Satellite Digital Audio Radio Service Receiver Front-End

Project Proposal

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Introduction

The Satellite Digital Audio Radio Service (SDARS) is primarily for entertainment broadcasting from orbital satellites and received by modules commonly found on modern automobiles. The project involves designs, simulations, fabrication, and testing of the individually designed components, such as the passive antenna and low-noise amplifier (LNA). The final system will be the integration of all the components of the active antenna (passive antenna + LNA) to receive SDARS signal by means of a SIRIUS receiver. The active antenna design must minimize physical size, while producing the best quality signal.

Goals

The goal of this project is to make an active antenna to receive frequencies from 2320 MHz to 2332.5 MHz. From this frequency range, the SIRIUS receiver will be able to process and play all the possible allocated radio channels. In previous years' projects for the SDARS system, students have been able to replace the manufacturer's antenna with a fabricated proximity coupled patch antenna. This antenna combined a separate Left Hand Circular Polarized (LHCP) passive antenna with low noise amplifiers in connecting the separate components. This time, the entire active antenna will be constructed with the passive antenna and low noise amplifiers combined onto a single Printed Circuit Board (PCB). Also, a square patch with probe fed design technique will be used for the passive antenna. By probe feeding the square patch antenna, it will be able to receive LHCP signals.

System Block Diagram

The figure below shows the top-level design of the active antenna from our system (FIG 1)

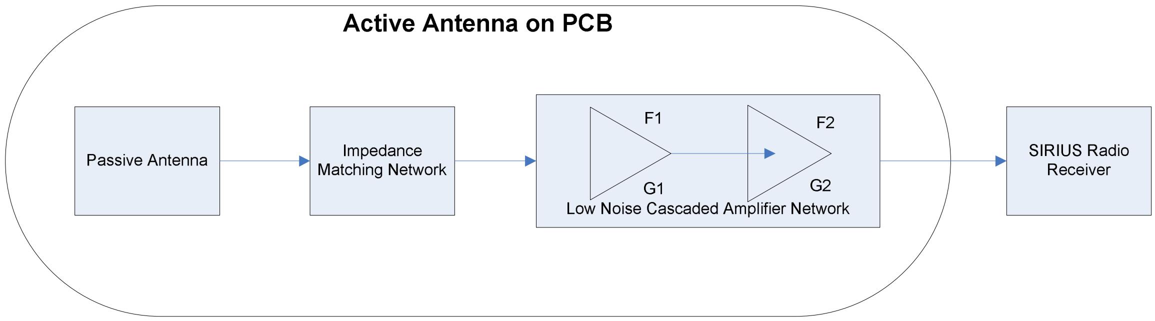

FIG 1: SDARS Functional Block Diagram

Antenna Requirements

- It shall receive signals in the frequency band from 2320 MHz to 2332.5 MHz (a bandwidth of 12.5MHz)
- The VSWR shall be under 2 in the designated frequency range (|S11| < -10dB)
- Shall be designed as a square patch, probe fed antenna to allow for Left Hand Circular Polarization (LHCP)
- Patch antenna matched in impedance to LNA network (impedance matching network)

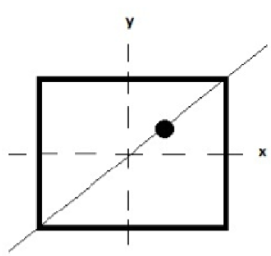

FIG 2: Top View of Patch Antenna, LHCP Probe Feed Alignment

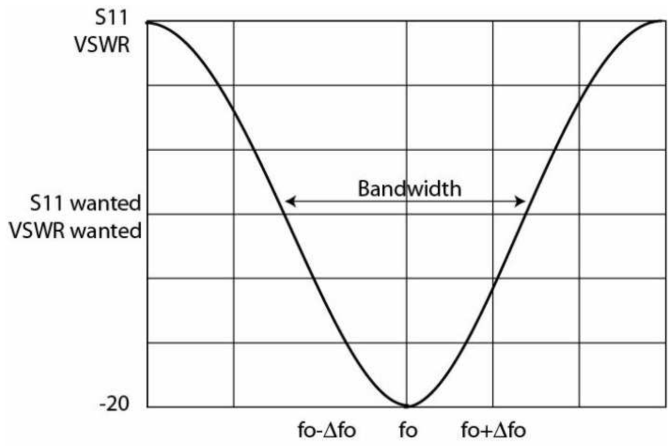

FIG 3: Anticipated Bandwidth plot of Antenna (fo=2.326 GHz, BW=12.5 MHz)

LNA requirements

- The cascaded LNA network noise factor shall be less than or equal to 1dB
  - First LNA in cascaded network shall be low noise, high gain (< 0.9 dB Noise Factor, > 20 dB gain)
  - Second and all following LNAs shall have a moderate to high gain, while allowing for higher noise factors
- Total gain for the cascaded LNA network shall be between 40-50dB

The Total Noise factor will be calculated according to EQ 1:

$$NF = F1 + (F2 - 1)/G1 + (F3-1)/(G1*G2) + \ldots \quad (1)$$

Notice that F1 corresponds to the noise factor of the first LNA, with G1 representing the associated gain with the same LNA. The same follows for F2 and G2, corresponding to the second LNA in the network.

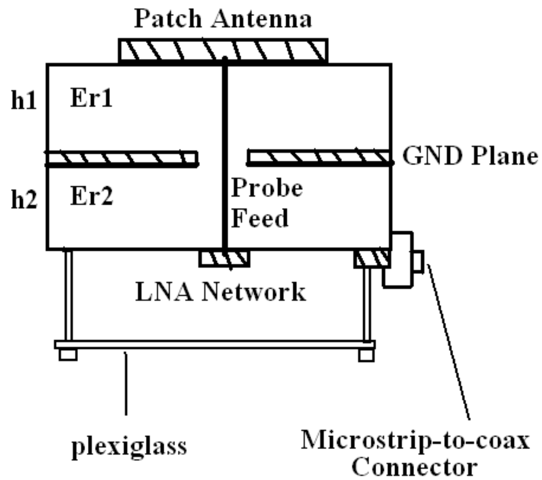

FIG 4: Physical Rendition of Patch Antenna and LNA Network

Parts and Equipment

- RO3003, R3010 substrate
- Sirius Radio Receiver
- HMC548LP3 LNA
- HMC667LP2 LNA
- MCL15542 DC Blocking Capacitor
- EM Simulation Software (Sonnet / Momentum)
- PCAAD
- Agilent ADS
- CPPATCH
- Network Analyzer
- Spectrum Analyzer
- Frequency Generator
- Power Supplies
- Choke Inductors

- Bypass / DC-blocking caps

Tasks for Next Semester

For next semester, we will plan on the following schedule in plans to finish our project:

- Complete EM simulations with Momentum and optimize antenna design (Feb)
- Test LNA evaluation boards with NA (Feb)
- Design Impedance Matching for the LNA network (Feb)
- Design Bias Circuitry for the LNAs (March)
- Simulate entire active antenna in Agilent ADS (March)
- Outsource Fabrication of Substrates (March)
- Test Fabricated Antenna and LNA Substrates (April)
- Test complete system active antenna board with Sirius Receiver (April)

References

[1] Zomchek, Greg and Zeliasz, Erik. “SDARS Front-End Receiver: Senior Capstone Project Report.” Bradley University, Spring, 2001.

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[3] Balanis, Constantine A., “Microstrip Antennas,” in *Antenna Theory, 3rd ed.* John Wiley and Sons, Inc., 2005, pp.811-882

[4] Pozar, David M. and Schaubert, Daniel H. “A Review of Bandwidth Enhancement Techniques for Microstrip Antennas,” in *Microstrip Antennas: the analysis and design of microstrip antennas and arrays* Institute of Electrical and Electronics Engineers, Inc., 1995, pp.157-165