# RFID Refrigerator

# Power System Module

# Mock Design Review

# Team Number 73


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# 1 Block Diagram

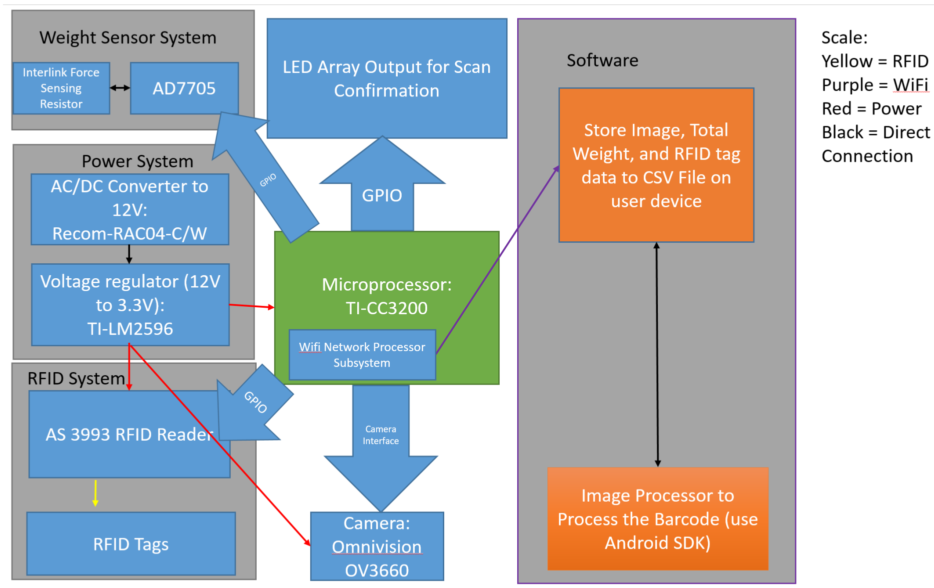


Figure 1: Block Diagram

Figure 1 shows the block diagram of our project. The RFID refrigerator can be broken up into 7 different components: a power system, RFID system, Weight Sensor System, LED Array, Microprocessor, Camera, and Software. The power system is going to be comprised of an AC/DC converter that is plugged in directly into the wall that takes in a 120V AC input and outputs a 12V DC output. It will then be attached to a voltage regulator that will take in the 12V DC input and output 3.3V DC. The power system will power up the RFID circuit, microcontroller and the camera.

The RFID system will consist of an RFID reader, along with passive RFID tags that we will place on the food items.

The camera will use the built in Camera interface in our microcontroller that will read the barcodes from the food items and then use the built-in WiFi Module in our microcontroller to send the image to our phone, where the processing will occur.

The weight sensor system will be comprised of an Analog to Digital Converter and a Force-Sensing resistor which will sense how much weight is placed on each shelf. The total weight will be recorded by the microprocessor and sent to the phone for data storage. This way, we will be able to more accurately record how much food is stored in the fridge and when food is removed from the fridge.

The LED Array will be used as a confirmation that the RFID tag was scanned correctly and whether or not it is removed or just placed in. That is, when we first put in the food item and scan the RFID tag with the reader, the LED array will display a green light, indicating that the food is about to be placed in the fridge. It will only display green after the RFID tag is scanned and the food is placed on the shelf (weight increases). When we remove the food from the fridge and scan it with the RFID reader, the LED array will display red (the sensor will detect a decreased weight).

The microprocessor we use must be able to take in I/O from a camera, RFID reader, our weight sensor system, and send data over WiFi. This is why we chose the TI-CC3200 which has a built-in WiFi module.

Finally, on the software side, our device must be able to receive data from the microprocessor over the WiFi Module and store the total weight, RFID tag data, and barcode data after processing the barcode image. That is, the device must be able to take in an image from an outside source and then use a Barcode Scanner SDK to process that image. After knowing what food item the barcode is, we must search in a database to know the expiration date for the food. Finally, we will write a simple phone application that will notify the user when a food item is about to expire.

## 2 Circuit Schematic

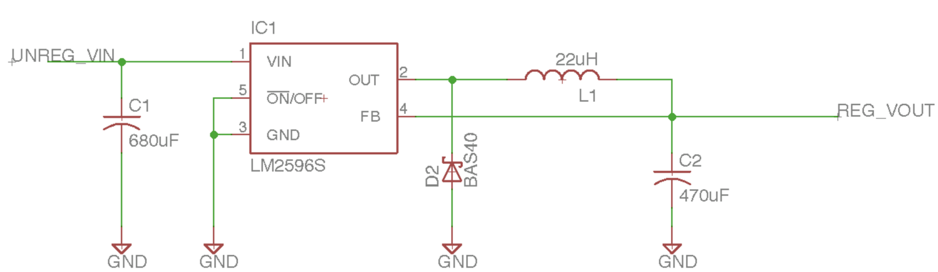


FIGURE 2: Circuit for Voltage Regulator with Input=12V and Output=3.3V

Figure 2 shows the circuit we will be using for the voltage regulator. The 12V unregulated DC input will come from our AC/DC converter and instead of the 5V shown in the circuits,

Table 1: Voltage Regulator Circuit Values

| Component | Value |
|---|---|
| $C_1$ | 680uF |
| $C_2$ | 470uF |
| D2 | 4A - 6A Current Rating, 20V Voltage Rating |
| L1 | 22uH |

we will have a 3.3V output instead. Thus, for the inductor, capacitors, and diodes, we have different values as shown in Table 1. The calculations to determine these values will be shown in the following section.

# 3 Calculation

## 3.1 Finding $C_{OUT}$

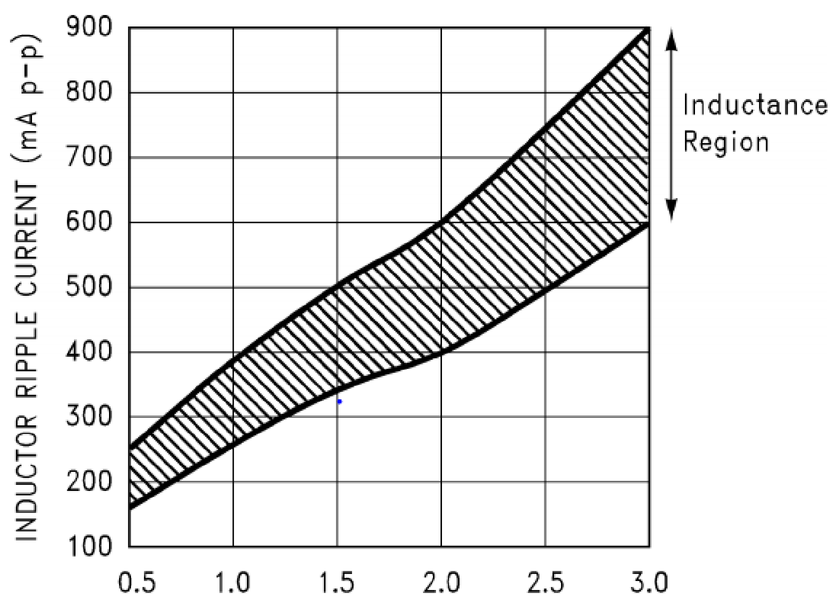


Figure 3: Peak-to-Peak Inductor Ripple Current vs Load Current [5]

Figure 3 shows the ripple current vs load current graph. From this, we can follow the 3A line approximately to the middle of the inductance region and get that $\Delta I_{IND} = 750mAp{-}p$. In addition, our output ripple voltage for an output of 3.3V is 300mV, or .3V. By using the equation:

$$\text{ESR of } C_{OUT} = \frac{\Delta V_{OUT}}{\Delta I_{IND}}$$

where ESR stands for effective series resistance, we get that the ESR of $C_{OUT}$ is .4, which we then use a lookup table to calculate that the value for $C_{OUT}$ is 470 uF.

# 4 Plot

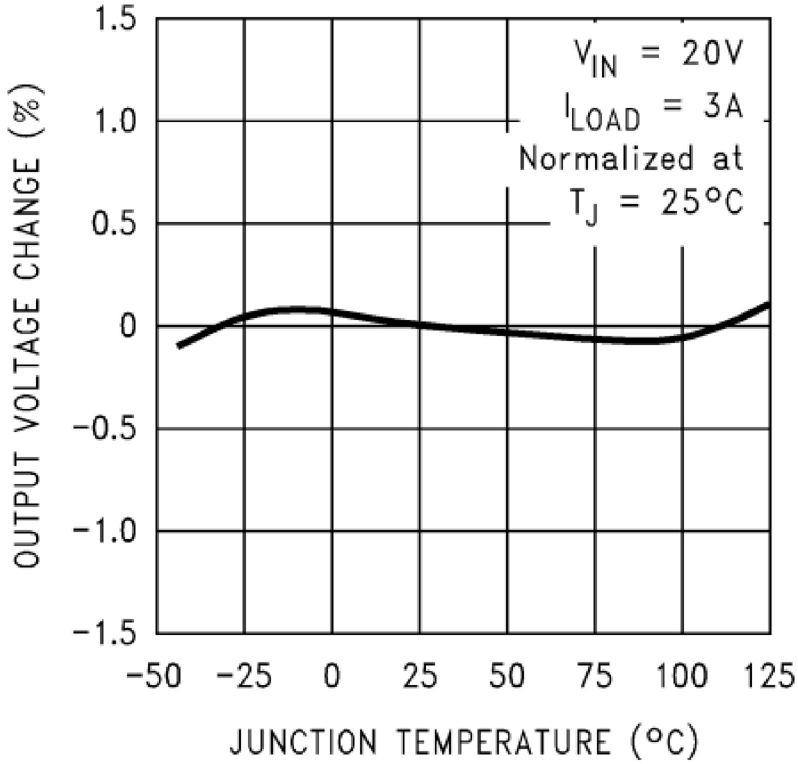


FIGURE 4: Normalized Output Voltage [5]

Figure 4 shows the output ripple vs temperature for an input of 20V and a load current of 3A. For an output of 3.3V that we desire and at an operating point of 0° celcius, there is very minimal output voltage ripple (less than 0.1 percent). Since our microcontroller requires our ripple to be ±300mV, a voltage ripple of

$$\frac{3.3 * 0.1}{100} = .0033V = 3.3mV$$

is ideal for our system.

# 5 Block Description of Power System

The purpose of our power system is to output a 3.3V DC voltage from a 120V AC Wall Power source. To do this, we must first use an AC/DC transformer that will convert our 120V AC voltage into a 12V DC output. The part that we propose to use for our transformer is the Recom RAC04-C/W. Next, this component will be connected to a voltage regulator that will take in a 12V DC input and output a 3.3V DC. The part that we propose to use for our regulator is the TI-LM2596.

# 6 Requirements and Verifications of Voltage Regulator

The voltage regulator that we propose to use is the TI-LM2596. This will be able to take in a 12V DC input and output many different types of DC outputs, including 3.3V, 5V, and 12V, and an adjustable output version[5]. For our project, the 3.3V output is desired.

*Requirement 1: The Regulator must be able to take in a 12V DC input and output a 3.3V output*

*Verification: We will use a multimeter to test if the output is 3.3V*

*Requirement 2: In order to use the WiFI module on our microcontroller, it requires less than* $\pm 300mV$ *of ripple.*

*Verification: We will use an oscilloscope to test how much ripple we have and to see if the output is between 3V and 3.6V.*

*Requirement 3: The voltage regulator must be capable of driving a 3A load.*

*Verification: Attach a* $1.1\Omega$ *resistor at the output and use a multimeter to measure the current to determine whether the current is 3A.*

# 7 Safety Statement

The main safety we might encounter with our project is the RFID circuitry. The moisture within the fridge could damage our circuitry, leading to short-circuits. We will need to ensure that our casing is able to sufficiently block out moisture to protect the user. Since the components of our RFID circuity will probably not 110/120 volts, we could be using batteries to provide power. Lithium-ion batteries can explode under certain conditions, so we must monitor battery temperature and cut it off from the circuit should the temperature drift outside safe operating conditions.

As engineers, we are called "to improve the understanding of technology; its appropriate application, and potential consequences", as stated in #5 of the IEEE Code of Ethics [3]. We believe that our project will have a positive impact on the application of RFID technology, and will serve to improve the environment by reducing waste. However, we are responsible for all information sent through our technology, and it is known that RFID tags can be compromised, and have their information extracted, deleted, or rewritten. In event that the tags are compromised, a user could lose track on items in the fridge, which could result in potential waste. However, we believe that the likelihood of a dedicated attack on our system is small, simply because of the low value of goods that our system is intended to deal with. Some users may attempt to use our project to facilitate in their storing of items that may be deemed illegal, or could be used to harm others. While we do not have a method to ensure that our project is used solely for legal purposes, we do not believe that limiting the functionality of our system is the right course of action, as they can easily use any number of alternatives. Furthermore, we believe that the ability to reduce the amount of food waste has huge benefits that would far outweigh the potential negative effects.

# 8 Citations

[1] ”Americans waste $2,200 worth of this every year ...”, CNBC, 2017. [Online]. Available: http://www.cnbc.com/2015/04/22/americas-165-billion-food-waste-problem.html. [Accessed: 08- Feb- 2017].

[2] ”FAO - News Article: Cutting food waste to feed the world”, Fao.org, 2017. [Online]. Available: http://www.fao.org/news/story/en/item/74192/icode/. [Accessed: 08- Feb- 2017].

[3] ”Terso Solutions”, Terso Solutions, 2017. [Online]. Available: https://www.tersosolutions.com/solutions/rfid-refrigerators/ts074-rfid-refrigerator/. [Accessed: 08- Feb- 2017].

[4] ”IEEE IEEE Code of Ethics”, Ieee.org, 2017. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 08- Feb- 2017].

[5] Texas Instruments, “SIMPLE SWITCHER Power Converter 150-kHz-A Step-Down Voltage Regulator,” LM2596 datasheet, Nov. 1999 [Revised May 2016].