Solar RC Boat 49

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Design

From a high-level perspective, our design is composed of five subsystems, shown in Figure 1. We will have a power block that supplies power to our communication control as well as our power regulating circuit. The regulator circuit will supply power to the motor controller and motor. The communication control subsystem includes the communication hardware that determines if the boat is going out of range and when we need to warn the user. We will design a PCB that contains the power and RF subsystems, along with the microcontroller that determines their behaviors.

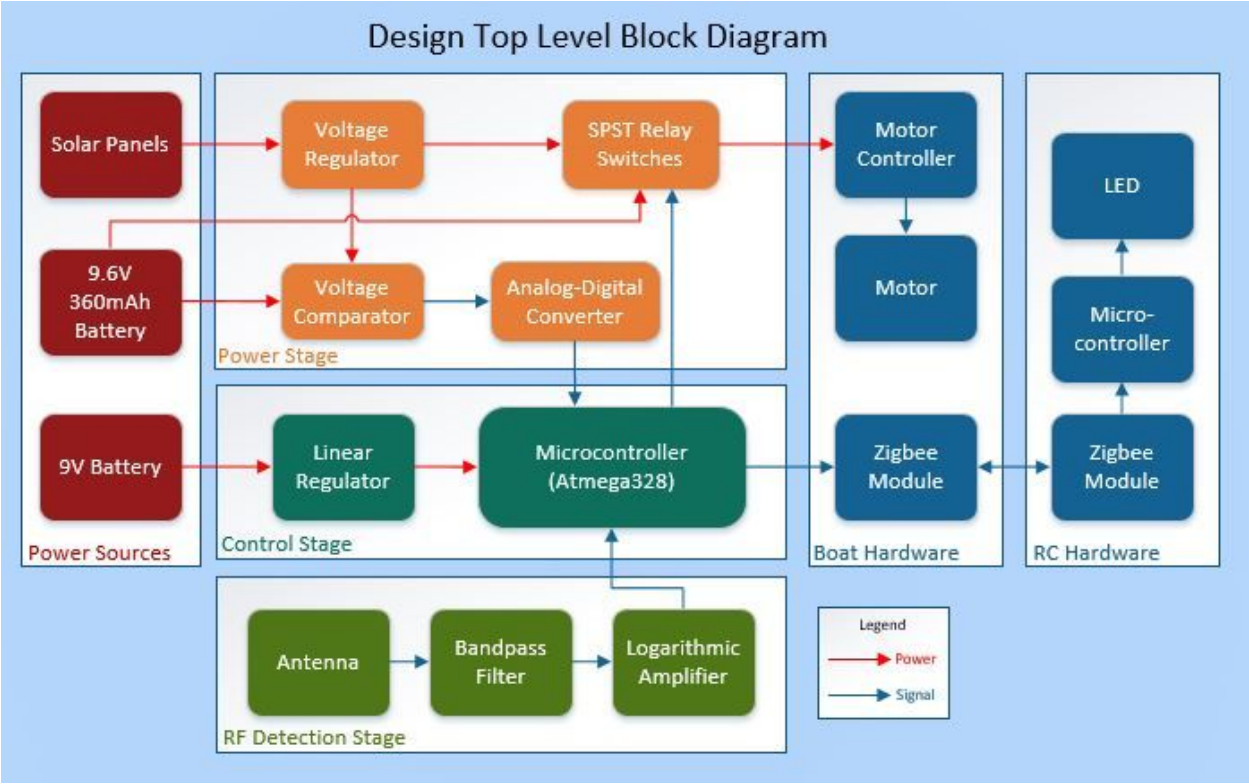

Figure 1: Block Diagram for Overall System

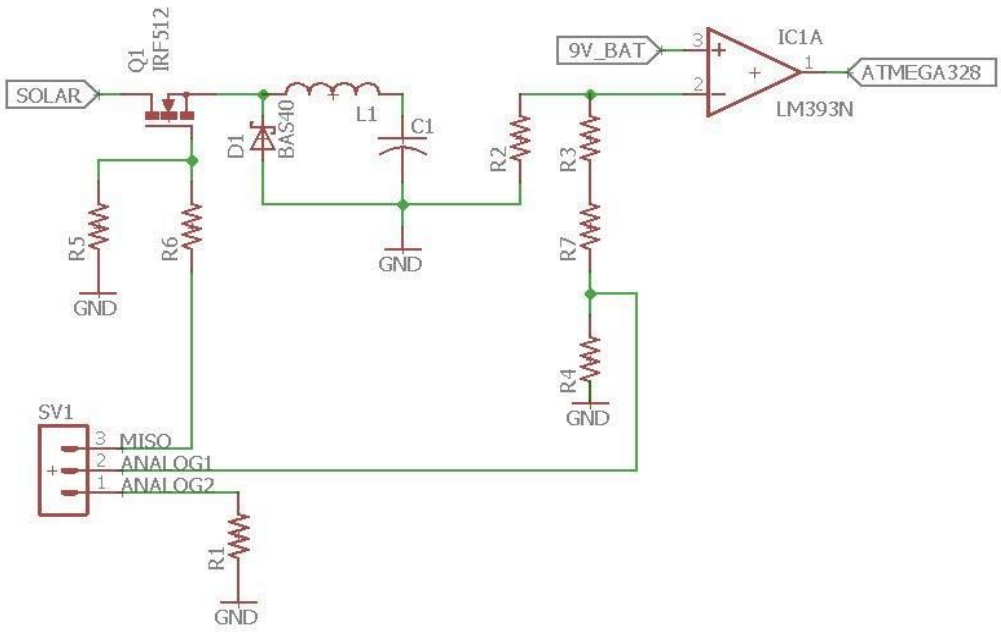

Figure 2: Power Stage Schematic

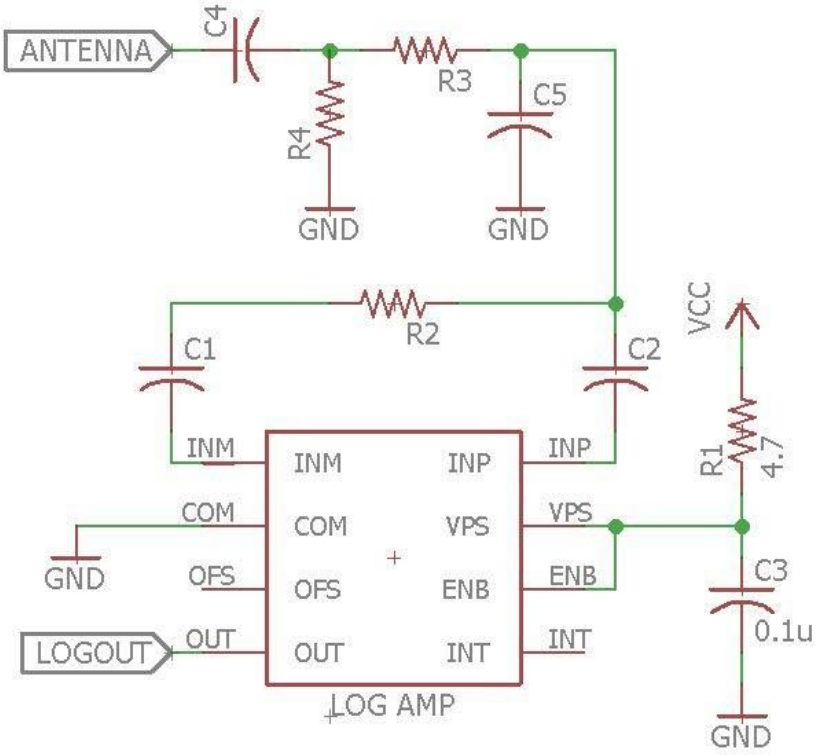

Figure 3: RF Stage Schematic

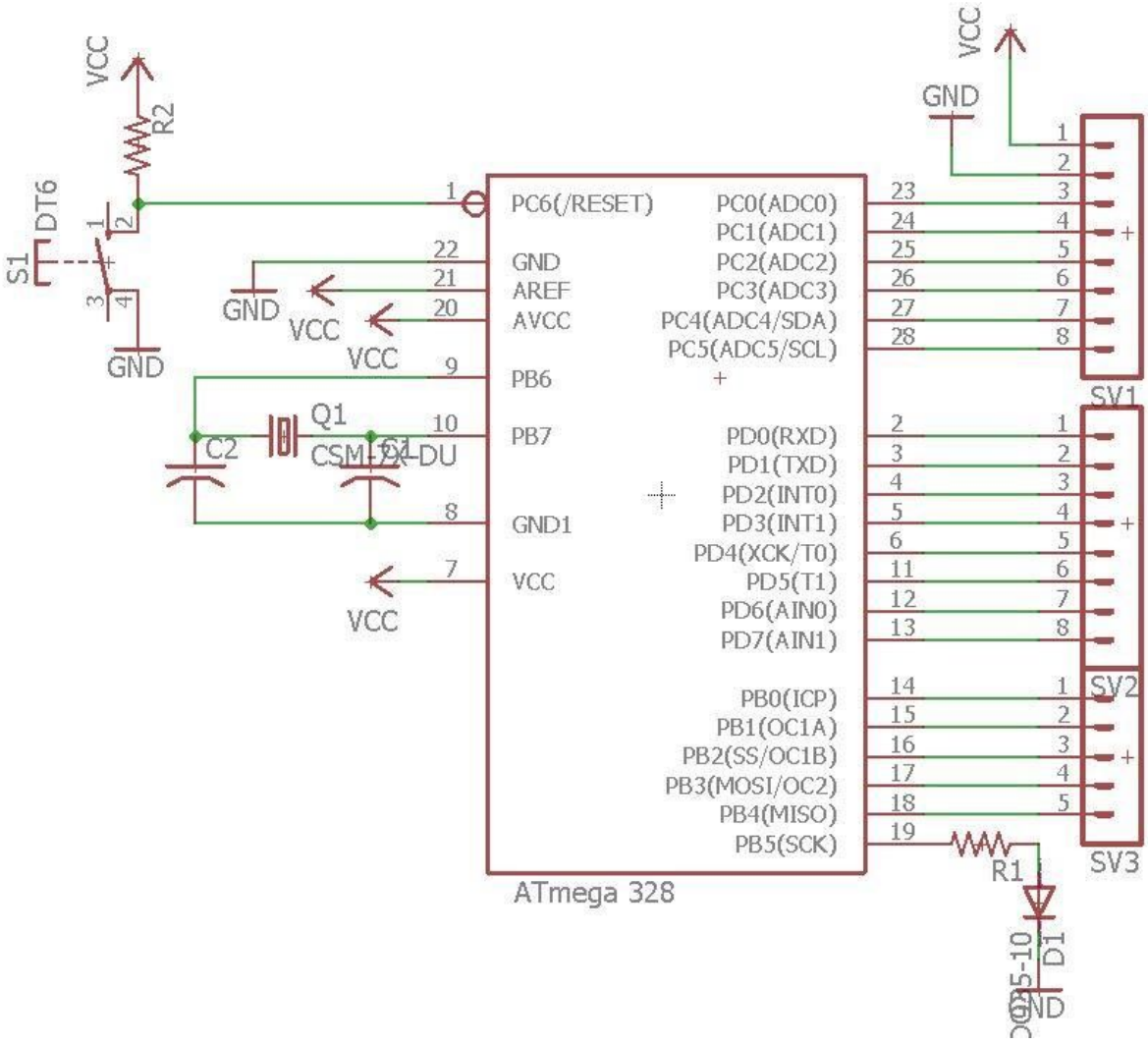

Figure 4: Microcontroller Schematic

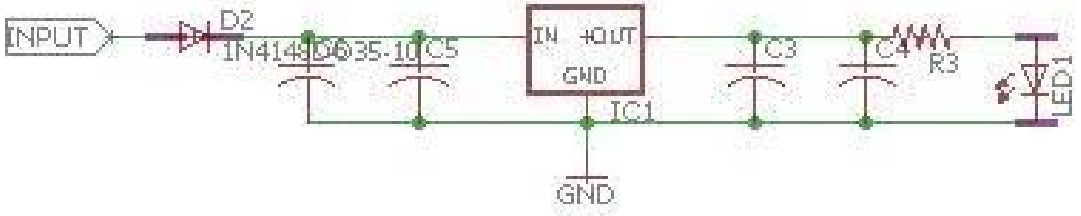

Figure 5: Linear Regulator Schematic

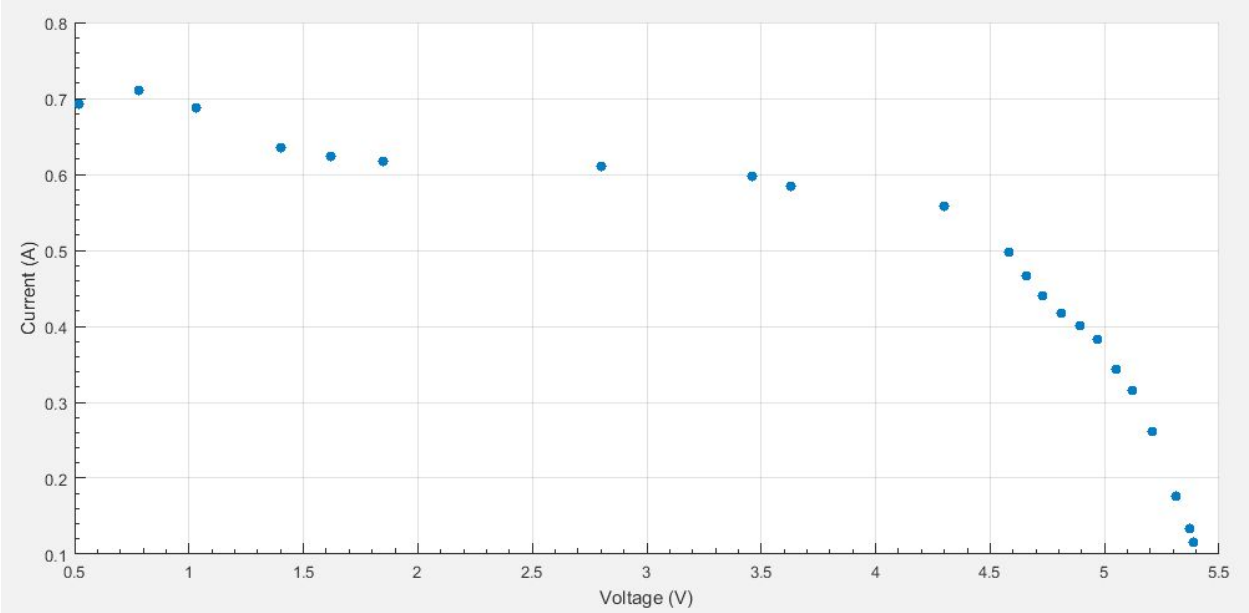

Fig. 2 I-V Characteristic for Single Allpowers Solar Panel

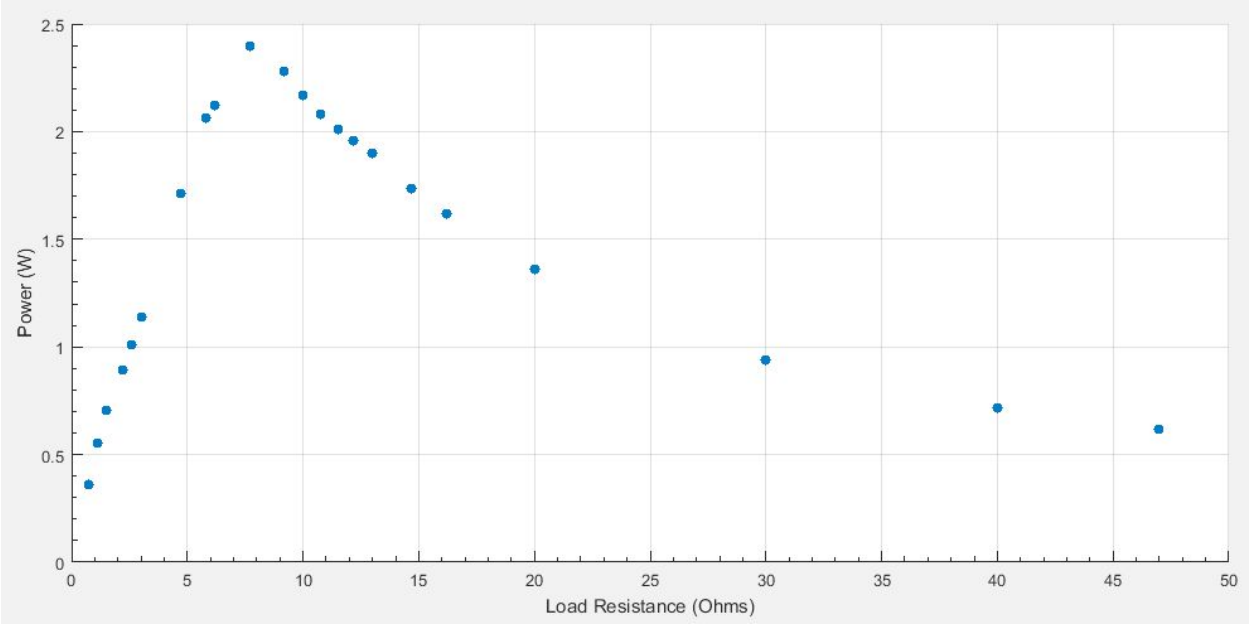

Fig. 3 Power (W) vs. Load Resistance (Ω) for Single Allpower Solar Cell

According to our solar cell characterization, maximum power output happens at 4.30V and 0.558A with a load resistance seen by the solar panel of 7.7 Ω . This allows us to produce 2.4W of power from each solar cell.

Requirements and Verifications

Requirements	Verification
Power Stage: 1. The boat must operate longer than 15 minutes when using both solar and battery power 2. The 9V battery must last longer than the internal boat battery and solar power during playtime 3. Provide regulated voltage of 6V from the solar panels 4. One power source must be connected before the other power source is removed to ensure continuous power supplied	Power Stage: 1. Verification for item 1: a. Operate boat after fully charging (2 hours) at 9V until the battery is noticeably drained b. Operate boat for at least 15 mins in the sun with solar cells powering the boat 2. Verification for item 2: a. Calculate power consumed by microcontroller and circuitry b. Determine for how long 9V battery can supply circuitry c. Linear regulator will light up LED when 9V battery is not enough to supply power to microcontroller, and battery can be replaced 3. Verification for item 3: a. Connect solar panels series and pass power to buck converter b. Attach 7.7Ω load c. Measure regulated voltage and verify that output is constant at 6V 4. Verification for item 4: a. Use two SPST Relays, one connected to regulated solar power, one connected to boat battery b. Program microcontroller to switch one relay at a time
RF Stage: 1. Bandpass filter must have a bandwidth of 20MHz, centered around 49MHz	RF Stage: 1. Verification for item 1: a. Use antenna and spectrum analyzer to capture center

2. LED must light up when boat is 10m away from remote control	frequency from remote control b. Capture frequency at various distances from antenna (up to 30m) to determine variation in center frequency c. Choose appropriate capacitors C4, C5 and resistors R3, R4 to implement bandpass filter, shown in Figure 3. 2. Verification for item 2: a. Use RF detection circuit, determine signal strength received at 10m b. Set threshold on microcontroller to that signal strength c. Check that LED turns on when controller is farther than 10m from boat

Calculations

Bandpass Filter Design:

We want a bandwidth of 20 MHz, centered around 49 MHz. This means our lower cutoff frequency $f_L = 39MHz$ and our upper cutoff frequency $f_H = 59MHz$. We chose our resistors $R3 = R4 = 10k\Omega$, and can solve for capacitors C4 and C5:

$C_4 = 1/(2\pi * R_3 * f_L) = 1/(2\pi * 10000 * 39x10^6) = .41pF$

$C_5 = 1/(2\pi * R_4 * f_H) = 1/(2\pi * 10000 * 39x10^6) = .27pF$

Buck Converter Inductor and Capacitor Design:

We want to keep the output voltage to around 6V with a 0.2V ripple.

Ethics and Safety

There are a few safety concerns with our RC boat project since we are manipulating the boat's power module. We must be highly cautious when taking apart the boat for modification; we need to maintain the battery integrity and make sure that the internal power circuitry remains protected. This is especially important because we will be doing a variety of testing in wet environments. Maintaining a protected power module is the most beneficial to the boat as well as the team members.

Although the voltage and current running through the circuitry are typically not life threatening, it could still dissipate a large amount of heat if the circuit is short circuited. This could cause burns if skin is in contact with the module, or possibly the boat. We must be careful when handling the boat, especially when we are testing our circuitry near water. A first aid burn kit should be ready at hand in case such an incident occurs.

We are responsible to make decisions consistent with the safety and health of the public and disclose any factor that might endanger the public or the environment as per Section 1 of the IEEE Code of Ethics [6]. As long as we properly handle our project during design and complete rigorous testing, none of the notable potential hazards would remain to cause any harm.

We will closely follow Section 5 and 7 in the IEEE Code of Ethics: to understand the application as well as the potential hazards of our project and promptly acknowledge and correct future errors of our design.

Resources

[1] Analog Devices. AD8307 Datasheet. [Online]. Available: http://www.analog.com/media/en/technical-documentation/data-sheets/AD8307.pdf

[2] TE Connectivity Relay Products. IM-B Relay Datasheet. [Online]. Available: https://media.digikey.com/pdf/Data%20Sheets/Tyco%20Electronics%20Corcom%20PDFs/IM_B_Relay.pdf

[3] Fairchild Semiconductor. Dual Differential Comparator Datasheet. [Online]. Available: https://www.fairchildsemi.com/datasheets/LM/LM2903.pdf

[4] DIY Hacking. [Online]. Available: https://diyhacking.com/make-arduino-board-and-bootload/

[5] Fairchild Semiconductor. LM78XX Datasheet. [Online]. Available: https://www.fairchildsemi.com/datasheets/LM/LM7805.pdf

[6] IEEE Code of Ethics. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html