEUTRAL components of the wire. We will then re-apply insulation using electric tape and heat shrink to ensure the wire is not exposed. A transformer will then be used to step down the voltage to 6.3 V AC and then a full bridge rectifier and capacitor will be used for AD/DC rectification. Finally, a voltage regulator will be used to get the desired 5V input for the microcontroller.

3. DESIGN

This device requires three main components to function properly: power, control, and a Wi-Fi communication module (as seen in figure 3.1). The device will be powered from a wall outlet (120V AC) and we will implement a AC/DC converter to get two different output voltages, being 5 and 3.33 volts. The AC/DC converter will be used to power the low voltage components of our device like the microcontroller and Wi-Fi module. Another thing to be considered is that we will have to plug the washer or dryer into our device to both power the washer or dryer and collect the current data going to the washer or dryer using a current transformer (CT). The CT will be loaded with a resistor, and the voltage across the resistor will be used to collect data for the microcontroller. After the data is analyzed, we will send that information over Wifi to a mobile device or computer so we can notify the user when the wash or dry cycle has been completed. The information transmitted out from the microcontroller will be analyzed through temboo and then transmitted to a parse server which will read the information and determine whether to send a popup notification to the cellular device through an android app.

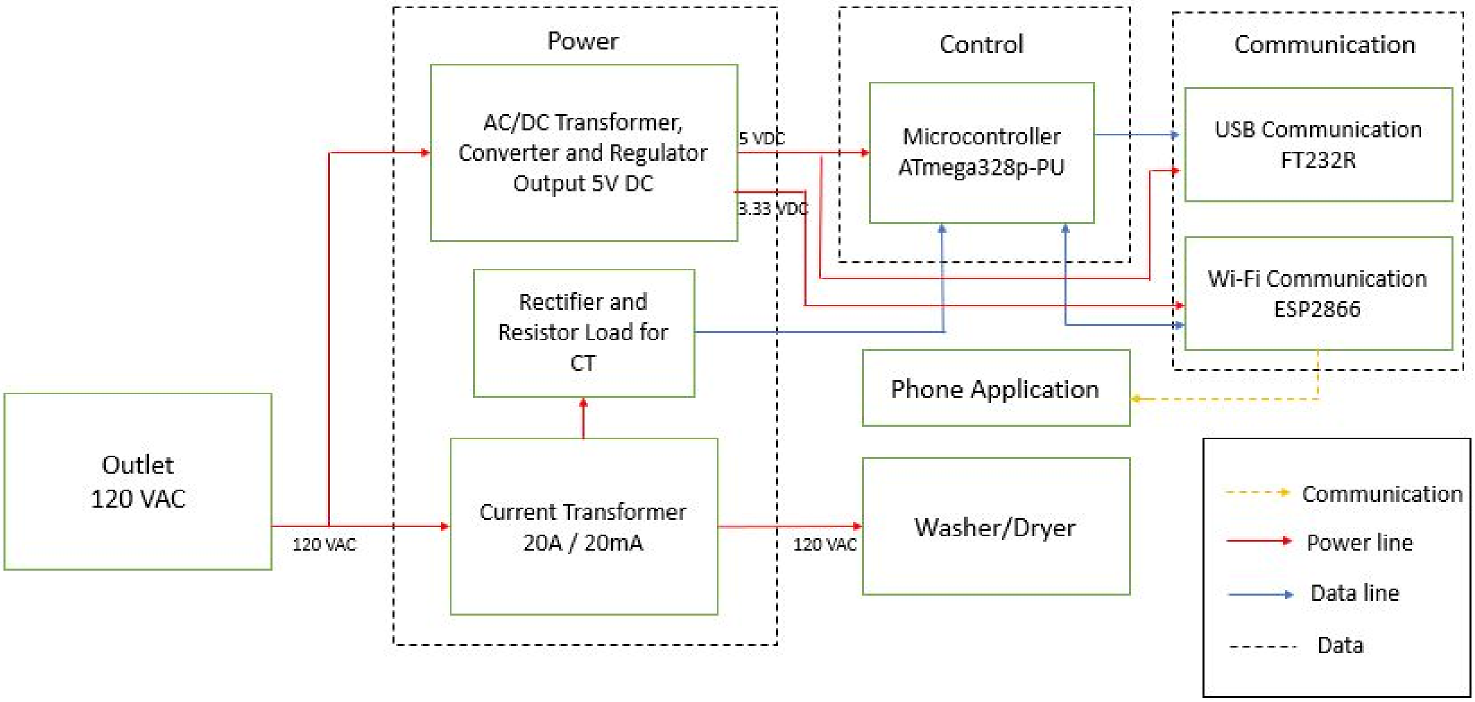

Figure 3.1 Block Diagram

3.1 Power

120 V AC needs to be stepped down and regulated to provide DC voltage for the ATmega328p-PU microcontroller, ESP2866 wifi adapter, and FT232RL USB adapter. Power for the washer/dryer will pass though the current transformer.

3.1.1 AC/DC power supply

Before the current transformer, an AC/DC power supply will be used to provide regulated DC voltage for the system. This consists of a transformer, full wave rectifier, a parallel capacitor and a voltage regulator to transform 115V AC to 5V DC ±5%. The microcontroller Wi-Fi communication, and USB communtion FT232RL are the only three devices needing power directly from the power supply, so current draw will be low for this power supply. This power supply will consist of a 115V/6.3V transformer, full bridge rectifier, voltage regulator, and some capacitors.

Specifications:
Output voltage: 5V ± 5%
Output current:

ATmega328p-PU:	0.2 mA @ 5 V
ESP2866:	120 mA @ 3.33 V
FT232R:	15 mA @ 5 V
Total:	**135.2 mA**

Requirements:	**Verifications :**
To ensure proper operation of the voltage regulator, input voltage to regulator must be between 5 and 12V. As explained in Tolerance section 4.2, the power supply rectified and filtered output is rated to be within this range with maximum component tolerance error.	Scope the output and make sure the output voltage ripple is within specification of the voltage regulator.

3.1.3 Voltage Regulator

The voltage regulator will step down the 6.3V DC coming from the rectifier to the desired voltage of 5VDC for the microcontroller and a voltage divider will provide 3.33 VDC for the ESP8266 wifi module. The ATmega328p-PU should receive 4.5-5.5V as shown in Figure 3.2.

Requirements:	**Verifications :**
Must step down 6.3 V DC from rectifier circuit to 5V ± 5% for the microcontroller Must step down 6.3 V DC from rectifier circuit to 3.33V ± 5% for the ESP2866	Use voltmeter across the output terminals of the voltage regulator to check if voltage is within the specified range Use voltmeter across output terminals of the voltage regulator to check if voltage is within the specified range.

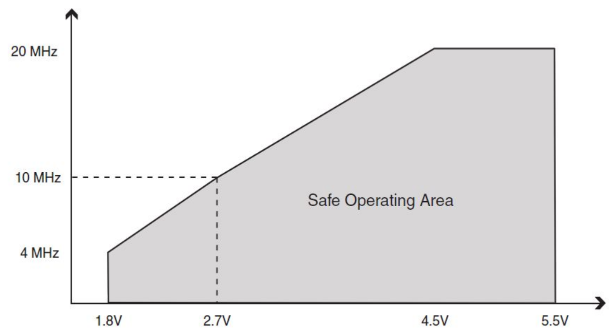

Figure 3.2 ATmega328p-PU Maximum Frequency vs Input Voltage

3.1.4 Smoothing Capacitors

After rectification we will need 470uF capacitors to smooth any fluctuations or ripples in the signal. As shown in Figure 3.3 the capacitor smooths the signal by charging and discharging effectively reducing the magnitude of the rectified ripple..

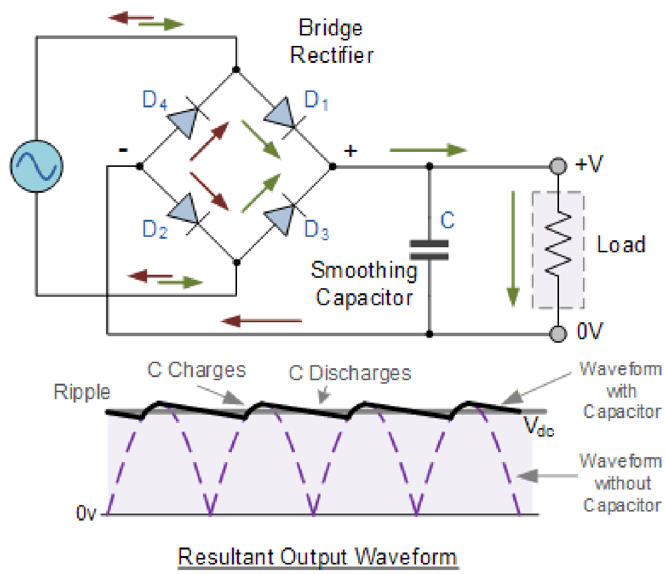

Figure 3.3 Full Wave Rectifier and Bridge Rectifier Theory [5]

3.1.2 Current Transformer, Rectifier, & Resistor Load

The current transformer will be measuring current after the power supply to avoid including the device's current in its measurements. The output of the current transformer will be rectified and loaded by a resistor. The voltage across the resistor will be measured by one of the microcontroller's analog inputs. The resistor that will be used as a load for the current transformer is calculated in the Calculations section 3.7 to provide 5V DC for the microcontroller at a high side load of 20A.

Requirements:	Verifications :
The voltage across the current transformer load must be below the absolute maximum analog input of 6V. As explained in Tolerance section 4.2, the voltage across the load is within this range with maximum component tolerance error as long as the load stays below the maximum CT input of 20A.	Create a test circuit with 20 A on a wire to measure the voltage across the load of the CT and ensure that it below 6V. This can be measured with a voltmeter.

3.2 Control Unit

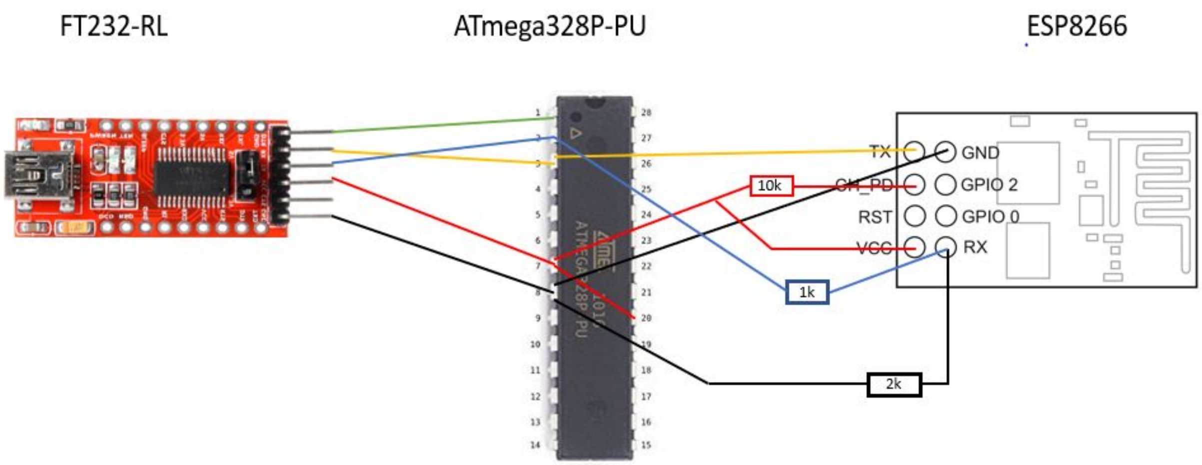

Figure 3.4

The control unit will receive current draw data from our current transformer and that will then be analyzed and determine when to notify the user through a mobile application. If the current falls below some threshold for around a minute, the control unit will send a signal to the wifi module and then to the user, so they can be notified. Figure 3.4 describes the connection shared (from left to right) between the FT232RL, the ATmega328p-PU and the ESP8266 wifi module. The FT232RL is connected to the microcontroller to enable communication between the ATmega238p and a computer in order to program it. The ATmega238p will be used to communicate with the ESP8266.

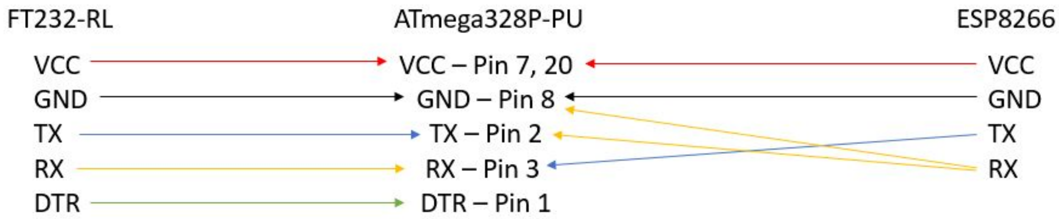

Figure 3.5

Figure 3.5 describes a high level of the different pinout configurations used between the FT232-RL, the Atmega328P, and the ESP8266 Wi-Fi module. The Atmega will be running at 9600 baud and communicating with temboo through the ESP8266, the Wi-Fi module will be running around 115200 baud. In order to flash programs onto the microcontroller, we will be adding a 16MHz crystal to offset the clock frequency to match that of what one would use on the arduino uno. The FT232-RL will be the connection between the computer and the microcontroller so that the controllers can have sketches uploaded to them.

Requirements:	**Verifications :**
Microcontroller: 1. Must receive current data from the current transformer	A. Create a simple program for the microcontroller that can receive that data obtained from the current transformer. B. The program will read the data from the analog pins of the microcontroller and display the values to the computer. C. We will test the output pins with an oscilloscope to determine if the signals are being transmitted properly.
2. The microcontroller must be able to communicate with UART at rates > 50 kbps, the fastest speed the microcontroller can run without significant data loss.	A. Establish a bridged communication between the microcontroller and a form of terminal emulator like PUTTY. B. Set the Baud rate to be 9600 bps or (50 kbd) via the SERCFG command which allows baud rate configuration parameters to be set over PUTTY through the micro-USB cable. C. Send and receive the echo of > 50 characters and verify that each character is correct.
3. Must be able to run at a voltage of 5.0V +/- 5%	A. Probe the input of the microcontroller with an oscilloscope to ensure it can run at the desired voltage range

3.3 Wifi Communication

3.3.1 Block Diagram for Software Communication

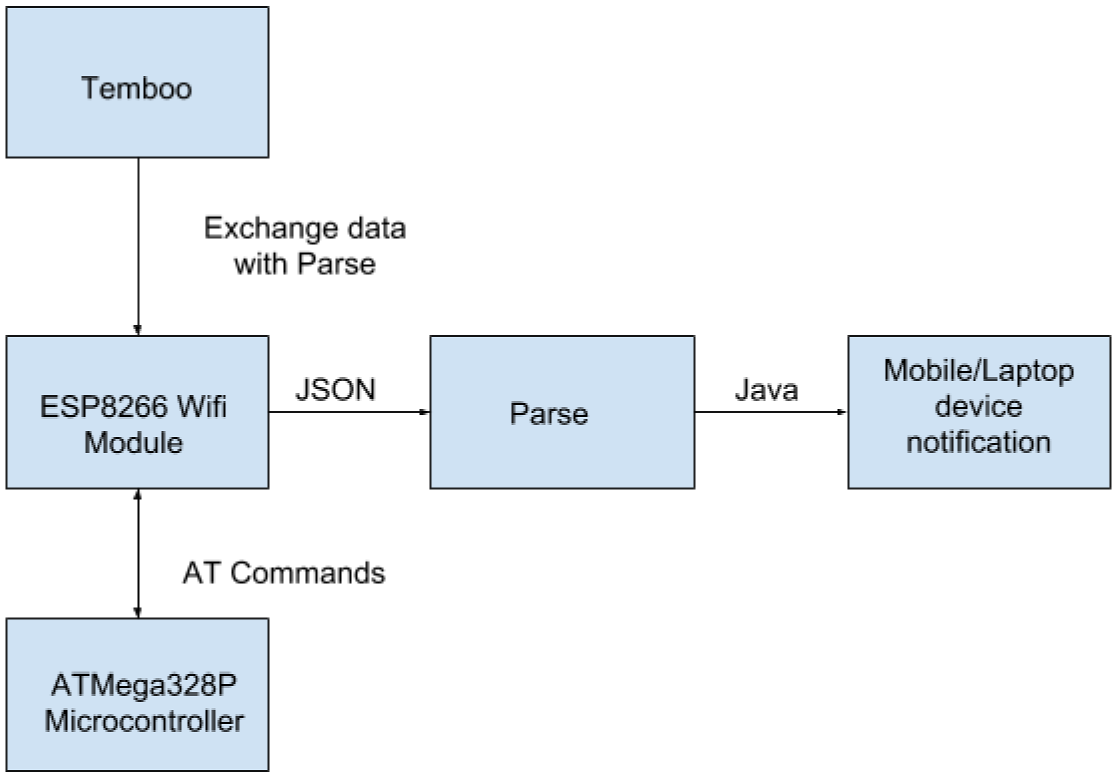

Figure 3.6 Software Block Diagram

As shown in figure 3.6:

- The ATMega328P will communicate with the ESP8266 module through the use of AT commands, a common protocol used with IOT projects.
- To enable the WiFi communication between the arduino and the cellphone, two third party apps will be utilized. One is “Parse.com” which will enable an environment from which push notifications to an android device can be created, and the other is “Temboo”.
- For the lower level, the Arduino Sketch application will be used to check the digital pin output from the arduino chip to obtain a signal, which will be sent when the Arduino notices a drop in current signifying the stop of a washer/dryer cycle.
- “Temboo” will be utilized to create a set of connections to the outside internet such as “google.com”, and in our case, will be an agent used to send data to “Parse.com”
- Writing a C++ script in “Parse.com” we can send out a push notification to our IOT device

3.3.3 ESP8266 WiFi module

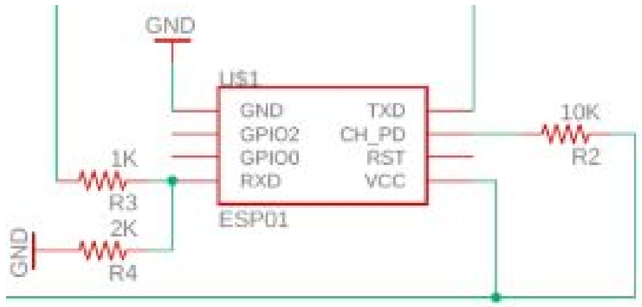

Figure 3.7

The ESP8266 module shown in figure 3.7 is the Wi-Fi device used by the microcontroller to communicate with a Temboo agent in order to deliver a notification to a user's cell phone through an IoT signal. This module is important because it has a Wi-Fi stack and a TCP protocol, both of which will be used to send information to and from the microcontroller to the Android device. It will primarily be used as a source of communication between the temboo agent and the microcontroller. We will run the ESP8266 at 115200 baud, as it will be rapidly sending commands through a temboo choreo the rate at which it needs to send data is very high. The primary concern is establishing a proper and consistent connection to ensure that no sent packets will be dropped.

Requirements:	**Verifications :**
Wi-Fi Module:	
1. Must be able to run at a voltage of 3.0V +/- 5%	A. Move the voltage over a the range of 3 +/- 3 volts and see if the AT command AT returns the response OK from the ESP8266 from the microcontroller.
2. Must have a transmission rate of around 125 +/- 25 feet.	A. A test notification program will be created in order to send a popup to an android device on command. B. The user will walk different distances around a building within the range of 100 to 150 feet and see if the notification can be successfully received.
3. Must allow for a data transfer rate of around 14 +/- 5% kBps	A. Establish a connection through the wifi module over the microcontroller and type the commands AT to make sure it is working properly. B. The command AT should return OK. C. The command AT+CWMODE=1 and

	AT+CWTAP=”wifi network”, “password” must return OK D. Open a web browser and enter the IP of the wifi module to receive data and open a putty session and set the proper baud rate using the SERCFG command and establish a server connection with the Wi-Fi module. E. Now, type in any length of characters > 50 and it should be echoed on on the web page through HTTP.

3.3.2 Android App

The android app will be created by an android development studio and will utilize the package from parse.com, which is utilized to create an environment from which a popup message (seen in figure 3.8) can be sent to a mobile device. The temboo choreo agent will communicate through parse.com to the android app through JSON and the app itself will be created in java. The app needs to be able to maintain a proper connection with the wifi module, so the ESP8266 will need to act as an Access Point for the android app to connect to and through temboo, the proper wifi api protocols will be created to ensure proper security when using the IoT application.

Figure 3.8

Requirements:	Verifications :
1. Must be able to receive a signal from the microcontroller through temboo at the microcontrollers rate of 50 kbps +/- 10%	A. Create a test application on an android development studio see figure 3.9. B. Create an account on parse.com and import all the packages. C. Compile and test to see if a popup notification appears correctly through the android app on the emulated environment.
2. Must be able to send a popup notification within 5 +/- 1 seconds to an emulated android environment.	A. The notification must be sent within 4-5 seconds of the signal being received.

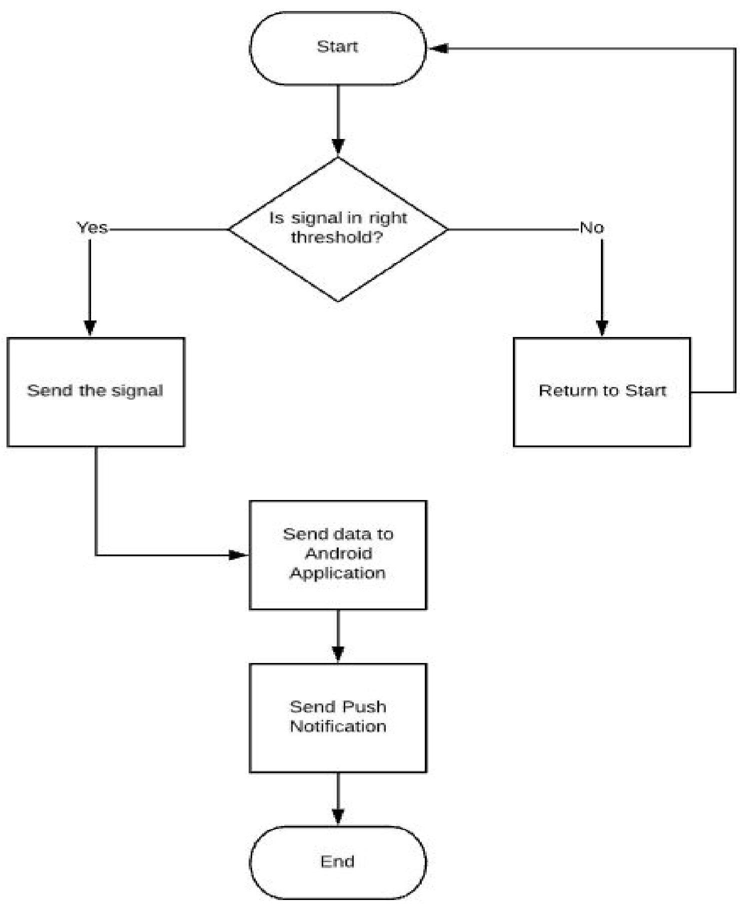

Figure 3.9 - Flowchart for Overall Program

3.4 Case

Requirements:	**Verifications :**
1. Design should fit all components inside a 6.1” x 4.6” x 2.37” case	1. Check dimensions of all components and ensure that they will fit inside the case with the specified dimensions. Case must seal and screw on securely.

3.5 Circuit Schematics

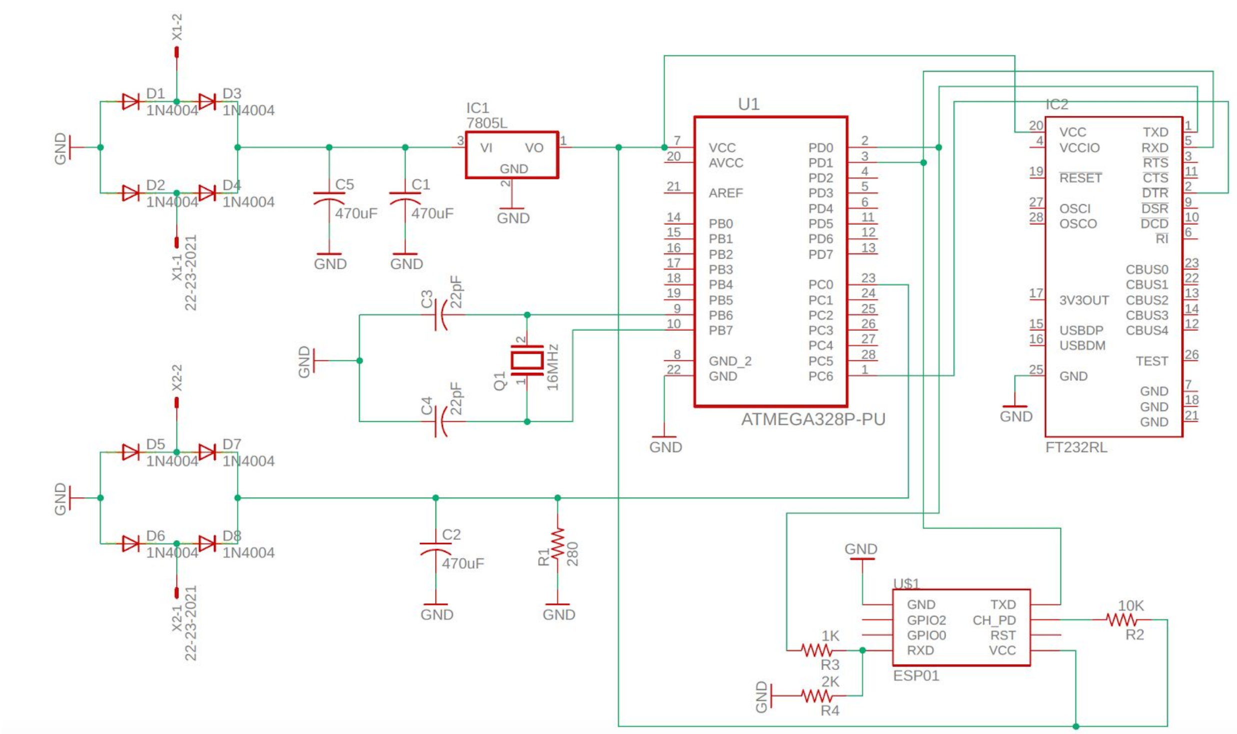

Figure 3.10 Circuit Schematic for Power, Control, and Communication

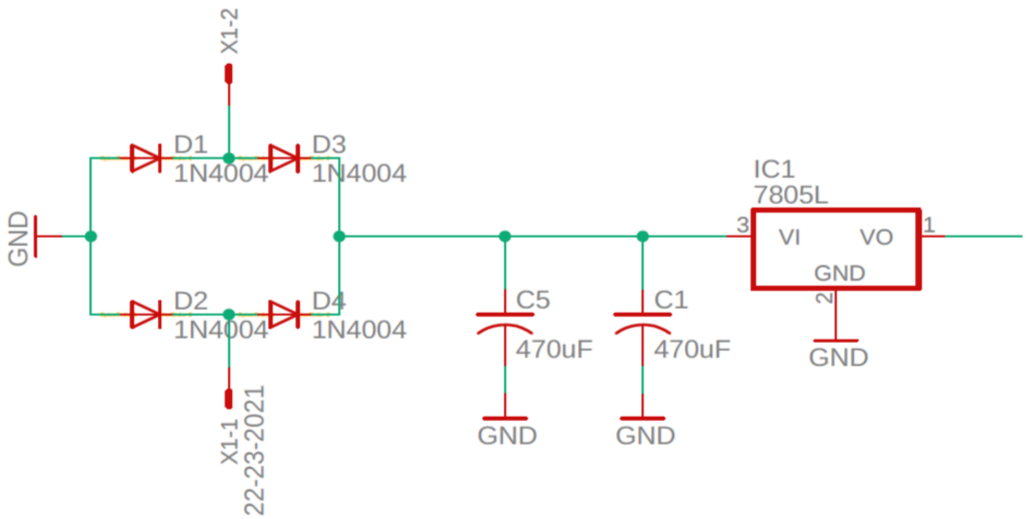

Figure 3.11 **Power: Rectifier and regulator circuit**

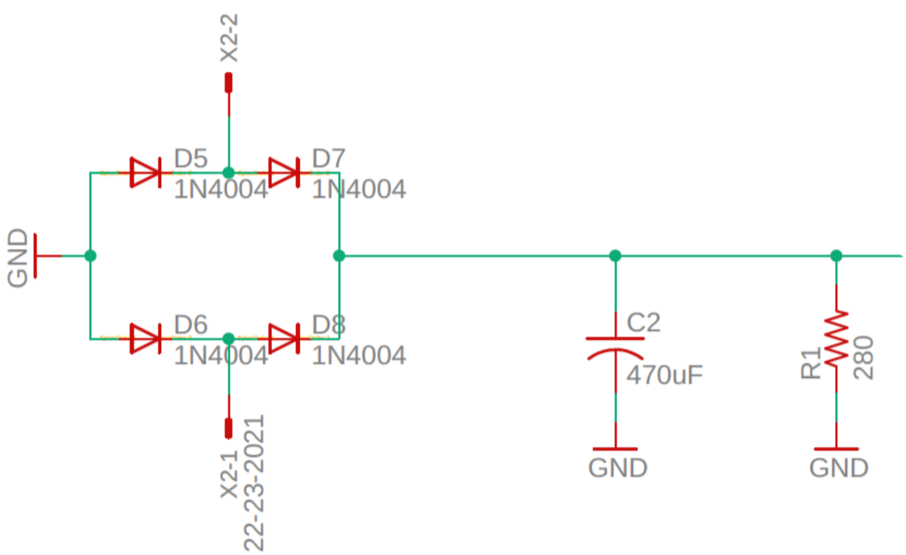

Figure 3.12 **Power: Current Transformer**

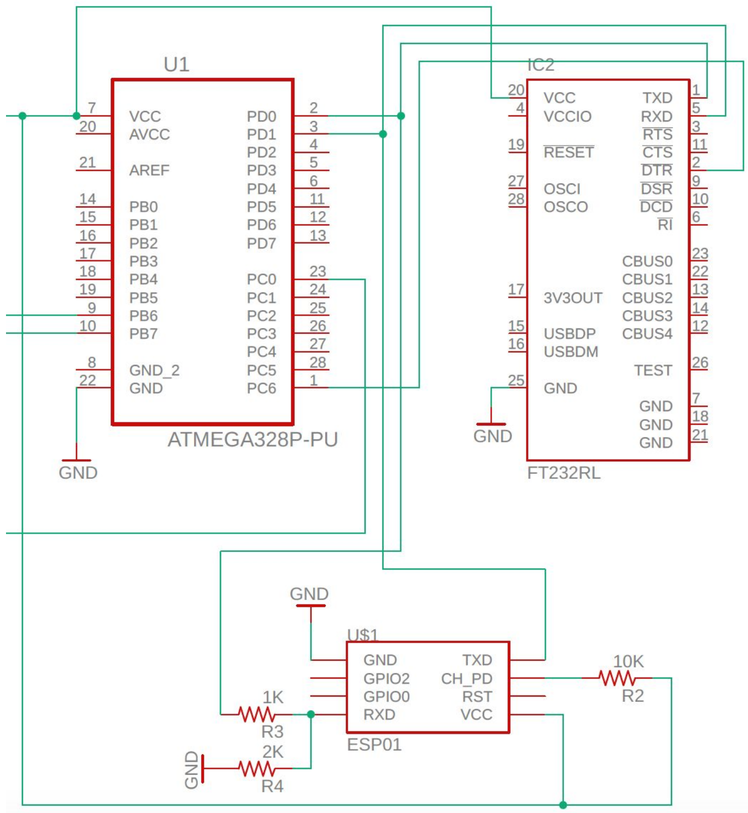

Figure 3.13 **Control & Communication: Microcontroller, Wifi Module, FT232RL**

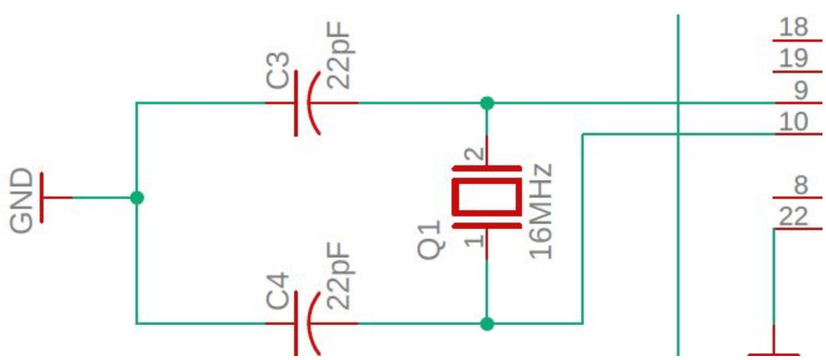

Figure 3.14 **Crystal Oscillator**

3.6 Simulations

Power Supply:

The power supply is simulated in LTspice using library files for a 1N4004 Diode and a lossless transformer (Figure 3.15). The load is the sum of current draw from the ATmega328P, ESP2866, and the FT232R. As shown in the power requirement in 3.1.1, this draw is calculated at 135.2mA. At 5V, the resistive load can be simulated as:

$$\frac{5}{0.1352} = 36.98\ \Omega$$

To ensure proper operation of the voltage regulator MIC5219-5.0YM5-TR, we need to make sure the lowest value of the ripple voltage is greater than the minimum input voltage of the regulator. This is value is 5V. Also, the greatest value of the ripple has to be lower than the maximum input voltage of the regulator. This value is 12V. Our simulation shows the minimum and maximum value with the calculated load to be 6.06 V and 7.25 V respectively, which is well within the limits. (Figures 3.16 and 3.17)

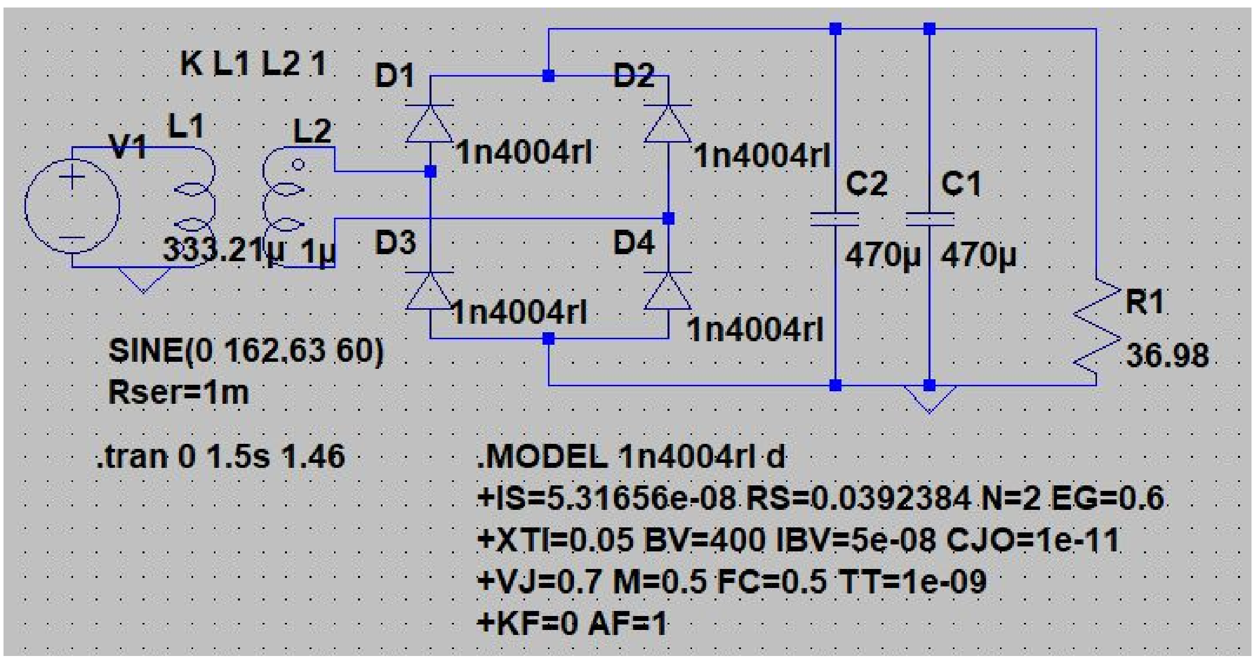

Figure 3.15 **Power Supply Circuit**

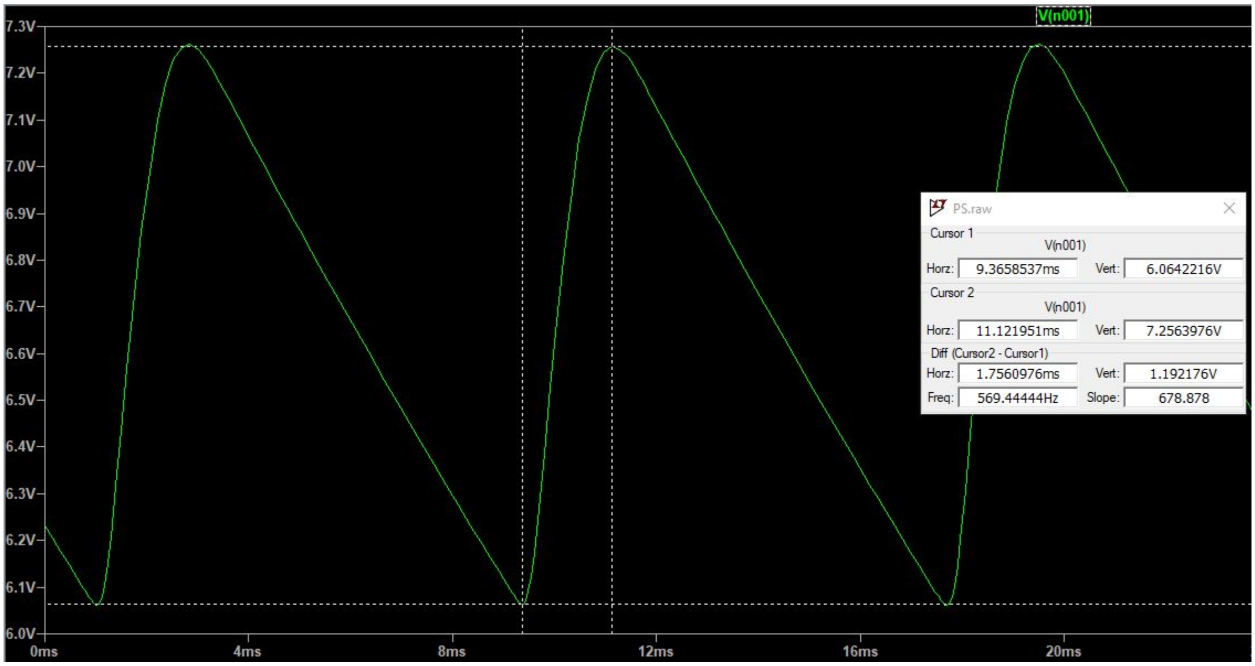

Figure 3.16 Power Supply Simulated Output Voltage - Without Voltage Regulator

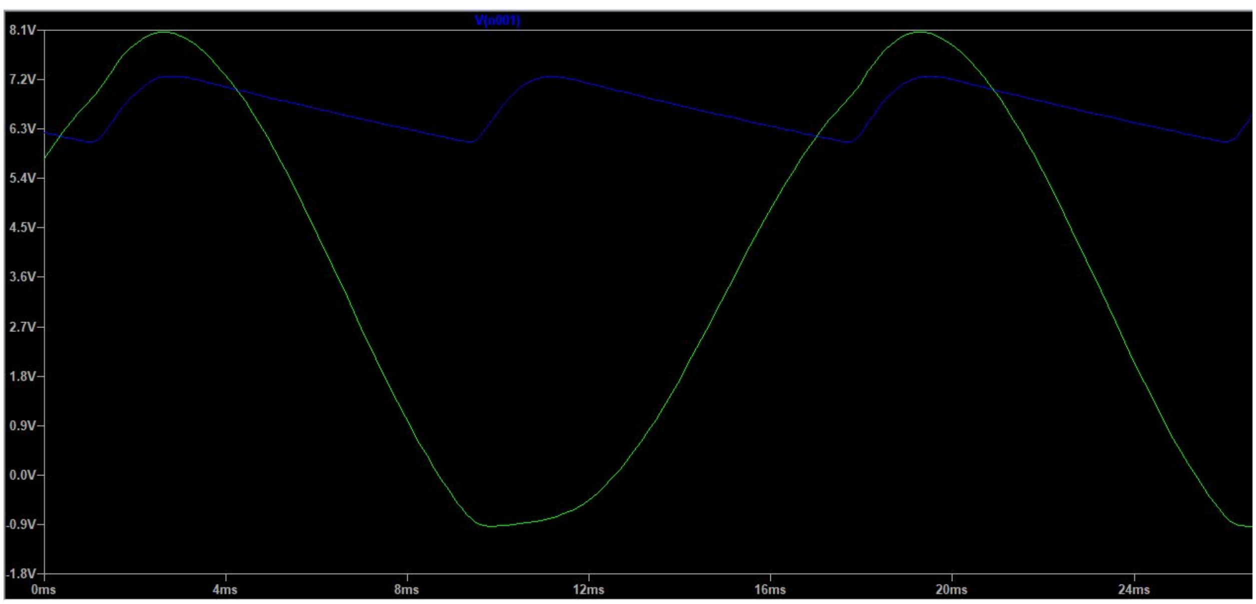

Figure 3.17 Power Supply Simulated Output Voltage (blue) and Transformer secondary voltage (green) - Without Voltage Regulator

Current Transformer:

The current transformer circuit is simulated in LTspice using library files for a 1N4004 Diode and a current source as the secondary windings on the CT (Figure 3.18). The load is calculated in the Calculations section 3.7. The voltage output across the load has very little ripple for high accuracy as shown in Figures 3.19 and 3.20.

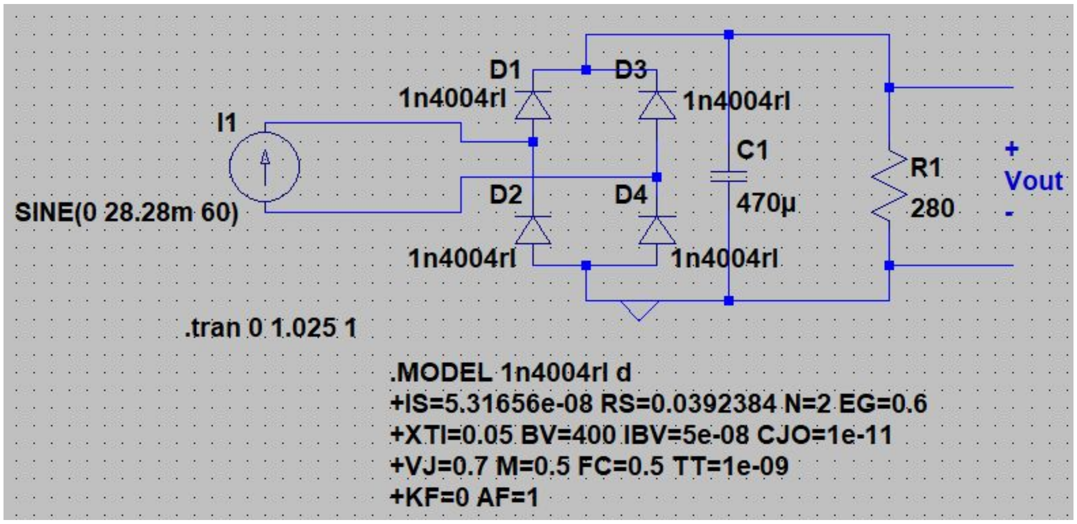

Figure 3.18 **Current Transformer Circuit**

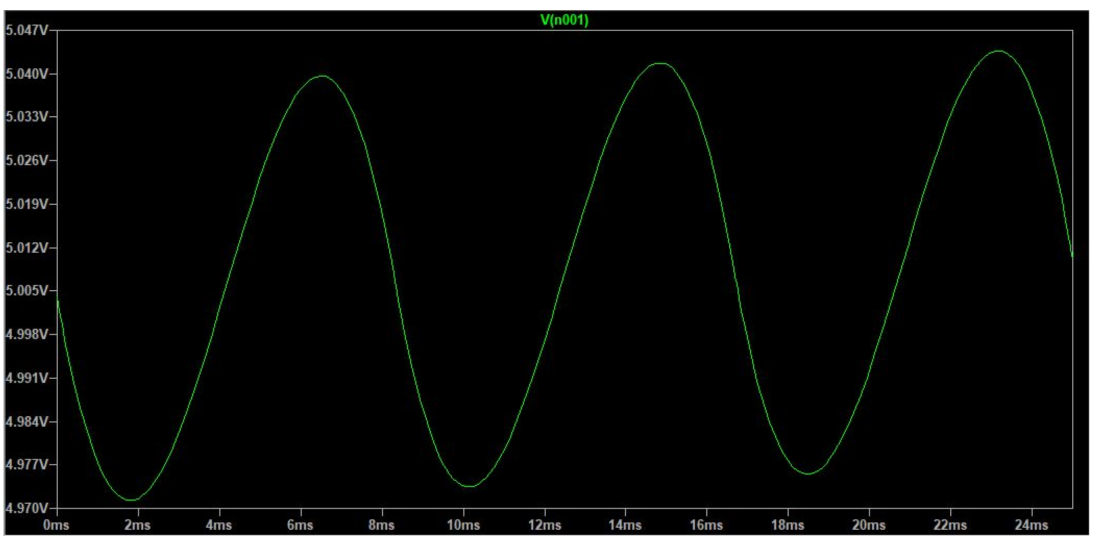

Figure 3.19 **Current Transformer Output Voltage**

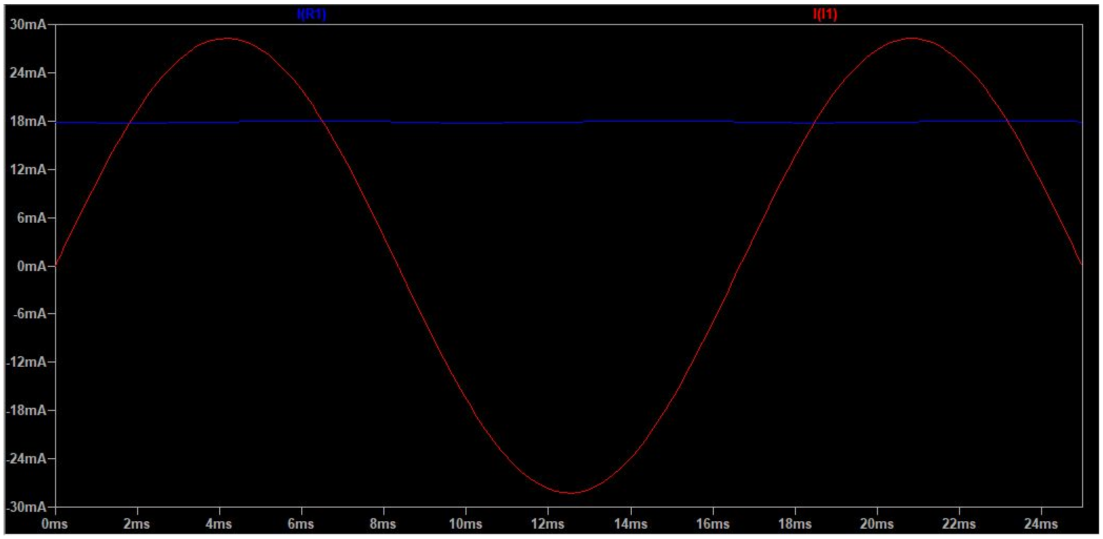

Figure 3.20 Current Transformer AC Output Current (red), Rectified Current (blue)

3.7 Calculations

Load Resistor for Current Transformer:

To calculate the load for our current transformer to output 5V at 20mA, we need to find the average current after rectifying the waveform:

$$I_{avg} = \frac{1}{T}\int_0^T I_{RMS}\sqrt{2} * sin(\theta)\, d\theta \quad \textbf{(1)}$$

$$I_{avg} = \frac{1}{\pi}\int_0^\pi 20 * 10^{-3}\sqrt{2} * sin(\theta)\, d\theta \quad \textbf{(2)}$$

$$I_{avg} = 18.006\ mA \quad \textbf{(3)}$$

$$With\ V_{out} = 5V,\ R_{load} = \frac{5}{18.006*10^{-3}} = 277.68\ \Omega\ \approx 280\ \Omega \quad \textbf{(4)}$$

4. Tolerance Analysis

4.1 Current Transformer

In order to determine whether or not the washer or dryer has finished it's cycle or is in a break period (starting rinse cycle), the performance of the current transformer and resistor load are key components. The current transformer will need a high degree of accuracy to ensure precise data collection and analysis.

The ATmega328p_PU analog input has an absolute maximum of 6V. The CT being used is rated at 20A/20mA at 0.1% ratio error, the load resistor has a tolerance of 5%, and the capacitor has a tolerance of 20%.

Assuming the maximum error for each component:

- At saturation of the CT (20A), the output would be 20.02 mA instead of 20mA
- The load resistor will be 294 Ω instead of 280 Ω
- The capacitor will be 376 uF instead of 470 uF

With these values, the output voltage is stimulated in Figure 4.1 to produce 5.260 +/- 0.0426 V, which is below the absolute maximum voltage of the analog input. Due to saturation limitations in the CT, our device is limited to washers/dryers drawing less than 20A.

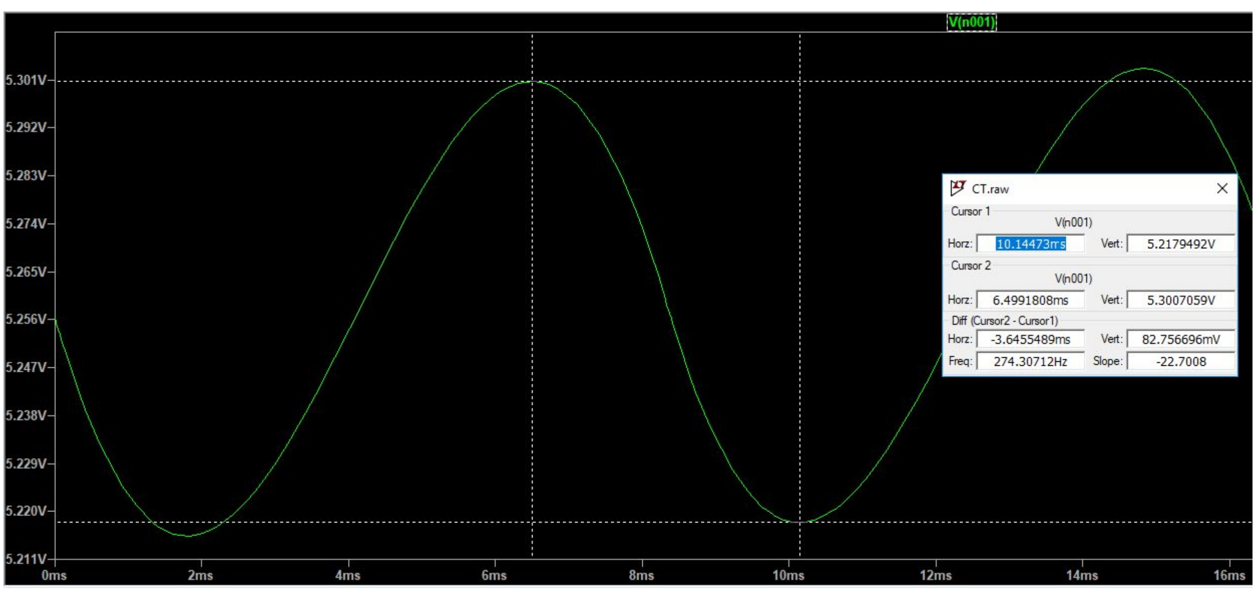

Figure 4.1 Current Transformer Output Voltage with Maximum Tolerance Error

4.2 Power Supply

As mentioned in section 3.6 for simulations, to ensure proper operation of the voltage regulator MIC5219-5.0YM5-TR, the input needs to be between 5 and 12 V. The capacitors used have a tolerance of 20%.

Assuming the maximum error for each component:

- The capacitors will be 376 uF instead of 470 uF

With these values the voltage ripple is 5.83 to 7.27V as shown in Figure 4.2, which is well within the specified tolerance of the voltage regulator.

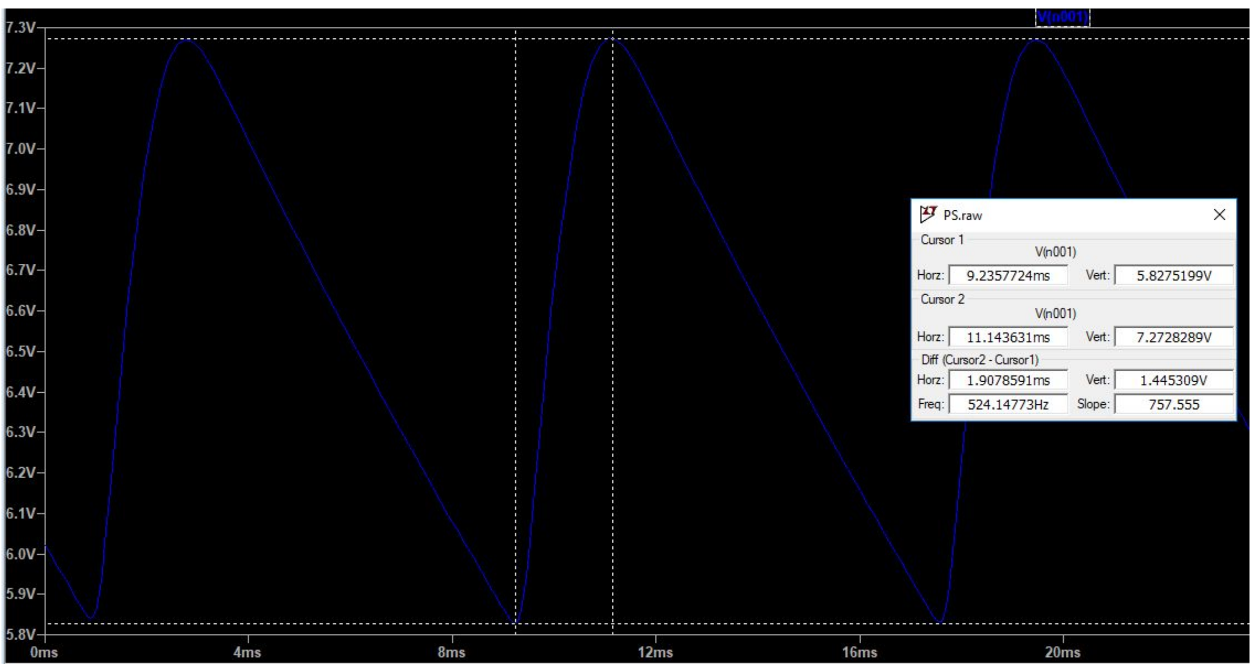

Figure 4.2 Power Supply Output Voltage with Maximum Tolerance Error

5. Cost Analysis & Schedule

5.1 Labor

Michelle Lamblin: ($40/hour) x 2.5 x (10 hours/week) (10 weeks) = $10,000
Marcin Horwat: ($35/hour) x 2.5 x (10 hours/week) (10 weeks) = $8,750
Thomas Mayer: ($35/hour) x 2.5 x (10 hours/week) (10 weeks) = $8,750
Total Labor Cost: $27,500

5.2 Parts List

Item	Quantity	Unit Cost	Total Cost
Bud Industries enclosure (Case)	1	$9.90	$9.90
Current Transformer(20A/20mA)	5	$1.67	$8.36
Voltage Transformer(115/6.3)	1	$8.99	$10
Voltage Regulator (5V)	5	$1.53	$7.65
Microcontroller (ATMEGA328P-PU)	3	$2.14	$6.42
Wifi Module(Mouser) (ESP8266)	2	$6.95	$13.9
Capacitor (470μF,25V)	4	$0.68	$2.72
Capacitor (22 pF)	4	$0.40	$1.60
Diode (1N4004)	8	$0.11	$0.88
Outlet(103.124mm x 33.274mm x 26.924)	1	$6.68	$6.68
3-Prong Power Cord with Open Wiring - 6 ft.	2	$3.29	$6.58
280 Ω Resistor	5	$0.15	$0.75
1 KΩ Resistor	5	$0.10	$0.50
2 KΩ Resistor	5	$0.29	$1.45
10 KΩ Resistor	5	$0.10	$0.50
16MHz Crystal	3	$0.66	$1.98
SO Cord connector	2	$1.06	$2.12

5.3 Grand Total

Cost to build 1 device (parts only): $47.23
Total cost of all parts used in R/D (above): $81.99
Grand Total Cost: $81.99 + 27,500 = $27,581.99

5.4 Schedule

Week	Michelle Lamblin	Marcin Horwat	Thomas Mayer
10/1	Work on and finish design document Mock design	Work on and finish design document Mock design	Work on and finish design document Mock design
10/8	Design Review	Design Review Order Parts	Design Review Order parts
10/15	Create a prototype app for the android popup through parse	Build and test rectifier circuit PCB Design	Build and test rectifier circuit PCB Design
10/22	Establish Communication with the microcontroller and temboo server	Finalize PCB for first round order	Finalize PCB for first round order
10/29	Create the communication between the microcontroller and the android push notification.	Solder components onto PCB and begin testing	Solder components onto PCB and begin testing
11/5	Enhance the capabilities of the android app.	Keep testing and make revisions if necessary for second round PCB order	Keep testing and make revisions if necessary for second round PCB order
11/12	Start preparing for Mock Demo	Finalize PCB for final round of PCB orders. Start preparing for Mock Demo	Finalize PCB for final round of PCB orders Start preparing for Mock Demo
11/19	Fall Break Finalize device revisions	Fall Break Finalize device revisions	Fall Break Finalize device revisions
11/26	Mock Demo	Mock Demo	Mock Demo
12/3	Demonstration Prepare for presentation	Demonstration Prepare for presentation	Demonstration Prepare for presentation
12/10	Presentation & Final Paper	Presentation & Final Paper	Presentation & Final Paper

6. Risk Analysis:

The Wifi component will be the most challenging component because we will have to establish a proper working frequency compatible with the atmega328p in order for it to operate correctly. In order to establish a proper connection between the ATmega328p and the ESP8266 wifi chip, the code must be able to input the proper username and password to connect to the wifi. This would mean we would either have to find some way to port data from the ATmega from udp/tcp or install a small LED screen on our project to prompt the user for the username/password so the user doesn't have to change the code. The only issue is if we cannot find a wifi chip which allows a fast enough rate of data transfer from the ATmega to the third party software server to notify a user when the laundry is completed, we will instead have to use an ethernet shield or create one ourselves to attach to the PCB.

Failure to complete this module would be detrimental to the success of our project, as the project would lose the majority of its meaning. The whole point of the project was to be able to notify a user in the event their washer/dryer cycle is completed via some sort of popup notification when the user does not hear the end cycle signal. The software side of the project is crucial otherwise the project itself loses its overall meaning and we would just be developing a sensor to detect a change in current for any device as opposed to this specific case.

7. ETHICS:

The primary concern for our project with regards to safety is the 120VAC outlet power we will be working with. We need to ensure that the process of lowering the DC voltage to a limit our PCB is safe. The live 120VAC power will cause concern and we will need to take the proper caution when working with it. As per the lab safety standards, we will make sure to check for any damage to the outlet/wires and will not bring food/drinks into the lab to avoid potentially getting liquids on any electronics and prevent damage to the electronics.

Along with taking extreme caution while using 120VAC, we will also follow Section 6 of the IEEE code of Ethics[7] while working with voltage converters and regulators and to keep true to Section 7 of the IEEE code of Ethics[7], making sure our work is compliant with ethical designs and sustainable development practices when working with 120VAC.

In terms of malicious interception of signals, the system could potentially be hacked, we intend to avoid this by creating a user and password authentication requirement when we enable wifi on the network so a potential malicious user would not gain an easy access way into a user's personal wifi.This will be done through proper API authentication ensuring a user will have to enter a username and password which will be encoded within the program to ensure someone who obtains the code cannot have access to the user's wifi login information.

8. SAFETY:

High voltage must be properly insulated to prevent an internal short or user from being electrocuted. Wires used to transmit power from the wall outlet to the washer/dryer will need to be rated to carry up to 20A. Our device will have to be properly grounded.

According to the United States Department of Labor Occupational safety and health Administration, "Grounding a tool or electrical system means intentionally creating a low-resistance path that connects to the earth. This prevents the buildup of voltages that could cause an electrical accident. Grounding is normally a secondary protective measure to protect against electric shock. It does not guarantee that you won't get a shock or be injured or killed by an electrical current. It will, however, substantially reduce the risk."

9. Possible Complexity Additions:

9.1 Detecting Leakage Current

In any electronic device, some current will flow through the protective ground wire to ground, which can be an indicator of the effectiveness of the insulation on the conductors. This current is called leakage current. This can be an issue because on circuits protected by GFCI's (Ground Fault Current Interrupters), leakage current can cause unnecessary and intermittent tripping and in extreme cases it can cause a rise in voltage on accessible conductive elements. Leakage current from the load can also be an indicator that there is something wrong with the washer or dryer [9].

To add a possible complexity, we could add another current sensors in our device around the hot and neutral wires. This will allow us to measure and monitor leakage current from the washer or dryer that is plugged into our device and let the user know if the appliance is working efficiently and safely. To do this we would add a current sense transformer around the hot and neutral wires to check for a difference in the current between the two wires, just like figure 9.1 depicts. The current flowing through the hot should equal the current that returns through the neutral, so if a large enough difference between the 2 currents is detected the user will be notified to let them know something is wrong with their device. Similarly, we could use a CT around the ground wire, as shown in figure 9.2, to check for any leakage currents directly in the ground wire, but that implies that the load is properly grounded, which is not always the case; therefore, it would be better to measure the current difference between the hot and neutral wires.

The output from the CT will go to a rectifier and then a resistor load similar to the CT's circuit measuring the loads current draw. The voltage across the resistor load will provide data to be analyzed using the microcontroller just like the other CT in our device. One potential issue with this additional feature might be the cost of the CT. The CT for this measurement would have to be able to measure currents in the mA range and higher sensitive CT's tend to be more expensive.

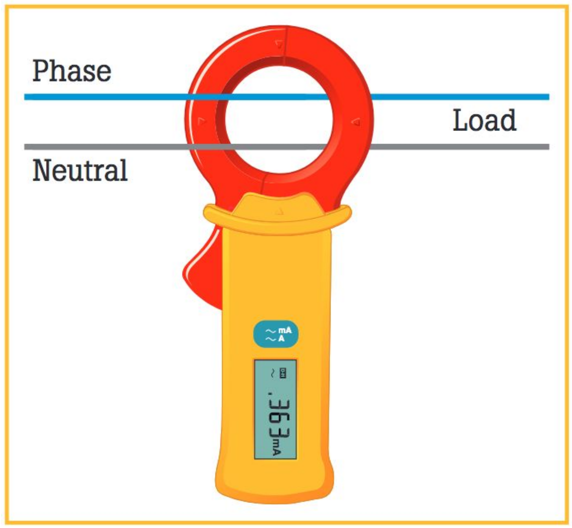

Figure 9.1 Leakage Current Measurement for Load [9]

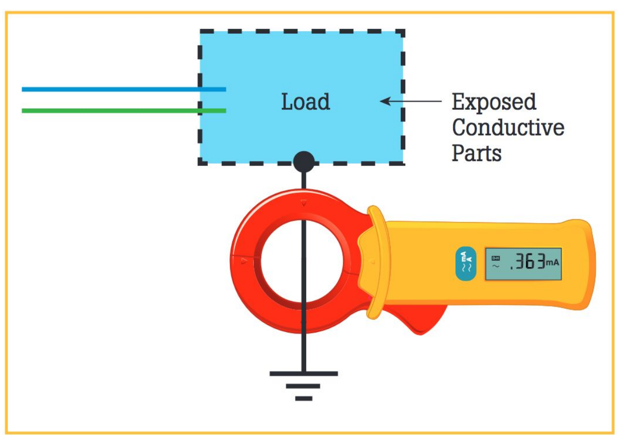

Figure 9.2 Leakage Current Measurement for Ground [9]

Requirements:	Verifications :
Detect the difference in current between the hot and neutral wire. Similar to a standard gfci, if we detect a current greater than 10-20mA, the user will be notified that there is an issue with their machine	Load the output of our device to operating current. While the device is loaded, switch on a power resistor between the hot and ground to simulate a leakage current. The power resistor will be valued to draw just over 20mA. The device should then send a warning signal to the user.

9.2 Fuses

A fuse is simply a short thin piece of wire designed to melt and separate the wire in the event of excess current flow. Fuses are always connected in series with the load or component to be protected from excess current, so when the fuse opens it will open the entire circuit and stop current from flowing to the load. To add more features to our device we could add a fuse in series with our device and the washer to prevent excess current going to the washer. This would protect the washer and prevent it from breaking. The fuse will be rated at 20 A, since the washer and dryer will be drawing less than 20A. Check section 4.1 for more details.

9.3 Scaling for Commercial Use

To potentially scale the product for commercial use each device produced would need to come with its own specialized identification key. The user would enter the identification key into the android application and it would then recognize the device and attempt to form a type of authentication with our product and it could then be utilized with that specific washer/dryer unit. An extra user input line will need to be created in order to help the device distinguish between different washer/dryer units. It’s a bit tricky to do within the scope of the class because you would either need to provide a demo and change the authentication key within the code itself or create two different products in which would have a different identification key each.

9.4 120/240V Compatibility

Another idea for adding a possible complexity was to make our device compatible with 120/240V plugs because some dryers require 240V to operate. Figure 9.3 depicts a sketch of what this could look like. Some issues with this is that the 120V plug would always have to be plugged into the device, but most washers are 120V already, so you should always have a way to power the low voltage components of the device. If you have a 240V dryer then you will need a 120V plug nearby to power the device. This could require an extension cord if you don't have both plugs nearby. Another issue is that there are many different types of 240V plugs used in the U.S., so it could be an issue to make a universal solution for all the different types of plugs. Figure 9.4 shows some of the different 240V plugs used in the U.S according the National Electrical Manufacturers Association (NEMA).

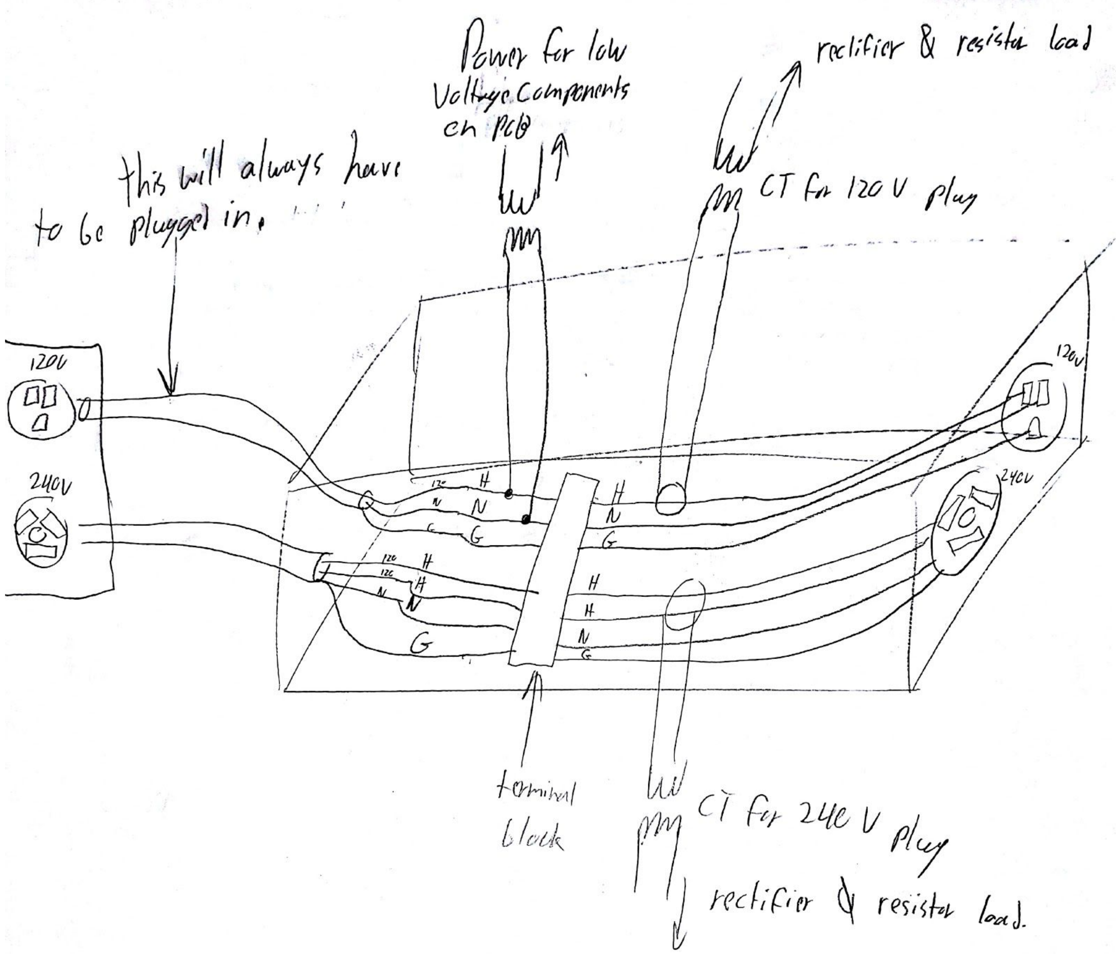

Figure 9.3 Sketch for wiring 120V and 240V plugs.

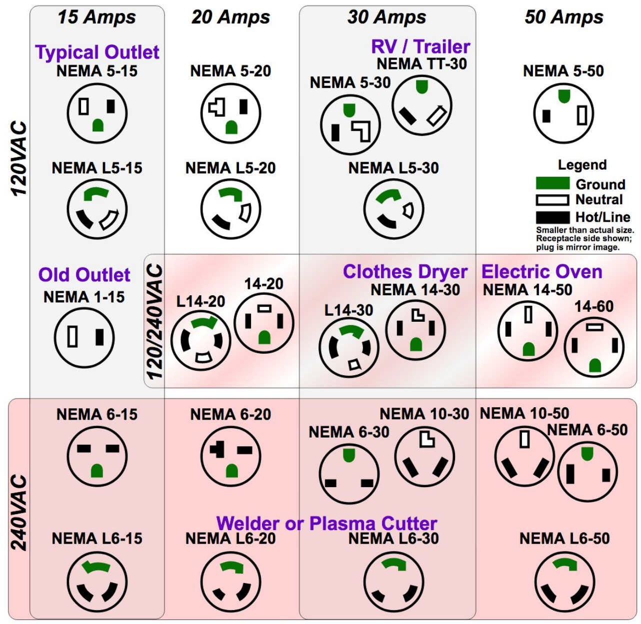

Figure 9.4 Different style 240V Plugs Used in the U.S.

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