ECE 445: Senior Design Laboratory

Fall 2017

Automatic Pill Dispenser

Mock Design Review - Design Document

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1 Introduction

1.1 Objective

Our product will help those who have medications and vitamins that they need to take on a daily basis. It can be quite difficult to remember what pills to take when and how much the correct dosage is. To overcome this difficulty, the pill sorter will be able to take in a full month's worth of several pills, sort them into the correct dosage, and dispense them at the correct interval. This takes the potential for error each day and moves it upstream to a single task: correctly inputting the prescription information into the pill sorter. Now instead of 30 or 31 opportunities for a mistake to be made, there is one. This method decreases the opportunity for error and makes it easier for the end user because all they have to do is open their hand and the correct medication will be dispensed.

This problem has been tackled in the past. However, the solution that others have come up with tends to resemble an alarmed box, still requiring manual sorting by the user, or a bulky countertop box without a direct user interface, requiring a somewhat high technical knowledge to operate. Our solution will overcome both of these common pitfalls with an intuitive user interface so even those with limited computer and technical knowledge can fully utilize the system and a simple design that avoids oversized motors, actuators, and containers. The end product will be a low-cost solution to an everyday problem [1].

1.2 Background

According to a study by NPR, 119 million Americans take prescription drugs. In addition to that group, our target population includes any person who takes over the counter allergy medication, pain relievers, and vitamins routinely. As figures 1 and 2 show below, there is a significant population between the ages of 0-18 and 65+ years old that take both prescription and over the counter medicines routinely. The Kaiser Family Foundation found that on average those who are 0-18 years old purchase medication 4.3 times each year and for those who are over 65 years old, that number jumps to 23.9 times per year in the United States. People between the ages of 19 and 64 purchase 12.7 medications annually. We are gearing towards helping those between 0 and 18 and over 65 because these are the age groups that typically require extra help whether it be from parents, guardians, or caretakers. Removing the task of counting out and alerting these groups to take their medication could preserve the autonomy of aging users and give children a sense of autonomy as they are able to take their medication without having a parent watching over them once the dispenser is programmed [2].

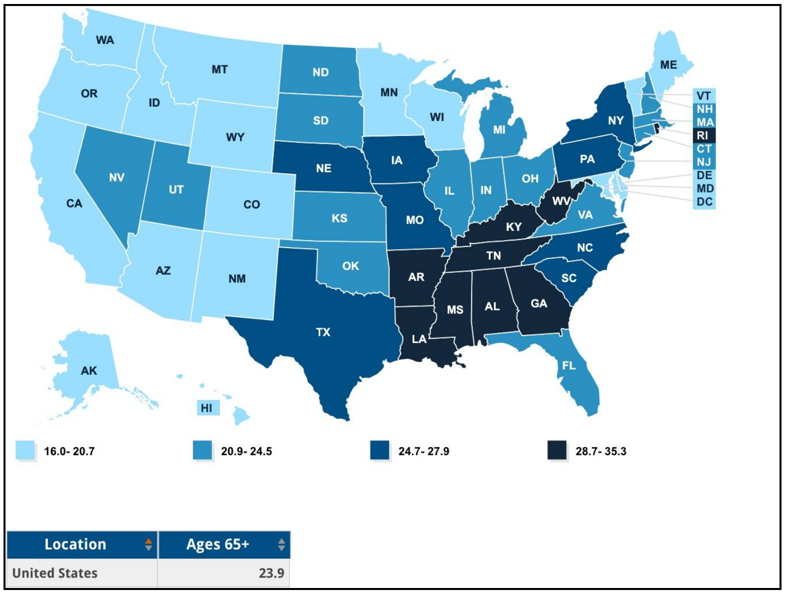

Figure 1: Retail Prescription Drugs Filled at Pharmacies (Annual per Capita Ages 65 and Up) [2]

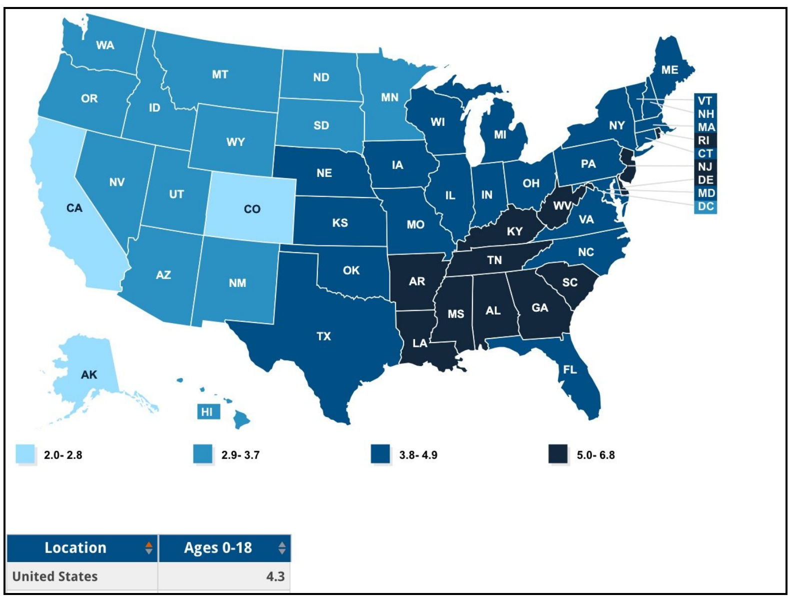

Figure 2: Retail Prescription Drugs Filled at Pharmacies (Annual per Capita ages 0-18) [2]

1.3 High-level Requirements

1. The machine will sort and properly dispense one pill at a time for any given pill.
2. The machine will be able to dispense medication at specified times.
3. The machine will audibly alert the user that it is time to take medication.

2 Design

2.1. Block Diagram

Our dispenser will require five separate sections: a power supply which will turn the 120 VAC 60 Hz to 5 VDC; a control unit featuring a microcontroller and sensors to properly alert and dispense medication; a user interface to program the proper dosage; three motors (one per type of medication) to dispense a single pill; and most importantly, a system of alerts so the user knows that it is time to take their medication. The block requirements are laid out below.

Power Supply - convert an incoming 120 VAC signal into a 5 VDC supply.

Sensing and Control - Detect when a single pill has been passed. Alert user if the wrong dosage has been passed. Turn motors on and off individually. Turn on LED and speaker when medication is dispensed. Turn off LED and speaker when medicine is removed from the machine. Pass the incoming 5 VDC supply to each component. Accept user input from the buttons and reprogram itself as commanded.

User Interface - Allow the user to see what pill they are setting a dispensing schedule for. Allow the user to change days that the pill will be dispensed. Allow the user to change the time that the pill will be dispensed.

Dispensing Motors - Turn on and off as commanded by the microcontroller.

Alerting Components - Turn on and off as commanded by the microcontroller.

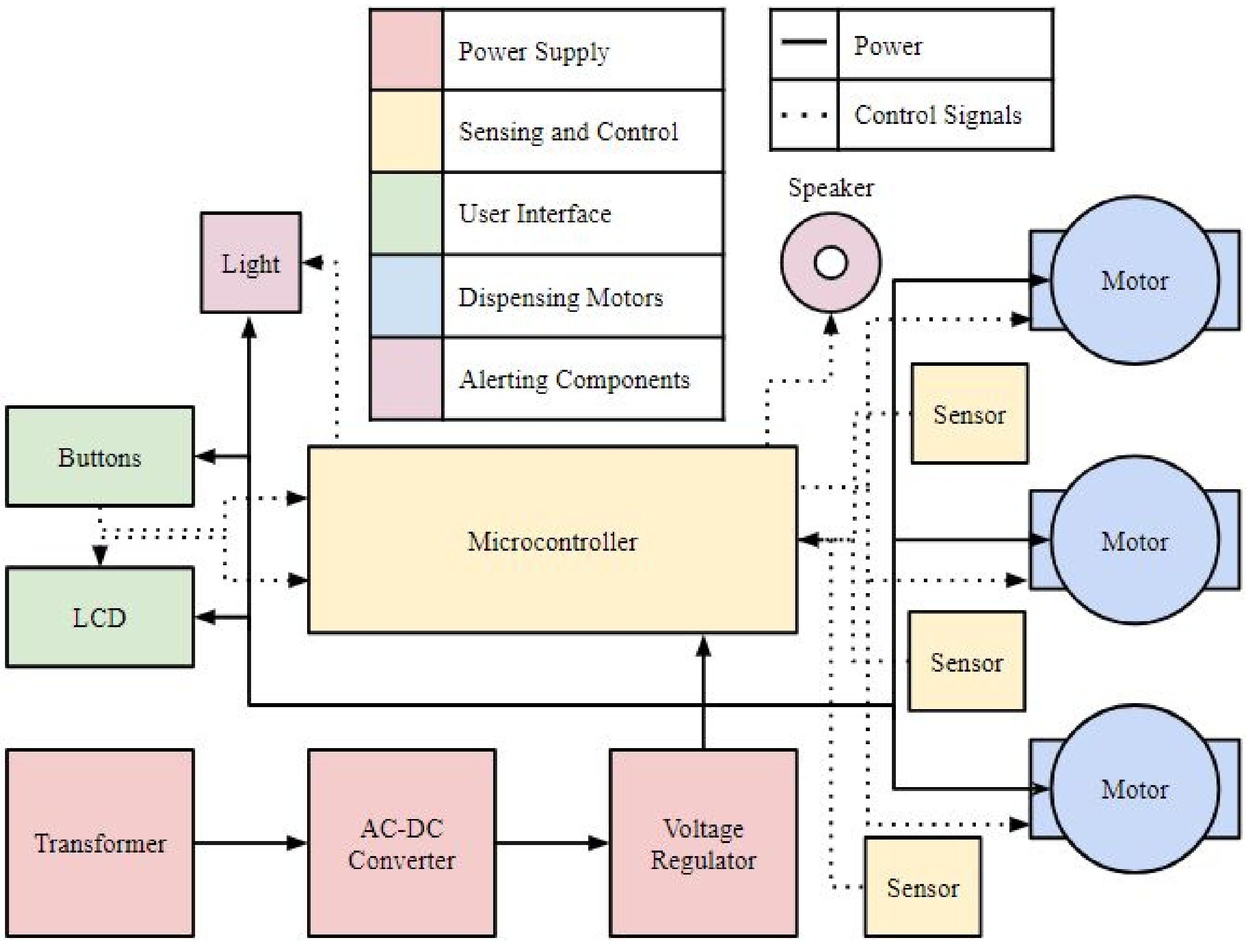

Figure 3: Block diagram

2.2. Functional Overview

The part numbers, vendors, part details, datasheet links, and purchasing links are all summarized in a separate document. A screen capture of the parts list document can be seen below in Figure 4.

2.2.1. Transformer

A transformer is the first of the three power supply components. Our board needs a reliable DC voltage supply to power the dispenser's circuit components, however, we desire this device to plug into the wall for accessibility. As a result, our circuit requires a transformer to step down the wall voltage of 120 VAC to 24 VAC.

2.2.2. AC-DC Converter

The second piece of the power supply is a bridge rectifier for full wave rectification of the incoming 24 VAC coming in from the transformer. This full-wave rectified signal will be smoothed out with a capacitor and then passed to two parallel voltage regulators.

2.2.3. Voltage Regulator

The final part of the power supply is the voltage regulator. Our voltage regulator will buck the 24 V DC input to a steady 5 VDC input; this constant direct current is critical to supplying the digital components the power they need.

2.2.4. Microcontroller

A microcontroller (MCU) is necessary for our circuit to function, for we have multiple control input and output peripherals. This MCU will have to accept the user's designated medication time while properly keeping track of the current time. That way, the controller can then control the motors to dispense the pills while sensing whether one came out.

We will be using the ATmega328P MCU to control our board. This microcontroller operates around the 5 V level and has a CPU which runs at 16 MHz.

2.2.5. Sensors

These sensors will work in tandem with the microcontroller to sense the proper dispensing of the pills; meaning, only the desired number of pills are administered. We will be using IR break-beam sensors. This will allow detection of whether or not a pill has passed through the sorting mechanism. The response time is less than 2 ms so these are able to take in data fast enough to be able to detect if more than one pill has been passed through with the intended dosage.

2.2.6. LCD

The LCD chosen can display two 8-character lines. This was chosen so that the user can see which of the three tubes they are setting a time for on the top line with the second line showing the desired days to have the medicine dispensed. After the days are selected, the top line will remain the same while the second line will show the time for the medicine to be dispensed so that the user can set it.

2.2.7. Buttons

These buttons will allow the user to enter information. There will be four directional buttons and an enter button. Allowing the user to fully program the machine without any need for a computer.

2.2.8. Dispensing Motors

We will be using compact stepper motors to precisely turn the pill dispensing tumbler. The motors must be finely controlled so that the correct dosage of medication is dispensed.

2.2.9. Alerting Components (Audio/Visual)

An LED light and a small speaker will be used to alert the user when to take their medication. The light will flash and the speaker will emit a sound starting at the time the medication is dispensed and ending when the receptacle is removed from the enclosure.

Add Screenshot of parts list document

Figure 4: Parts List

2.2 Physical Design

Our device will use precisely controlled motors to spin a hopper. When desired, the pills will trickle down into a common tube and out to the medication cup. Figures 5 and 6 show a digital rendering of our projected final design. The three orange cylinders on top are where the user will pour their pill bottles into. The power supply, sorting mechanisms, microcontroller, break beam sensors, and motors will all be hidden from the user's line of sight within the enclosure. The LCD screen and buttons will be on the front left of the enclosure. The purple box is what the pills will be dropped into after they are sorted and dispensed.

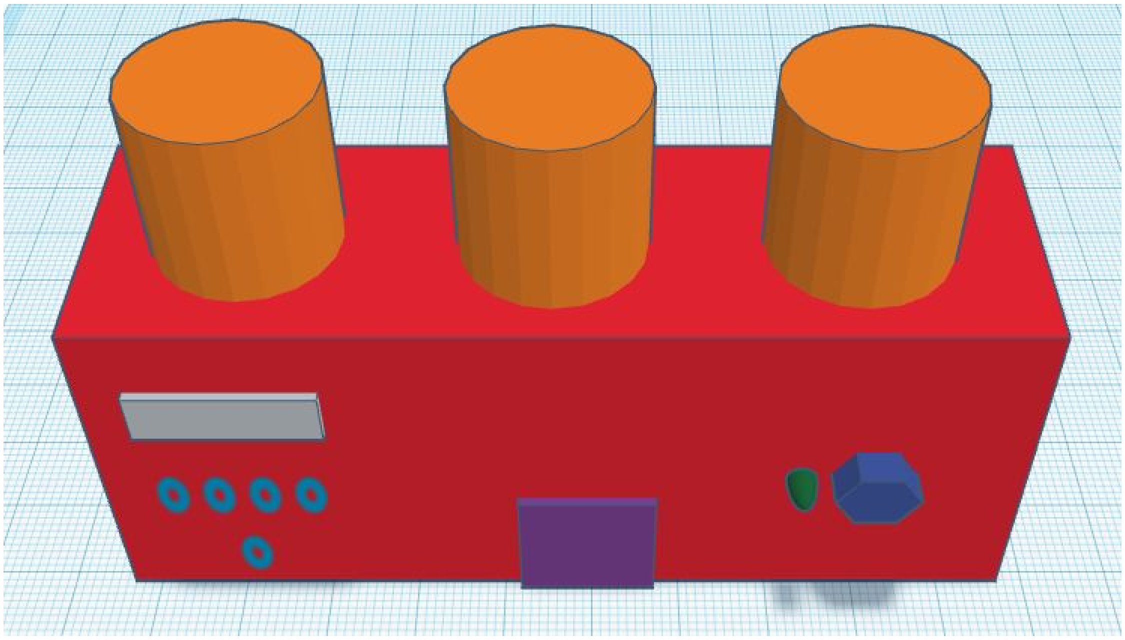

Figure 5: Aerial View of Physical Design

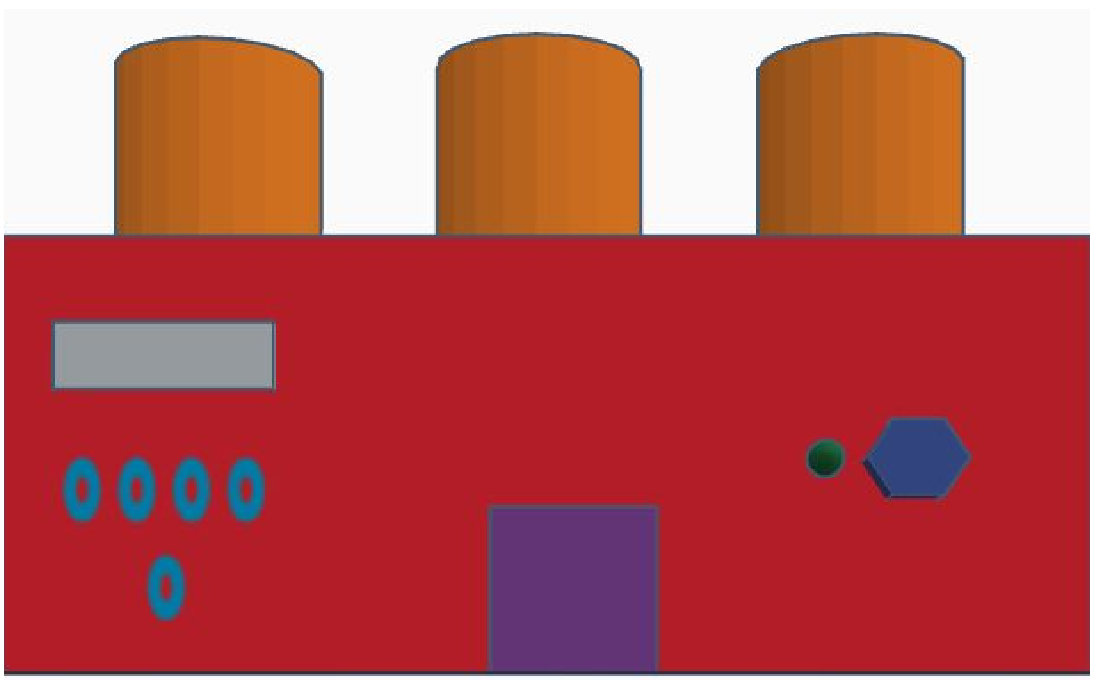

Figure 6: Front View of Physical Design

2.3 Safety and Risk Analysis

The main concern we have while thinking about and designing this circuit is the improper dispensing of medication by the machine. We must assure that only the proper dosage will be administered. Additionally, we assure that our machine will alert and dispense the medication at the correct time. Currently, we have one faux pas; we cannot assure who takes the medication. In our design, we only have one user. We may implement a keycode to enter a PIN number, and definitely will if we have extra time and expand the number of users.

When building a circuit to be in the center of someone's home, one needs to make sure the circuit is safe and stable. A faulty circuit risks starting on fire. We must ensure that our circuit and housing come together to create a reliably safe device.

The two components that pose the greatest risk to successful completion of the project are the microcontroller and the software. These two things pose the greatest risk because they are the pieces that we as a group have the least familiarity with. The proper selection of a microcontroller that can perform the tasks we need is a crucial and time heavy task. As a group of electrical engineering majors, the software provides another obstacle similar to those that we have faced in previous computer engineering focused classes.

3 Cost and Schedule

3.1. Cost

Our projected cost for parts is XXX. We came to this number by finding sources for all of the electrical parts and components we will be buying. The itemized list can be seen below in Figure 8. Our projected labor cost is $13,500. We have allotted 180 hours at a rate of $30 per hour which translates to a salary of $62,400. The total labor cost is calculated with the following equation: $Total\ labor\ Cost\ =\ Hourly\ Rate\ *\ 2.5\ *\ Hours\ Worked$. The total project cost is the summation of parts and labor. This comes out to XXX.

Add screenshot of cost column from parts document

Figure 7: Itemized Costs List

3.2. Schedule

The project schedule has been laid out in an online calendar. Figures 8, 9, 10, and 11 show each full month and on which days what will be completed. On the calendar, our weekly meetings are in yellow; online documents submissions are in red; group project milestones are in purple; and design reviews, presentations, and demonstrations are in green.

SEPTEMBER 2017

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26 Weekly Meeting @ 5:00pm - 5:30pm	27	28 Eagle Assignment due	29 Last day for first machine shop meeting	30

Figure 8: September

OCTOBER 2017

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
1 Parts list Finalized	2	3 -Mock Design Review 10:00am 2072 ECEB -Weekly Meeting @ 5:00pm - 5:30pm	4	5 Design Document due 11:59pm	6 LAB TIME - parts recieved	7
8 Circuit Schematic Finalized	9	10 Weekly Meeting @ 5:00pm - 5:30pm	11 -Design Review 9:00am	12	13 LAB TIME - parts tested and validated	14
15	16	17 Weekly Meeting @ 5:00pm - 5:30pm	18	19	20 -Soldering Assignment Due -LAB TIME - hardware build completed	21
22	23	24 Weekly Meeting @ 5:00pm - 5:30pm	25	26 First Round PCBway (Audit passed by today)	27 LAB TIME - software started	28
29	30	31 Weekly Meeting @ 5:00pm - 5:30pm	1	2	3	4

Figure 9: October

NOVEMBER 2017

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
29	30	31	1	2	3 LAB TIME - software debugging	4
5	6	7 Weekly Meeting @ 5:00pm - 5:30pm	8	9 Final Round PCBway (Audit passed by today)	10 -Last day for machine shop revisions -LAB TIME - software build complete and merged with hardware	11
12	13	14 Weekly Meeting @ 5:00pm - 5:30pm	15	16	17 LAB TIME - hardware fitted within enclosure. Total project debugging and finishing	18
19 Thanksgiving Break	20 Thanksgiving Break	21 Thanksgiving Break	22 Thanksgiving Break	23 Thanksgiving Break	24 Thanksgiving Break	25 Thanksgiving Break
26	27	28 MOCK DEMO Weekly Meeting @ 5:00pm - 5:30pm	29	30	1 Complications from mock demo worked out	2

Figure 10: November

DECEMBER 2017

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
26	27	28	29	30	1 All dsign documents finalized for presentation	2
3	4 DEMO	5 DEMO	6 DEMO	7 MOCK PRESENT	8 MOCK PRESENT	9
10	11 PRESENT	12 PRESENT	13 FINAL PAPER DUE @ 11:59pm	14 -Lab checkout and notebook due 3:30pm-5:00pm -Awards and pizza	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31	1	2	3	4	5	6

Figure 11: December

4 Ethics and Safety

The potential costs of delivering incorrect doses or medications from the dispenser are extremely high. It would not be outlandish for this error to result in a hospital visit or death. Therefore, we take responsibility in "in making decisions consistent with the safety, health, and welfare of the public" [3] as per IEEE Code of Ethics, #1. With the correct automation and double checking, these mistakes could be avoided with our system. As spoken about above, if used correctly this product takes 30 potential opportunities for error each month and shrinks it into one step. Also, our multi layer design of power supply is a standard practice intended to minimize any chance of fire hazards [4].

When making design decisions we take responsibility into making our design implementation of all components and peripherals user-friendly for different demographics of users, as per requirements of the IEEE Code of Ethics, #5: "To improve the understanding of technology; its appropriate application, and potential consequences" [3]. While there is more importance put on the programming of the machine, it is much easier for a parent, guardian, or caretaker to set aside the proper amount of time once to set the correct dosage and timing information than it is for them to set daily reminders to set up, count out, and provide medication to the patient.

We intend to set up some sort of identification system to verify that it is actually the intended patient receiving the medication. Our current methods are a simple four-digit PIN number, a typed password, or RFID sensor. These can all be added as a peripheral to the central sorting and dispensing mechanism so our design will not be affected should these methods not work. As a whole, the proper use of this system does not cross any IEEE and/or ACM ethics codes as its intended use will streamline the lives of those taking multiple medications each day.

4 References

[1] R. Harris, "Federal Survey Finds 119 Million Americans Use Prescription Drugs", *NPR.org*, 2017. [Online]. Available: http://www.npr.org/2016/09/08/493157917/federal-survey-finds-119-million-americans-use-prescription-drugs. [Accessed: 22- Sep- 2017].

[2] "Retail Prescription Drugs Filled at Pharmacies (Annual per Capita by Age)", *The Henry J. Kaiser Family Foundation*, 2017. [Online]. Available: http://www.kff.org/other/state-indicator/retail-rx-drugs-by-age/?activeTab=map&currentTimeframe=. [Accessed: 22- Sep- 2017].

[3] Ieee.org, "IEEE IEEE Code of Ethics", 2016. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 02-Oct-2017].

[4] Bob Mammano and Lal Bahra, “Safety Considerations in Power Supply Design,” TI Literature No. SLUP227. Available: https://www.ieee.li/pdf/essay/safety_considerations_in_power_supply_design.pdf. [Accessed: 02-Oct-2017].