Patch Antennas

UNIK9700 Radio and Mobility

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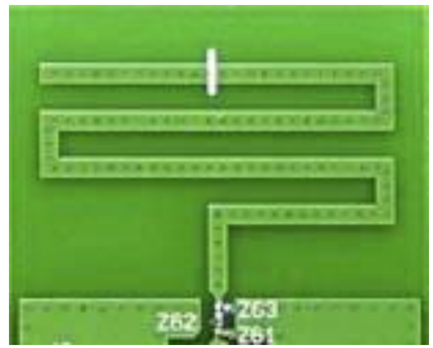
Outline

- Introduction – Patch antennas
- Theory - Rectangular patch antenna
- Case study – Design of a patch antenna

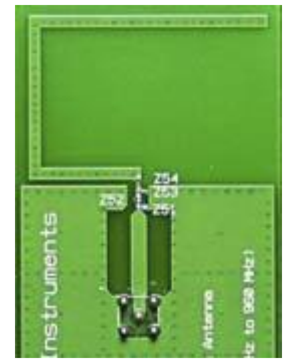
Microstrip Antennas

- First proposed in 1953
- Commercialized in the 70s

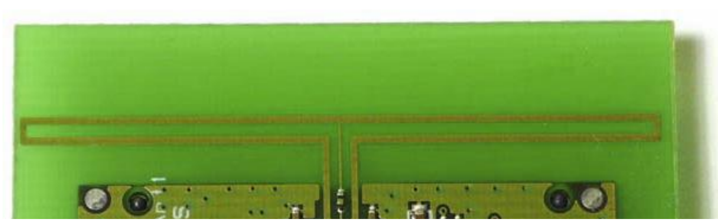
- Inexpensive
- Compatible to PCB
- Easy to manufacture
- Low profile
- Used in the >1GHz range



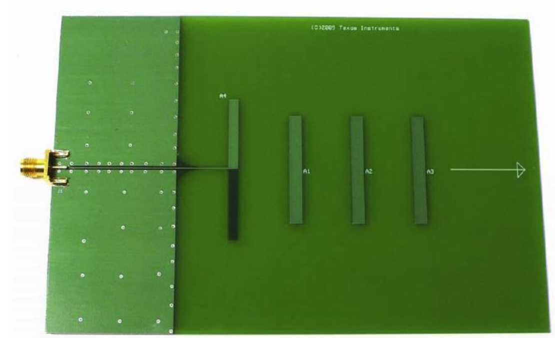
Meandering Monopole antenna



Loaded Stub Antenna



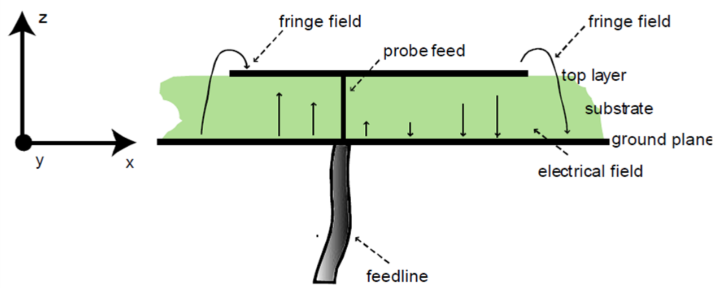
Folded Dipole antenna



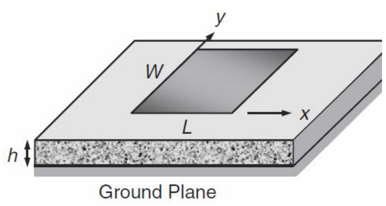
YAGI antenna

Rectangular Patch Antenna

- Popular type of microstrip antenna
  - High gain
  - Wide beam
  - Lower efficency
  - Lower bandwidth



- Antenna bandwidth
  - Measured in % -> $\% = \frac{BW}{f_0}$
  - increases with substrate thickness
  - decreases with substrate permitivity
  - Efficency deceases with substrate permitivity
  - WLAN uses air as substrate



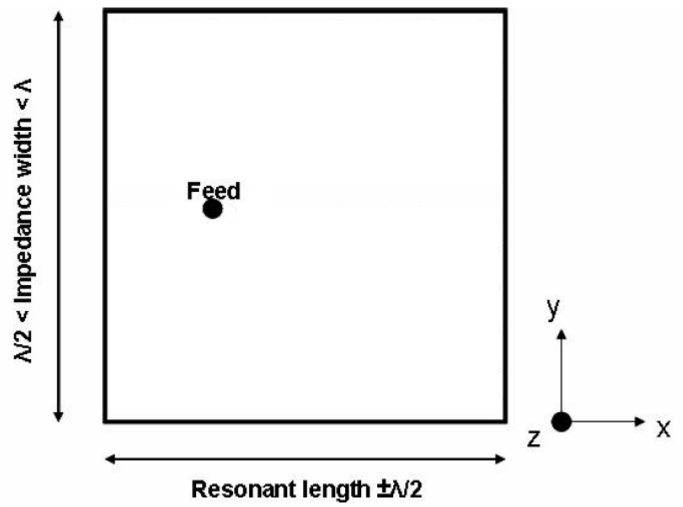
Rectangular Patch Antenna

- Calculating the antenna dimensions

  - $L = 0.49\lambda_d = \frac{\lambda_0}{\sqrt{\varepsilon_r}}$

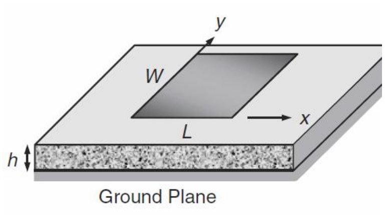
  - $\frac{W}{L} = 1.5$

  - $f_0 = \frac{c}{2(L+2\Delta L)\sqrt{\varepsilon_r}}, where\ \Delta L = f(h, W)$



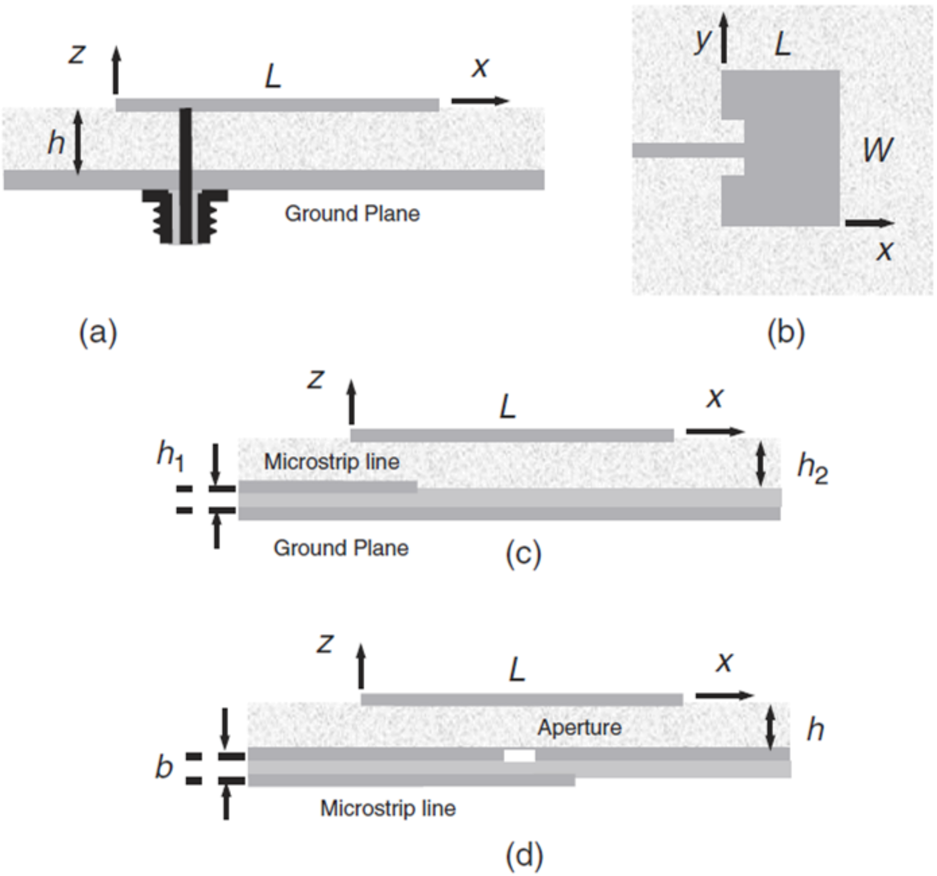
Resonance frequency (f_0) is influenced by:

- ground plane size
- copper thickness
- Impedance width



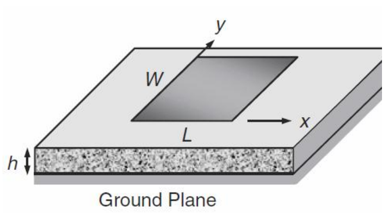
Signal Feeding

- Coaxial probe feed (a)
  - Simple feed
  - Probe reactance must be considered
  - Used for standalone antennas
- Inset feed (b)
  - Used for antenna arrays
  - Allows for more flexible impedance matching
- Proximity feed (c)
  - More complex
  - Reduces emissions from the feed line
- Aperture feed (d)
  - reduces radiation from feed line
  - Some back radiation
  - Probe reactance not an issue

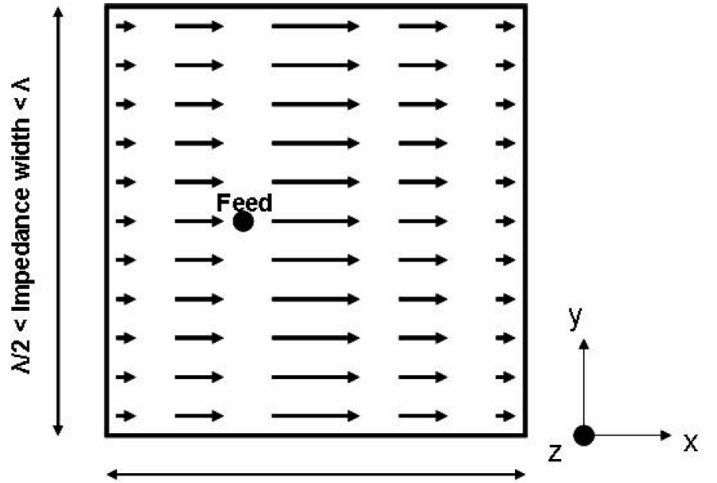


TEM - Mode

- Transversal Electro Magnetic (TEM_{xyz}) field distribution



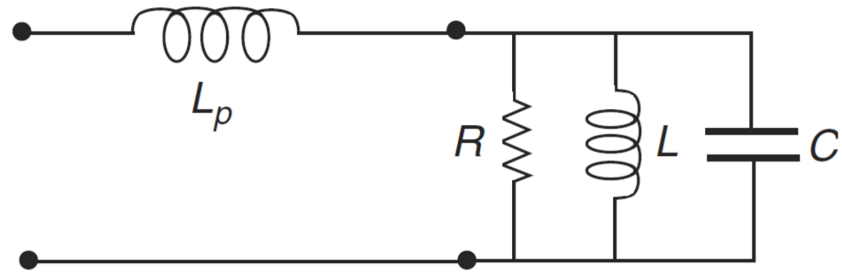
- Patch antennas denoted TM_{10} using cavity theory



Current distribution on the patch surface.

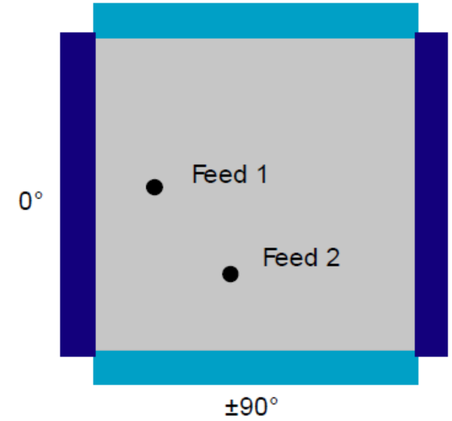
CAD model

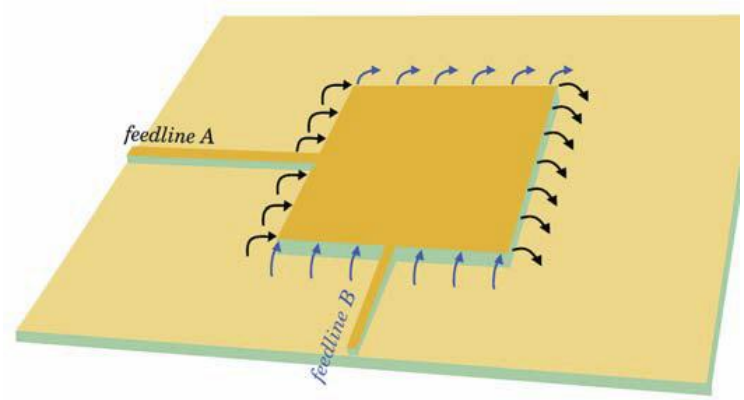
- Patch cavity resonator
  - CAD modeling
  - Simplified model of a patch antenna
  - Applicable for patch antennas with a thin substrate
  - CAD modeling can be used when antenna complies with TM_{10}



Circular Polarization

- Signal split in two
- Vertical and horizontal radiator
- One feed phase shifted by 90 Deg.

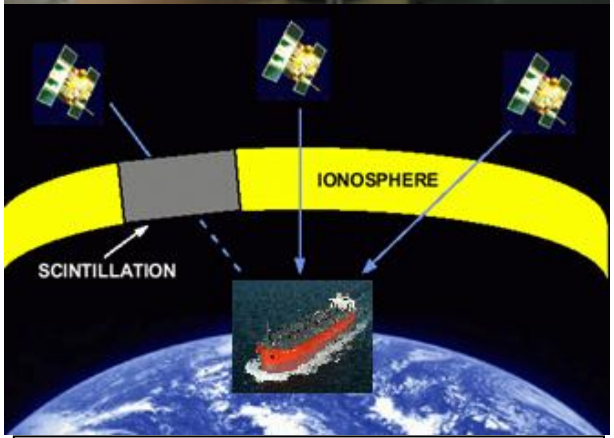




STAR

Space Technology And Research center

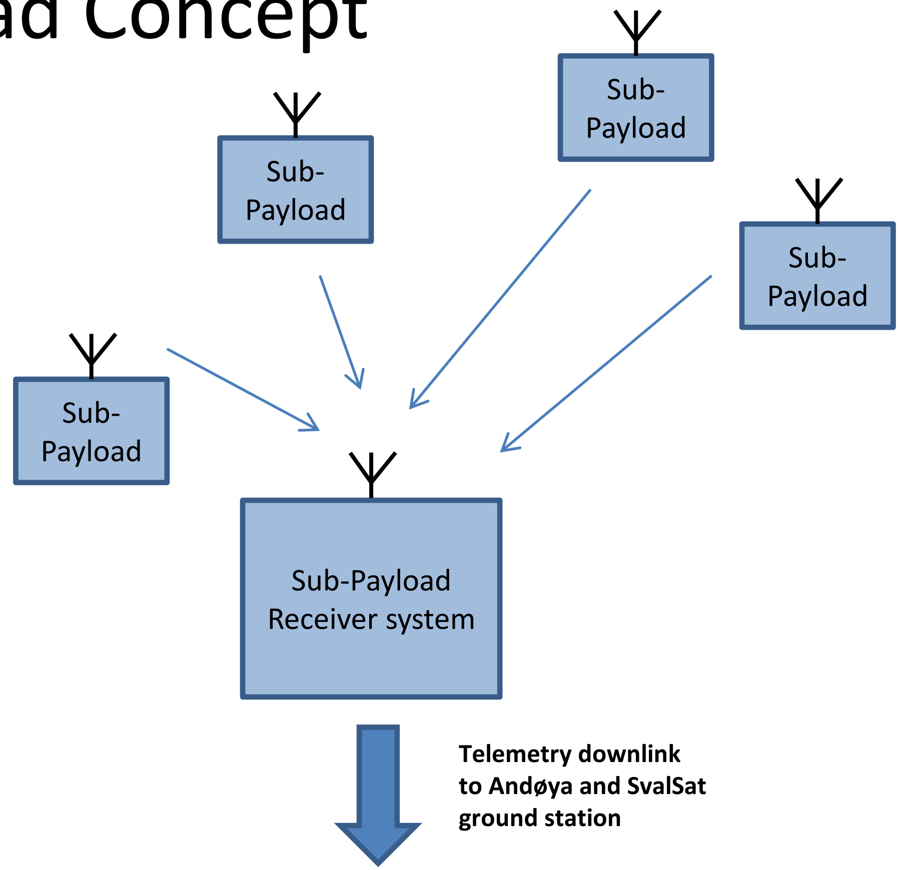
- Cooperation between the Space- and Plasma Physics group and Electronics group
- Investigate plasma density and turbulence in the ionosphere
- Mitigate satellite communication outage
- multi-Neddle Langmuir Probe (m-NLP)



(Top): A neddle Langmuir probe.
(Bottom): GPS signal interference induced by scintillation in the ionosphere

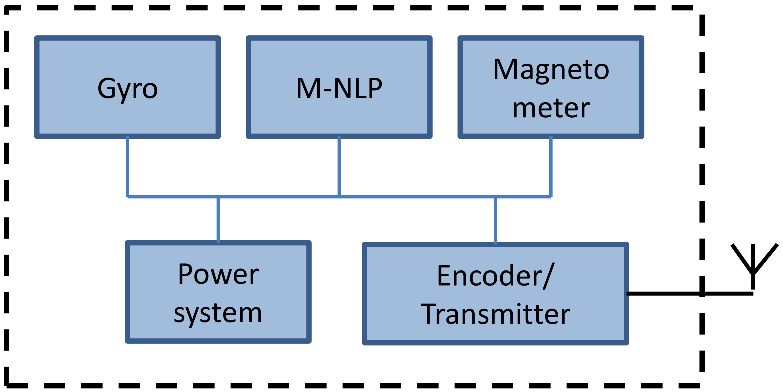
Sub-Payload Concept

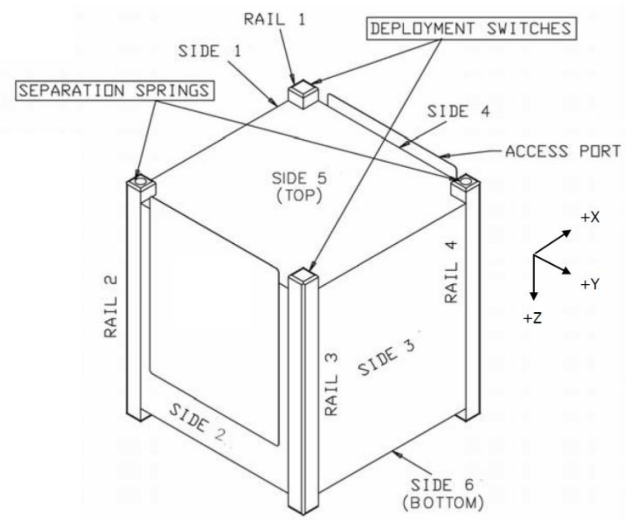
- Deployable sensor platform for sounding rockets
- Objective is to increase data points on electron density measurements
- Receiver system employs Frequency Division Multiple Access (FDMA) to gather data from all sub-payloads simultaneously
- Received data is encoded into the rockets telemetry system and forwarded to ground



Sub-Payload

- Sensors
  - M-NLP
  - Gyro
  - Magnetometer
- Data budget
  - Data rate: ~200Kbit/s
  - Coverage: <2000m
- Radio link
  - 250kBaud
  - Minimum Shift Keying (MSK) modulation scheme

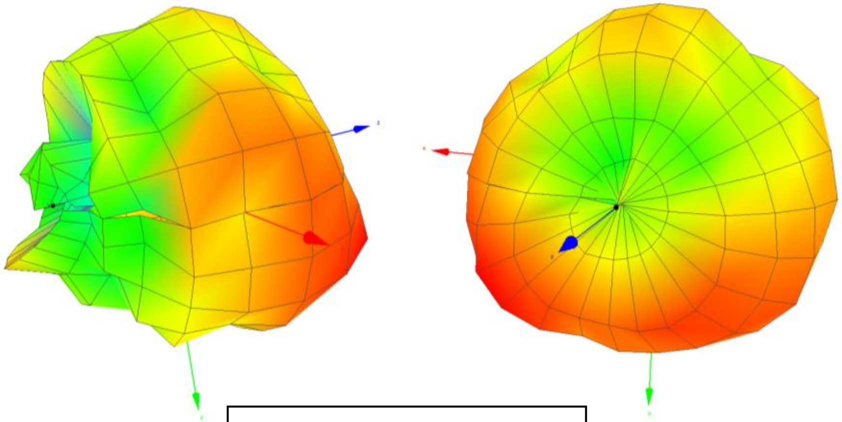




Sub-Payload Antenna Measurements

- Antenna coverage
- Receiver antenna: constrained by the launch team at Andøya Rocket Range (ARR)
- Selected prefered antennas from ARR
  - Polarization: Linear
  - Gain: 0 – 3dB

Receiver antenna



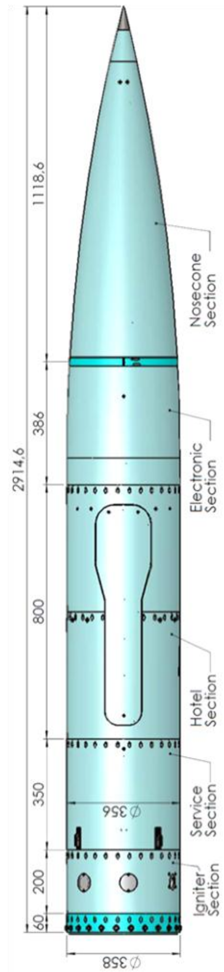
Measured radiation pattern

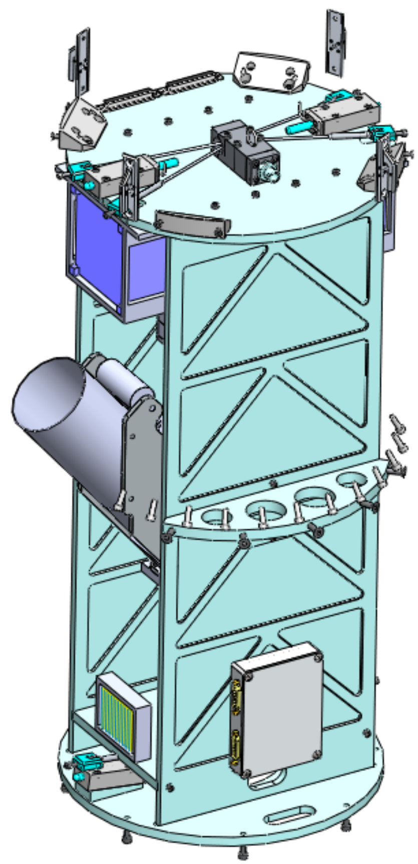
MAxiDusty Campaign

- Rocket campaign from Andøya Rocket Range (ARR)

- Timetable:
    - 1. Hardware integration Jan.2013
    - 2. Hardware integration April 2013
    - Launch Aug. 2013

- Objectives
    - Perform proof of concept
    - Perform 3D ion density measurements

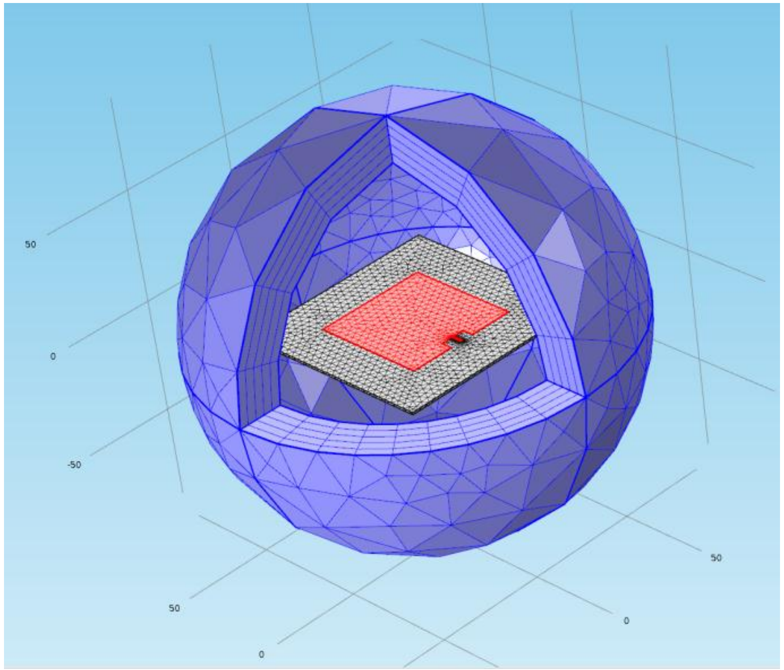




CAD model of MaxiDusty and the Hotel section

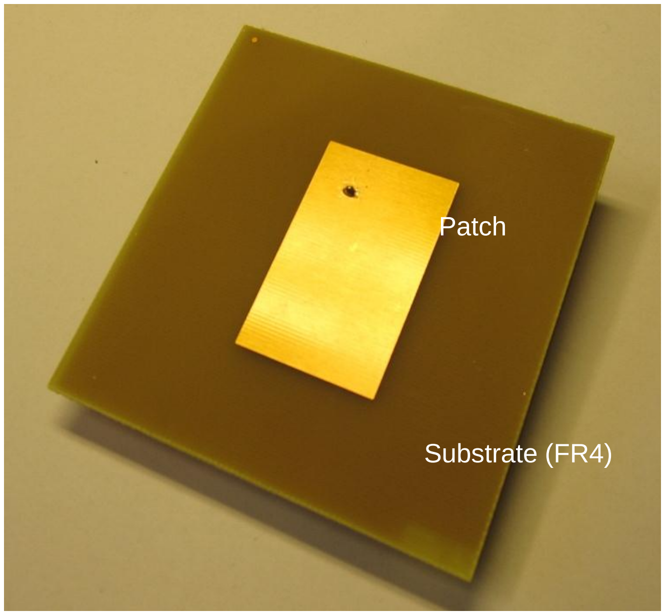
Sub-Payload Patch Antenna

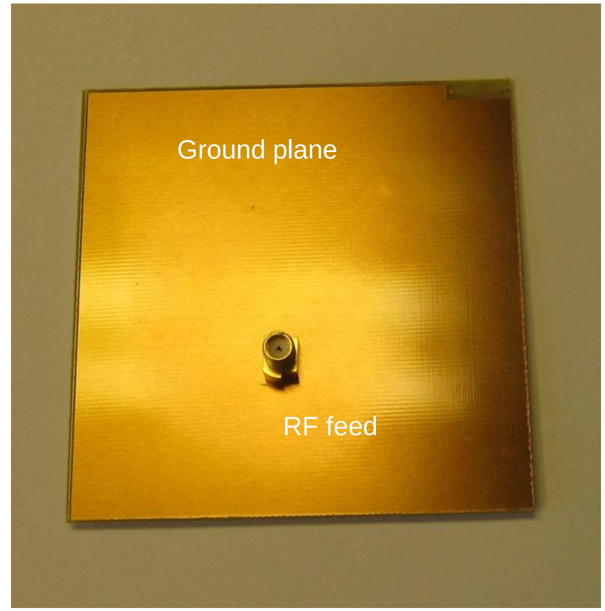
- Low profile
- Half-Sphere radiation pattern
- Circular polarization
- Mounted on opposite sides of the sub-payload
- Antenna design
  - Multiphysics simulation tool
  - Measurements in antenna chamber



CAD simulation model of the patch antenna

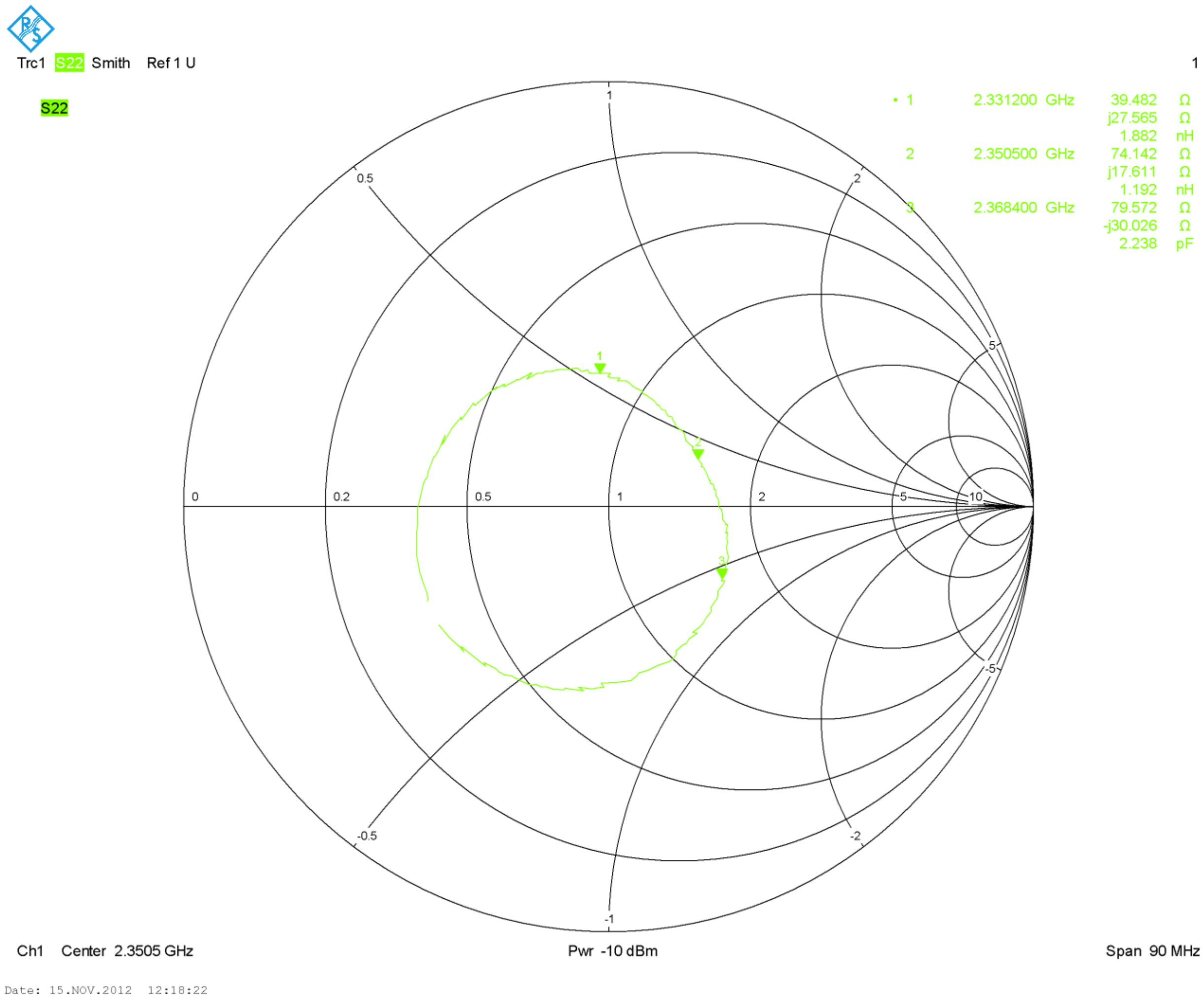
Sub-Payload Patch Antenna





- $L = 0.49\lambda_d = 0.49\frac{\lambda_0}{\sqrt{\varepsilon_r}} = 0.49\frac{12.5cm}{\sqrt{4.5}} = \underline{2.88cm}$
- $\frac{W}{L} = 1.5 \rightarrow W = 1.5 \times 2.88cm = \underline{4.33cm}$

Patch Antenna Measurments



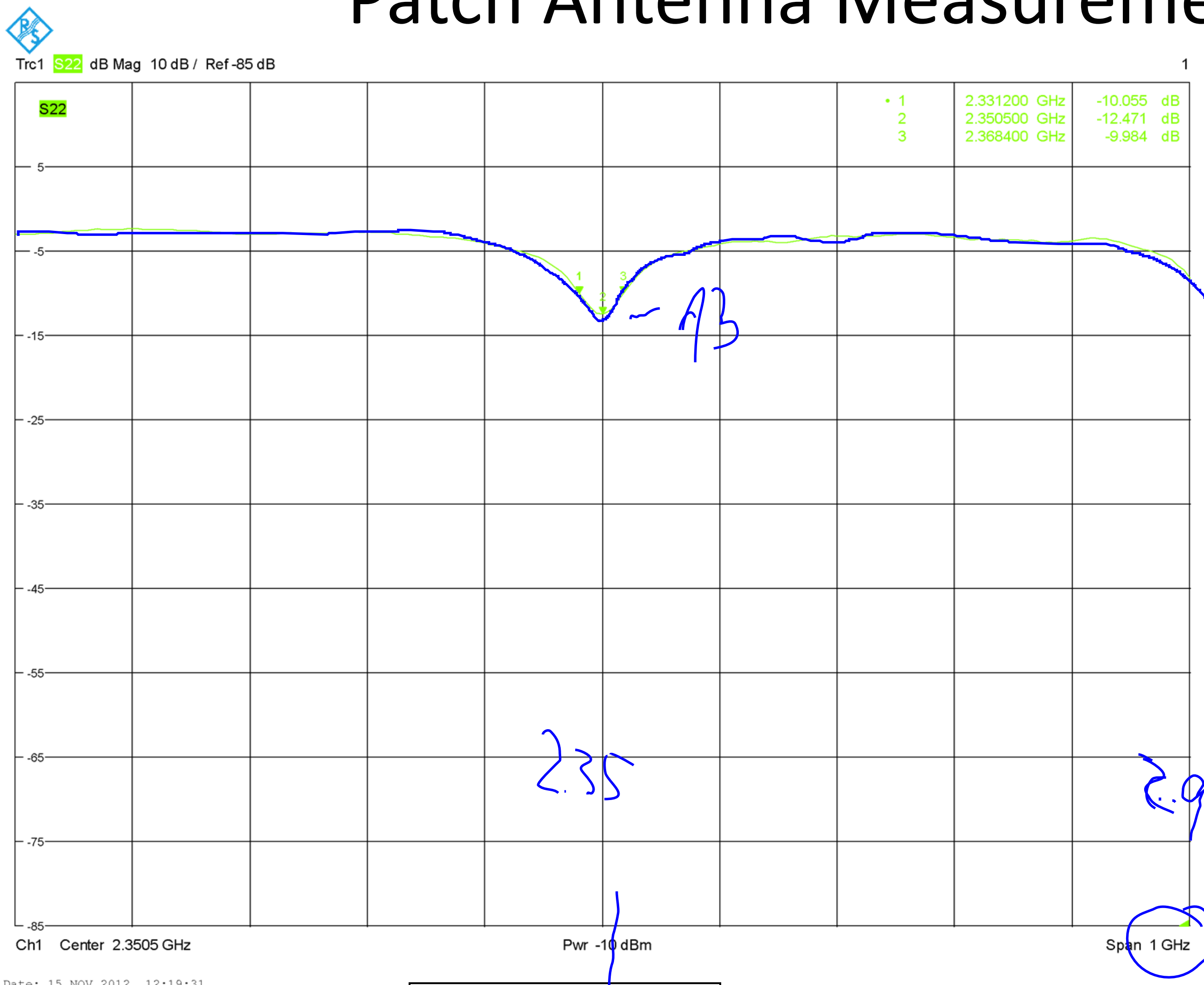
$$Z_L = 39.5 + j27.6\Omega$$

$$Z_C = 74. + j17.6\Omega$$

$$Z_U = 79.6 - j30.0\Omega$$

Impedance measurements

Patch Antenna Measurements



Bandwidth measurement

$$BW = 37MHz$$

$$B(\%) = \frac{37MHz}{2350MH} \times 100\%$$

$$B(\%) = 1.67\%$$

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References

[1] *The Basic of Patch Antennas*, D. Orban & G.J.K. Moernaut, Orban Microwave Inc

[2*] Antenna Engineering Handbook*, Chapter 7, D.R. Jackson, McGraw-Hill Inc

[3] *The Fundamentals of Patch Antenna Design and Performance*, G. Breed, High Frequency Design, p.48-50

[4] *CAD OF RECTANGULAR MICROSTRIP ANTENNAS*, D.R. Jackson et al

Questions?