Reconfigurable Antenna with Matching Network
Project Proposal

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Introduction:

The goal of this project is to develop an antenna that has the capability of changing its resonant frequency and switch to the corresponding impedance matching network. The two frequencies chosen to switch between are both GPS signals that occur at 1.227GHz and 1.575GHz. The system will have two varying sized patches, with lengths $\frac{1}{2}\lambda_{desired}$. These patches will be integrated through various switches in order to create a minimalist system (see Figure 1-1)

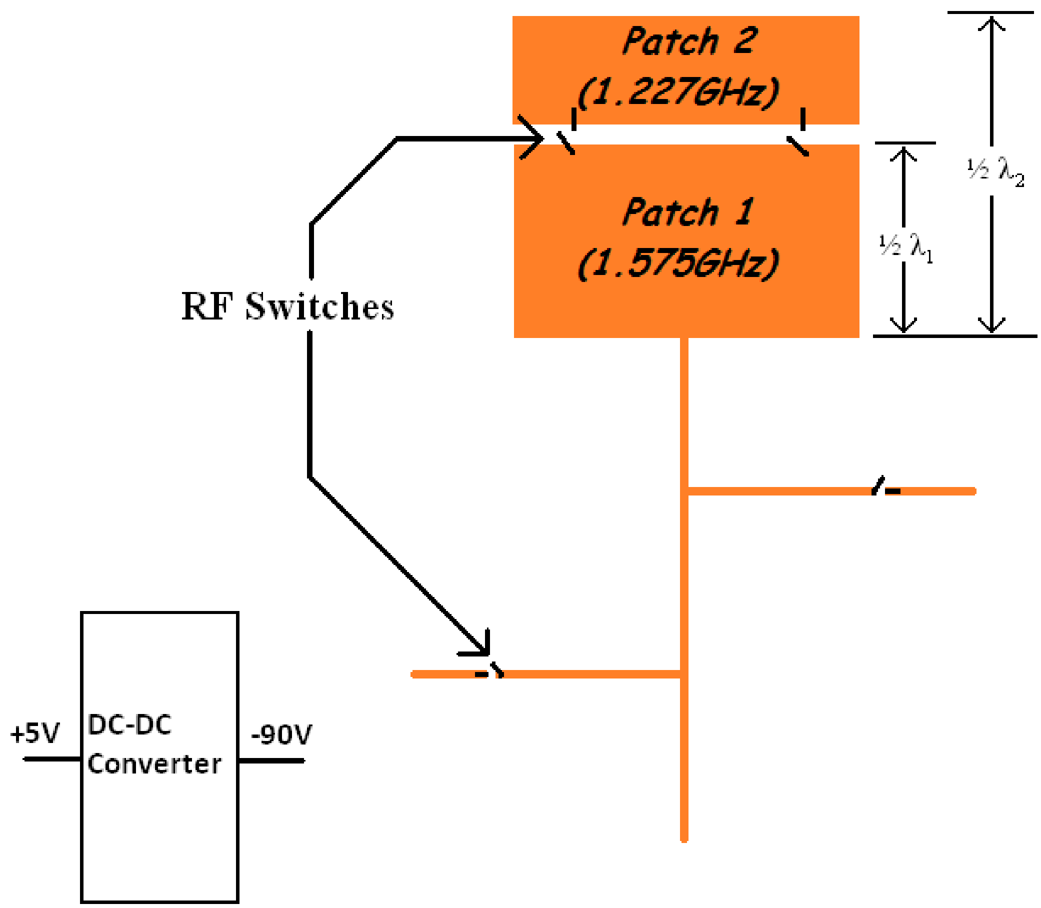

Figure 1-1: Basic design of the reconfigurable antenna for two GPS frequencies using Linear Polarization.

Detailed Description:

Reconfigurable antennas present a new option for antenna capability and technology in wireless devices. They require less space and increase functionality of an antenna system. Reconfigurable antennas are a single system that accesses multiple frequencies through various switches, patch antennas and patch networks. This eliminates the need for multiple antennas or wideband antennas. Multiple antennas take up more space, as they require an antenna for each use, and are always on. Wideband antennas, due to their inherent wide-bandwidth, receive more noise at a specific frequency than a single patch antenna. The reconfigurable antenna is an alternative solution to these possible antenna options that we seek to design and analyze its performance.

The premise of the design is simple. The longer the resonant length of the patch antenna the lower the resonant frequency becomes. The width of the patch antenna controls the impedance of the patch antenna. If we have two nearby patch antennas with small RF switches (RMSW201 MEMS) in between them, biasing the switches will connect the patches together, thus changing the frequency being received. The same switching system can be used to match the impedance of the antenna by adjusting the lengths in the double stub impedance matching network. Therefore, we can use identical RF switches in interconnecting the patch antennas and to also interconnect an impedance matching network stub. The biasing signals of the patch antenna switches and impedance matching network switches can use the same signal to alter the frequency being received by the reconfigurable antenna. This switching will be done through a +5V to -90V DC-DC Converter to bias the RMSW201 MEMS Switch.

High Level System Block Diagram:

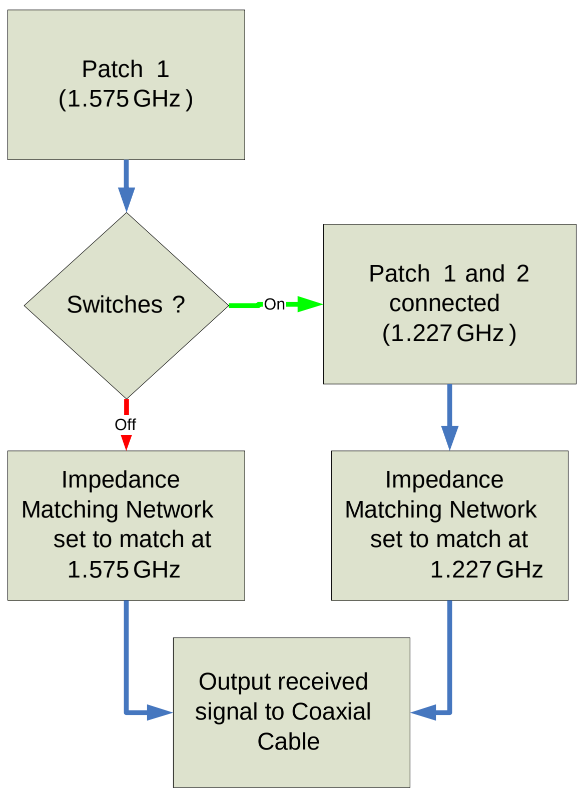

Figure 2-1: High Level System Block Diagram of Reconfigurable Antenna with Matching Network.

If the 1.575GHz GPS signal is desired, then the switches will be off, holding the patch antenna at the smaller length and thus higher resonant frequency. If the 1.227 GHz is desired, the switches will be turned on thus closing the connections between the patch antennas, this will adjust the length of both the antenna to resonant at 1.227 GHz. The operation of the reconfigurable antenna is illustrated in Figure 2-1.

Polarization:

The GPS frequencies that we will be receiving are transmitted using right-hand circular polarization according to http://www.fcc.gov. However, to meet project deadlines we will be simplifying our patch antenna design to consist of linear polarization. This means we will use square or rectangular patches without any modifications for polarization (truncated corners, slots, etc.). If we prove the linear polarization design to be possible, it will open up possibilities for future projects to add in right hand circular polarization.

Switching Technology:

We needed to determine which method of switching will not only be the most plausible but the best for our system. A small switch size is desired to limit the gap size between patch antennas. It is also very important that the RF switches have low insertion loss and high isolation in addition to operation at RF frequencies. Our goal was to implement RF MEMS switches, to meet the project objective. The drawbacks are high cost and high biasing Gate-Source Voltages. We are going to try to implement RadantMEMS RMSW201 MEMS Switches in our patch antenna. Its specifications are:

- DC to 20 GHz Operation
- 0.3dB Insertion Loss @ 2GHz
- 35dB Isolation Loss @ 2GHz
- 1.9mm x 1.85mm package size
- +/- 90V Gate-Source Voltage
- Gold Plating on Micro Strip Board required for wire bonding

Switching Control System:

To bias the MEMS Switches, we need to apply a +/- 90V to the Gate-Source of the switch. For the patch antenna system, the switches will either be all on or all off. If possible, we would like to try to have the matching network switches be on at the same time as the patch antenna switches, and vice versa. This would simplify the switching process.

Functional Requirements and Specifications:

Antenna System:

- The first patch antenna shall have a center resonant frequency of 1.575GHz, impedance of 50 ohms, and Linear Polarization.
- The connected patch antennas shall have a combined center resonant frequency of 1.227GHz, impedance of 50 ohms, and Linear Polarization.
- The patch antenna area shall be kept small without sacrificing too much performance.

Switching System:

- The switch package size shall be less than or equal to 2.0mm (for length) to ensure close proximity of patch antennas.
- The switches shall have a Low Insertion Loss (<0.7dB @ 2GHz).
- The switches shall have a High Isolation loss (>15dB @2GHz)
- The switches shall operate at least within 1 to 2 GHz frequency range.
- The switches shall have a fast switching speed (<10us).

Substrate:

- The substrate shall have a high dielectric constant, ε_r (~10).
- The substrate shall have as small of thickness as possible without sacrificing durability (> 10mils).
- The substrate shall minimize the bandwidth around the resonant frequencies to reject noise of outside frequencies while meeting the minimum bandwidth required for GPS.
  - 1.575 GHz Bandwidth is 1.563 GHz to 1.587 GHz
  - 1.227 GHz Bandwidth is 1.215 GHz to 1.239 GHz
- The microstrip board shall be gold plated in the areas where wire bonding is required for the MEMS switches.

Remaining Schedule:

Simulations (Current to Week 3 Spring Semester - Mike)

- Using Momentum
- Linear Patch Antenna
  - 1.575 GHz, 1.227 GHz
- Linear Patch Antenna w/ switches (on/off)

Impedance Matching – Double Stub (Current to Week 3 Spring Semester – Josh)

- Smith Chart
- Stub Lengths
- Open or Short Circuit

Board Fabrication (Week 4-Week 10 – Mike and Josh)

- Microstrip Board
- Implement MEMS – Wire Bonding
- Switching Device

Analysis (Week 11-End of Spring Semester – Mike and Josh)

- Resonant Frequencies
- Bandwidth
- Efficiency
- Comparison to Simulation Results

Equipment List (For 1 Reconfigurable Antenna):

- **From RadantMEMS**
  - 7 RMSW201 MEMS Switches
  - 1 RMDR1000 8-Channel, 90 V Evaluation Driver
- **From Rogers Corporation**
  - RO3010 12”x18” High Frequency Laminate

Conclusion:

The goal of the project is to create the GPS reconfigurable antenna described throughout this paper. The system will use RF MEMS switches. It will implement a double stub matching network for proper antenna use, by creating an impedance matching network. The antenna will be configured to linear polarization at GPS signal resonant frequencies. Since we just recently changed the design from right hand circular polarization to linear polarization, we will have to redo a few length and width calculations before continuing simulations.

References:

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Yang, Songnan, Chunna Zhang, Helen K. Pan, Aly E. Fathy, and Vijay K. Nair. "Frequency Reconfigurable Antennas for Multiradio Wireless Platforms." *IEEE Microwave Magazine* (2009): 67-84. Print.