Power Analysis

Part I

Power Supply Requirements

AeroBal will be a system that always stays in the same place. Therefore, we will use the voltage coming out of a regular power outlet as our main voltage source. In Puerto Rico, the voltage coming out of a standard wall outlet is 120V with a frequency of 60 Hz (http://www.kropla.com/electric2.htm). This would act as our *unregulated voltage source*.

120 Volts is excessive for the amount of peripherals we are going to use. Besides that, the recommended V_{DDRec} values of all of our components were are always one of the following three values: 3.3V, 5V, or 12V.

Due to this problem, we though that it would be convenient to get a power supply that regulates the 120V AC from the outlet into the convenient values mentioned. After some research, we found a power supply that met our demands. This was the **Cooler Master eXtreme Power Plus 550-Watt ATX**, which comes at a cheap price and perfectly meets our voltage demands.

This power supply gives us seven different output voltages through Molex Power connectors. These are summarized in the following table.

Source	Voltage	Current
1	+3.3V	25A
2	+5V	25A
3	+12V 1	16A
4	+12V 1	16A
5	-12V	0.8A
6	-5V	0.8A
7	+5VSB	2.5A

1 Voltage

AeroBal uses a variety of peripherals that have different operating conditions. All of these will be presented in the following table.

	V_{DDRec}	V_{IH}	V_{IL}	V_{OH}	V_{OL}
MCU (TM4C123GH6PM)	3.3V	2.48V	1.16V	2.4V	0.4V
Wind Speed Window Actuator (SM-42BYG011)	12V	-	-	-	-
Barometric Pressure Sensor (BMP085)	3.3V	2.15V	0.66V	1.32V	0.3V
Humidity and Temperature Sensor (DHT11)	5V	-	-	-	-
Instrumentation Amplifiers (x6) (INA125)	12V	2V	0.8 V	1.4V	0.8 V
Bluetooth (JY-MCU)	3.3V	2V	0.66V	2.64V	0.66V
LCD (C2004A)	3.3V	2.25V	0.66V	2.5V	0.66V

The V_{DDRec} values of all of our components are either 3.3V, 5V, or 12V. The power supply that we chose gives us outputs for all three of these voltages. One of the main reasons we chose the chosen power supply was because of how convenient it would be to have a cheap power supply that gave us the exact voltages we needed for all of our components.

It is also worth mentioning that there will be two extra components not in the list. They are not in the list because we will make them ourselves, so there are no data sheets for them.

These components are:

- **Anemometer Sensor**
- **Wind Vane Sensor**

Both of these components will be designed to work with an V_{DDRec} value of 3.3V. Thus, the final number of components in each one of the three used output power connectors will be:

The number of components per connector are:

- **+12V connector** - 2 Components
- **+5V connector** - 1 Component
- **+3.3V connector** - 6 Components.

2 Current

The following table summarizes the values of the currents of each one of our components.

	I_{In}	I_{Out}	I_{Leak}
MCU (TM4C123GH6PM)	4mA	4mA	1μA
Wind Speed Window Actuator (SM-42BYG011)	330 mA	-	-
Barometric Pressure Sensor (BMP085)	7.7 mA	1.5 mA	5 μA
Humidity and Temperature Sensor (DHT11)	2.5 mA	1mA	150 μA
Instrumentation Amplifiers (x6) (INA125)	6 mA	700μA	2 nA
Bluetooth (JY-MCU)	40 mA	-	-
LCD (C2004A)	150μA	50μA	1μA

There are plenty of I_{In} values for our components. Luckily, our power supply has a wide and comfortable amount of current in each output. This was another of the top reasons why we chose this supply source.

The analysis of whether the current provided is enough for our components is as follows:

- **+12V connector**(Capacity: 16A):

  This connector will have seven components. The sum of I_{In} if these components is:

  $$\sum_{i=1}^{7} c_i = 4mA + (6)(6mA) = 60mA.$$

  $$60mA < 16A$$

- **+5V connector** (Capacity: 25A):

  This connector will only have one component, and it's value is greatly below our capacity:

  $$2.5mA << 25A$$

- **+3.3V connector** (Capacity: 25 A):

  This connector will have six components. Two of them will be made by ourselves, so we don't know yet how much current they will need. The ones we do know are the following:

  $$\sum_{i=1}^{4} c_i = 4mA + 7.7mA + 40mA + 150uA = 51.9mA$$

$$51.9mA << 25A$$

Although we are not considering the two remaining components, we are sure that the remaining current capacity of the connector will be more than enough to supply them without any problem.

NOTE: Although 6 instrumental amplifiers were listed, we are studying a way of using only 3 instead. This would decrease the needed current out of the +12V connector.

3 Driving Capability

The value V_{OH} of the GPIO pins of our MCU is 2.4V. This means that all the components interfaced to is working as loads would need to have a V_{IH} lower than 2.4V. This condition is met, given that the component closes to 2.4V is the LCD, which has a value V_{IH} of 2.25V.

The value of V_{OL} of the GPIO pins of our MCU is 0.4V. This means that all the components interfaced to it working as loads would need to have an V_{OL} above of 0.4V. This condition as also met, as the component with the lowest value of V_{OL} in the other components is 0.66V.

4 Maximum Pin Current

The maximum current of the GPIO pins of our MCU depend on which juncture they are in, and their position in the board. To show the values of each, they will be presented in two tables. The first one describes where in the board they are located. The second shows the max current value per position in the board:

Side	GPIO's
Left	PB[6-7], PC[4-7], PD7, PE[0-3], PF4
Bottom	PA[0-7], PF[0-3]
Right	PB[0-3], PD[4-5]
Top	PB[4-5], PC[0-3], PD[0-3,6], PE[4-5]

Side	I_{MAX}
Left	30 mA
Bottom	35 mA
Right	40 mA
Top	40 mA

Part II
Voltage Compatibility

None of our components require alternating current (AC) Voltage to work. Given that we will use power supply that converts the AC voltage off the outlet into DC voltage, the output DC voltage should suffice for all peripherals. Thus, we should not have any compatibility issues regarding voltages between source and peripherals.

Part III
Power Components

5 Thermal Analysis

6 Power Supply Capacity

For our project, we chose Cooler Master eXtreme Power Plus 550-Watt ATX as our power supply. The main characteristics of our power supply were shown at the start of the Power Analysis. As a reminder, they are as follows:

Source	Voltage	Current
1	+3.3V	25A
2	+5V	25A
3	+12V 1	16A
4	+12V 1	16A
5	-12V	0.8A
6	-5V	0.8A
7	+5VSB	2.5A

There are various reasons why we chose this power supply. Some of these are:

- **Convenience** - All of our interfaced components use voltage sources of either 3.3V, 5V or 12V. This power supply gives us all three.
- **Price** - The price of our power supply without any discount is $59.99. Online, the supply can be obtained at $19.99 using discounts. We consider this to be a completely acceptable value for the power supply of our system.
- **Efficiency** - According to our power supply's website, it is 70% better efficiency-wise at typical load operation.
- **Risk Free** - We initially considered doing our own power supply for *Aerobal*. However, once we discovered this power supply we thought that maybe it was better to buy one that was already made and worked instead of taking the risk of wasting more time trying to build a power supply. This is something we have never done before, and we prefer focusing in the interfacing aspects of the projects in order to make sure it is ready in time.