A LOW-PROFILE DIELECTRIC WAVEGUIDE ALTIMETER ANTENNA

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Introduction

- Demand for sophisticated antennas in spacecraft and military applications
- DIFFICULTIES:
  - ➢ Small allocated space
  - ➢ Effect of surrounding elements
  - ➢ Environmental effects such as high temperatures

Motivation I

- Implementation of altimeter antenna in the course of take-off/landing
- Design and implentation of dielectric waveguide antenna
- Based on the antenna with end-fire radiation[1] exploited for desired radiation
- Ketron-1000 Peek, plastic grade, ε_r=3.2, resistant up to 250°C[2]

[1] H. Rentang, S. Lihua, Q. Shi, and Z. Yinghui, "A novel low-profile antenna with end-fire radiation," in 2015 7th Asia-Pacific Conference on Environmental Electromagnetics (CEEM), November 2015, pp. 47–49.

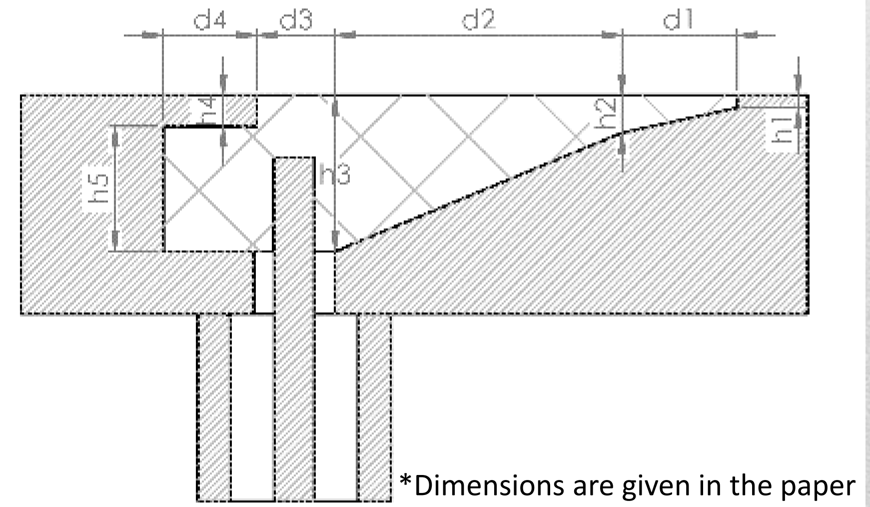
[2] Ketron 1000 PEEK, Mitsubishi Chemical Advanced Materials, March 2019. [Online]

Motivation II

- Desired antenna specifications
  - Low-profile
  - Compact
  - Cost-efficient
  - Easy to install
  - High temperature resistant

Antenna Design I

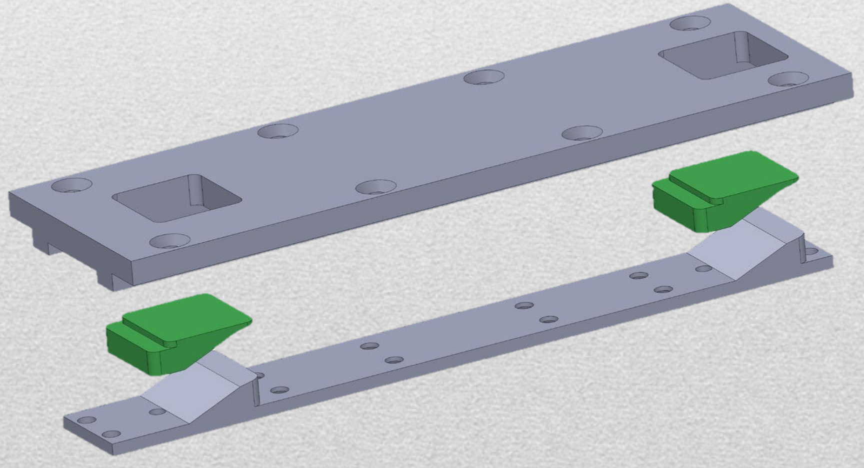
- Dielectric filled top-open waveguide antenna
  - Waveguide height gradually decreased/optimized for desired performance
  - An aperture cutted off the top plane
  - SMA-type 50 ohm connector inserted into the dielectric



*Dimensions are given in the paper

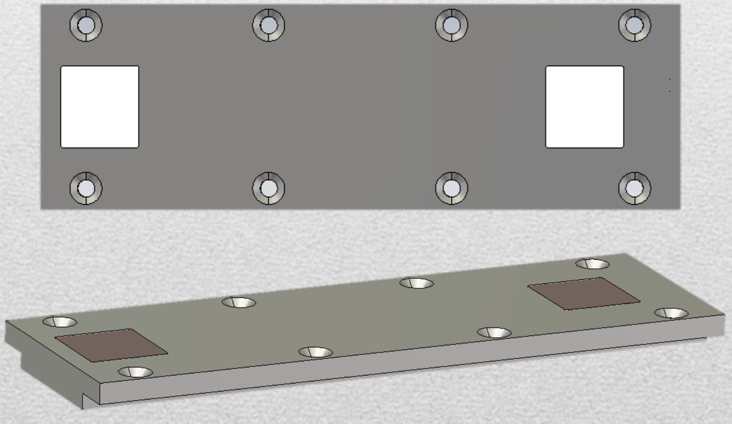
Antenna Design II

- Dielectric filled top-open waveguide antenna
  - TX and RX antennas located 12.5 cm apart to achive low mutual coupling
  - Consisting of dielectric waveguide fillings and metal case of two piece



Antenna Production

- Aluminum ground cases and Ketron-1000 Peek fillings proccessed in CNC
- Screw holes around the antenna for easy installation



3D CAD Model

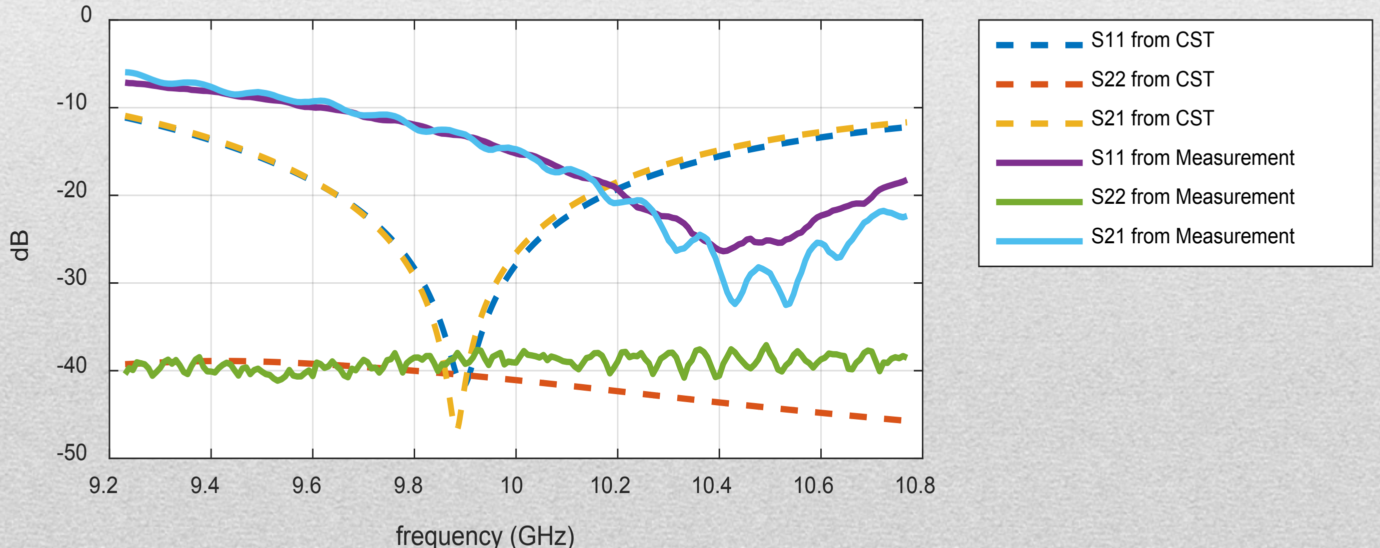
Produced antenna photograph

Electrical Characteristics

- Comparing S-parameters from the EM sim. tool and VNA measurments

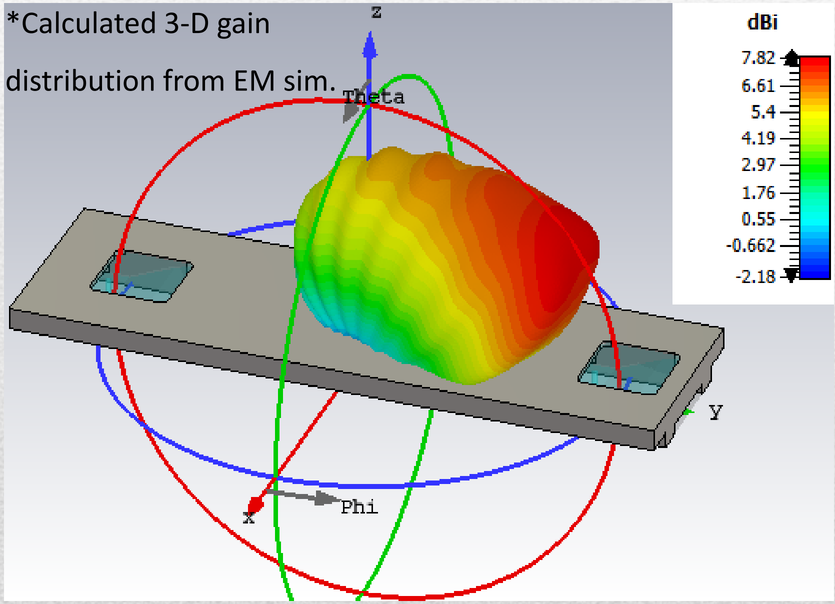
  Measured return loss < -10 dB from 9.6 GHz to 11 GHz

- S_{21}≈-40 dB → Satisfactory since the need for low coupling in radar applications



Radiation Performance I

- The antenna system can transmit and recieve data for any landing angle as:
  - It radiates from 20 to 70 degrees on the elevation plane
  - Almost 90 degrees wide radiation on the azimuth

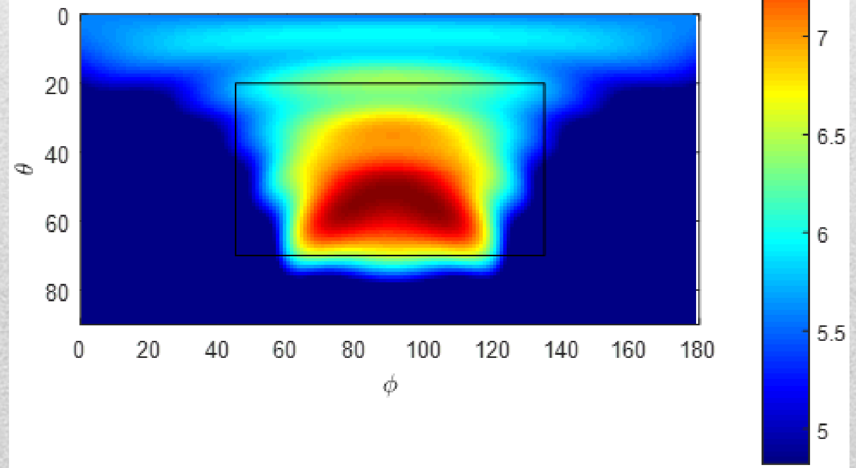


Radiation Performance II

- The maximum gain is about 7.8 dBi
- Radiation larger than half power at θ: 20°→70° and φ: 45°→135°

Note: As antenna mounted conformally on PEC body, gain slightly decreases and the illumination area slightly extends

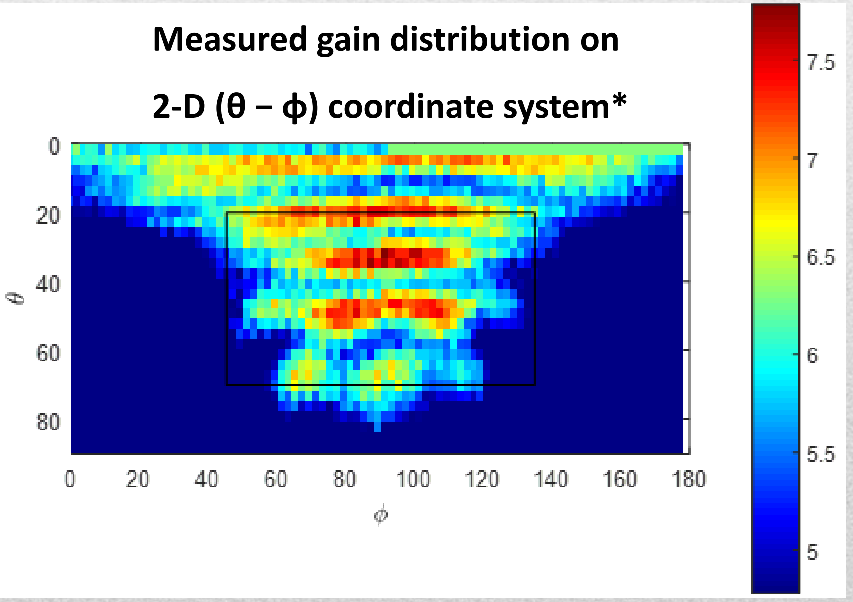
Simulated gain distribution on 2-D (θ – ϕ) coordinate system*



*Black rectangle on the graph indicates the area from θ = 20° to θ = 70° and from φ = 45° to φ = 135°

Radiation Performance III

- Anechoic chamber measurements are very close to the EM simulation results
- Radiation larger than half power at θ: 0°→70° and φ: 45°→135°
- Mesaured maximum gain is around 7.7 dBi, close to the EM simulation



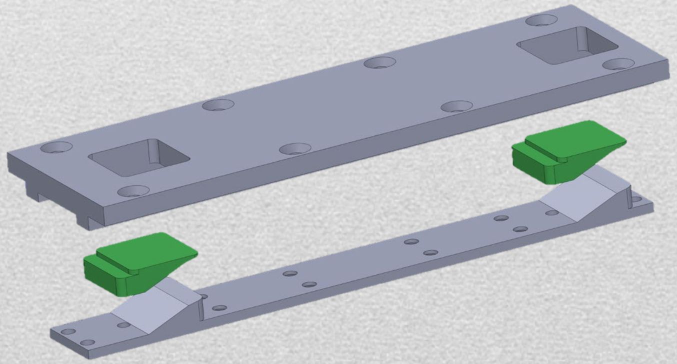
*Black rectangle on the graph indicates the area from θ = 20° to θ = 70° and from φ = 45° to φ = 135°

Summary I

- Goal → A low profile, high-temperature resistant antenna for avionic systems
- Design → Dielectric filled rectangle waveguide @10 GHz

  WG height gradually decreased for desired performance

  Optimization of the aperture along with the other dimensions



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Summary II

- Production → Metal and dielectric parts produced in CNC
  All parts assembled along with the connector
- Analysis → Antenna performance is verified through VNA and anechoic chamber
- Results → Both electrical and radiation performances are satisfactory
  CST simulations results and measurement results are in accordance

Conclusion

- Design and implementation of radar altimeter antenna pair
- Fit military/aircraft/spacecraft applications
- Mounting on flat surfaces or on cylindrical surfaces conformally
- High temperature durability, no need for a radome
- Efficient, feasible and cost efficient antenna solution for radar applications

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