Overview

• Project description / goals
• Antenna and LNA specifications
• Parts obtained / still needed
• LNA measurements
• L.P. antenna simulations
• C.P. antenna preliminary simulations
• Plan of Action
• Schedule review
System Description

- A radio station uploads the signal to satellites.
- Satellites broadcast over entire nation.
- Terrestrial repeaters supplement blocked satellite signals.
- Signal is received with a consumer radio unit by an active antenna.

http://cegt201.bradley.edu/projects/proj2001/sdarsprj/funcdesc.html
Project Goals

1) Design and perform CAD simulations on a linearly polarized, proximity coupled patch antenna which meets SDARS specifications - complete

2) Design and perform CAD simulations on a proximity coupled patch antenna configured for Left-Hand Circular Polarization (LHCP), which meets SDARS specifications - in progress

3) Fabricate the Antennas in-house – linearly polarized antenna next week 2/29/11

4) Research and purchase a low-noise amplifier in a prefabricated surface mount package to integrate with the antenna - complete

5) Fabricate a test board and measure the gain and noise figure characteristics of a purchased LNA to ensure it meets SDARS specifications – S-parameters were measured

6) Test the antennas experimentally to determine that it meets performance specifications

7) Construct the active antenna (antenna plus LNA) and test its performance.

8) Replace the manufacturer’s provided active antenna system with the fabricated version and test overall system.
Antenna Specifications

- 2320 MHz to 2332.5 MHz
- 3 dBi gain
- VSWR 2:1
LNA specifications

- 25.5 to 29.5 dB LNA gain
  - 2 amps cascaded: each with minimum 12.75 dB gain
- 28.5 to 32.5 dB total gain (LNA + antenna)
- 2320 MHz to 2332.5 MHz operation
- $Z_0 = 50 \, \Omega$
- NF $\leq 0.9$ dB
- HMC715LP3
  - 2.1 to 2.9 GHz operation
  - NF = advertises 0.9 dB, but is 0.86 on data sheet
  - Gain = 19 dB
  - 3 to 5 V supply
  - Output P-1dB $\approx 18.5$ dBm at 2326 MHz
Parts Obtained

- 2 HMC715LP3 LNAs and one evaluation board.
- Sirius radio receiver
- SMA/SMB coaxial cable converters
- Copper - clad PCB boards used for the active integrated antenna fabrication
Additional Parts Needed

- IC chip resistors and capacitors operating within frequency band (2 each of) 100pF, 1000pF, 0.47μF, 68 pF, 3.3 pF, 2 kΩ
- Additional LNAs (10)
LNA measurements: $V_{\text{bias}} = 3V$

HMC715LP3 gain (S21 mag dB), 2.32 GHz: 17.925 dB, 2.32625 GHz: 17.956 dB, 2.3325 GHz: 17.993 dB, 3V, 14mA
LNA measurements: $V_{\text{bias}} = 3\text{V}$

S21 Phase. 2.32 GHZ: -99 degrees, 2.32625GHz: -94.841 degrees, 2.3325GHz: -90.553 degrees. 3V.
LNA measurements: $V_{bias} = 3\text{V}$

S11 magnitude dB. 3V. 2.32GHz: -10.159 dB, 2.32625GHz: -10.11 dB, 2.3325GHz: -10.145 dB.
LNA measurements: $V_{\text{bias}} = 3\text{V}$

S12 mag dB. 2.32GHz: -31.246 dB, 2.32625GHz: -30.827 dB, 2.3325 GHz: -30.102 dB. 3V.
LNA measurements: $V_{bias} = 3V$

S22 mag dB. 2.32GHz: -11.571 dB, 2.32625GHz: -11.56 dB, 2.3325GHz: -11.582 dB. $V_{bias} = 3V$
LNA measurements: $V_{\text{bias}} = 5\text{V}$

S21 $\text{mag \ dB. } 5\text{V. } 70.66\text{mA. L: } 19.288\text{dB, C: } 19.205, \text{ R: } 19.245.$
LNA measurements: $V_{\text{bias}} = 5V$

S21 phase. 5V. L: -88.856 degrees, C: -89.439 degrees, R: -90.147 degrees
LNA measurements: $V_{\text{bias}} = 5\text{V}$

LNA measurements: $V_{\text{bias}} = 5V$

LNA measurements: $V_{\text{bias}} = 5V$

LNA measurements: $V_{bias} = 5V$

- Hittite specs match measurements.
- Ports are reasonably matched to 50 Ohms.
- Comparison of min gain spec in yellow.
Initial Calculations and PCAAD 6.0
Linearly Polarized Antenna

- Length of patch: 1538 Mil
- Width of patch: 1592 Mil
- Length of feed line: 814 Mil
- Width of feed line: 89.25 Mil (50 Ohms)
- Red = upper layer
- Yellow = lower layer
L.P. Antenna 3D view
Proximity Coupled Patch: PCAAD 6.0

- 3.9065 cm = 1538 Mil
- 4.0437 cm = 1592 Mil
L.P. Antenna Measurements: $Z_{\text{in}}$ at port 1

- Measurements using Momentum
- Center frequency = 2.32625 GHz

![Graph showing real and imaginary parts of $Z_{\text{in}}$ against frequency.](image)

- **m1**
  - freq = 2.327 GHz
  - real($Z_{\text{in}}$) = 10.476
- **m2**
  - freq = 2.327 GHz
  - imag($Z_{\text{in}}$) = -0.232
L.P. Antenna S(1,1)
L.P. Antenna gain and efficiency

Gain → Based on input power
Directivity → Based on radiated power
Efficiency = G/D

Gain → Directivity
Efficiency [%] = 78.594

THETA = 0.000
10*log10(mag(Gain)) = 6.406
L.P. Antenna Polarization

- Gain is measured at max radiation

\[ AR_{cp} = \frac{|E_{lh}| + |E_{rh}|}{|E_{lh}| - |E_{rh}|} \]

Axial Ratio

Diagram showing the polarization of E_left and E_right.
L.P. Antenna with Quarter-wave Transformer Matching Network

- Chart showing dB(S(1,1)) values from 2.300GHz to 2.400GHz.
- S(1,1) = 0.006 / 146.475
- Impedance = Z0 * (0.990 + j0.007)
- Chart with dB(S(1,1)) values ranging from -40 to 0 dB.
- Chart with freq values ranging from 2.300GHz to 2.400GHz.

Design parameters:
- m3: freq=2.325GHz, S(1,1)=0.006 / 146.475, Impedance = Z0 * (0.990 + j0.007)
- m4: freq=2.326GHz, dB(S(1,1))=-45.317, Min 2.326GHz
L.P. Antenna with Shorted Single-Stub Matching Network

**S-PARAMETERS**

- **S_Param**
  - **SP1**
    - Start=2.3 GHz
    - Stop=2.4 GHz
    - Step=

**Impedance**

- **Zin**
  - $Z_{in} = Z_0 \times (1.014 - j3.984 \times 10^{-4})$

**Readout**

- **m4**
  - freq=2.326 GHz
  - $\text{dB}(S(1,1)) = -42.985$

**freq (2.300 GHz to 2.400 GHz)**

- **m3**
  - freq=2.326 GHz
  - $S(1,1) = 0.007 / -1.587$
  - Impedance = $Z_0 \times (1.014 - j3.984 \times 10^{-4})$
Circularly Polarized Design

- In progress
- Utilization of Momentum’s existing built in optimization tool, or manual measurements of Lo and S.
- Iwasaki Source gives $f$, $\varepsilon_r$, $h$ has a small effect. We can estimate position of the feed line
- $S \rightarrow 12 – 18 \%$ of total patch length
- $W \rightarrow 34 – 46 \%$ of offset range, measured from the center to the edge of the patch width
Circularly Polarized Design
Circularly Polarized Design
Plan of Action

• Design a matching network for the linearly polarized antenna, fabricate, and test.
• Finish design of the circularly polarized antenna, designing for minimum axial ratio.
• Design the matching network for the circularly polarized antenna, fabricate, and test.
• Simulate the cascaded LNAs
• Fabricate and test the cascaded LNAs
  – Outside services needed for fabrication
# Original Timeline

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## Revised Timeline

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<td>Simulation and fabrication of cascaded LNA board and testing</td>
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Questions