INVESTIGATION ON 3D PRINTED MICROWAVE LENS FOR HORN ANTENNA

INTRODUCTION

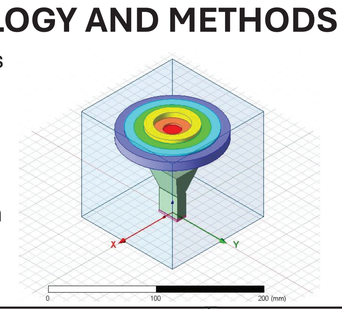
- Flat top beam: Radiation pattern with a constant gain, flat intensity profile over a range of angles
- Problem: When measuring antenna performance in an anechoic chamber, other objects reflect signals and cause distortions
- Our solution: Use a lens to produce a flat top beam with low sidelobes and high rolloff to direct energy

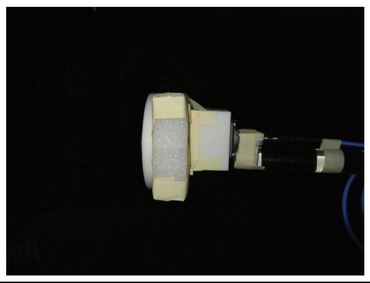
OBJECTIVE

3D print a microwave lens using Polylactic Acid (PLA) lens of homogeneous dielectric constant to achieve a flat top beam with high rolloff and low sidelobes with a horn antenna

METHODOLOGY AND METHODS

Simulate in Ansys Electronics, 3D print (PLA+ for lens, PLA+ with copper tape for flare), measure in an anechoic chamber





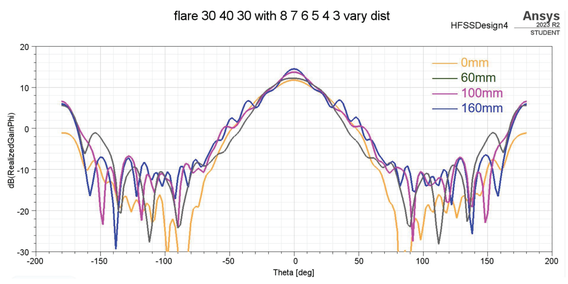
RESULTS

PRELIMINARY INVESTIGATION

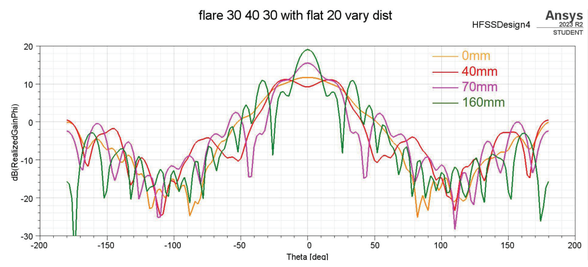
- Effect of varying distance between lens and antenna, dielectric constant, curvature were investigated for converging, diverging, flat lenses
- To reduce time taken for simulation (e.g. can eliminate some possibilities/reduce no. of parameters)

(1) DISTANCE BETWEEN LENS & ANTENNA

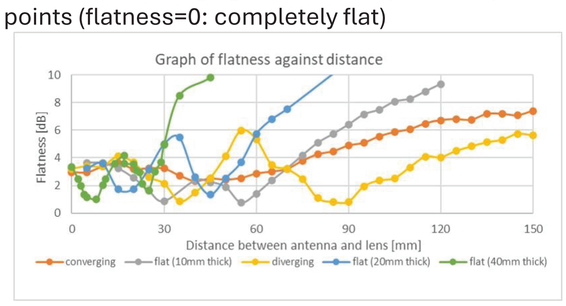
- varying distance for a converging lens
  - as distance increases, peak gain increases, gain of sidelobes increases and 3dB beamwidth narrows



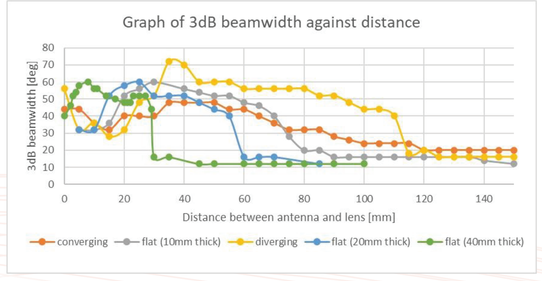
- varying distance for diverging and flat lenses
  - as distance increases, gain decreases, peak reduces, forming either a null or a flat top
  - as distance increases further, peak increases forming a higher peak, 3dB beamwidth narrows, gain of the sidelobes increase



- for flat and diverging lenses: multiple flat top points (flatness=0: completely flat)

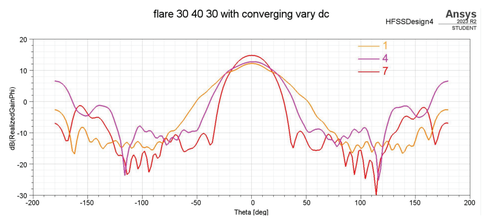


- after a certain point, distance has little effect on lens performance: all lenses have similar radiation pattern
  - angle subtended to lens is small (same rad of lens)
  - little illumination receive from antenna
- comparing lenses of diff thickness: 40mm lens plateaued faster --> change in dist more significant when lens is thicker

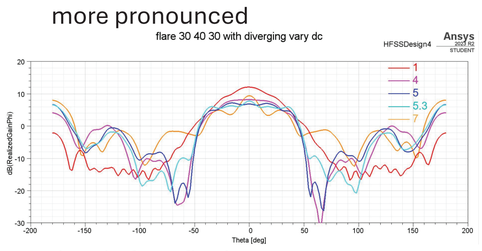


(2) DIELECTRIC CONSTANT OF LENS

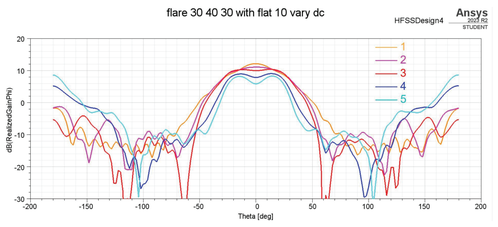
- varying dielectric constant (dc) for a converging lens
  - as dc increases, peak gain increases and 3dB beamwidth narrows



- varying dc for a diverging lens
  - as dc increases, gain decreases, 3dB beamwidth narrows, gain of the sidelobes increases, peak reduces and flattens
  - as dc increases further, gain increases, 3dB beamwidth narrows, gain of sidelobes increases, ripples became more pronounced



- varying dc for a flat lens
  - when dc increases, gain decreases, 3dB beamwidth narrows, sidelobes increase, peak reduces forms a null

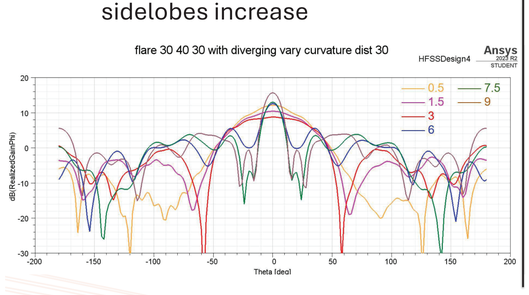


(3) CURVATURE

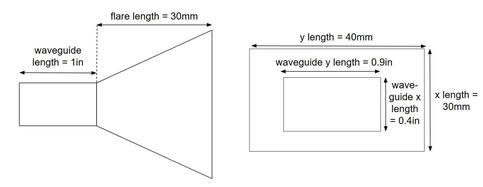
Lens profile	h1	h2	h3	h4	h5	h6
Converging	1+5p	1+4p	1+3p	1+2p	1+p	1
Diverging	1	1+p	1+2p	1+3p	1+4p	1+5p

increase curvature by increasing step size [p]

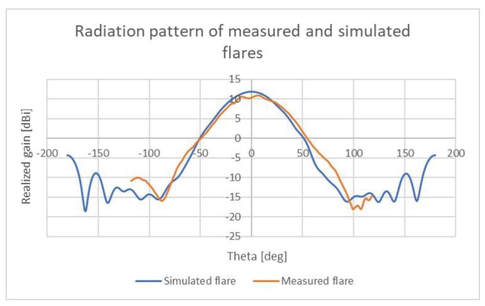
- varying curvature for a converging lens
  - as curvature increases, peak gain increases, 3dB beamwidth narrows, first sidelobe increases
- varying curvature for a diverging lens
  - as curvature increases, peak gain decreases, 3dB beamwidth widens, peak reduces and flattens
  - further increase in curvature cause increased gain, narrowed 3dBi beamwidth, increased gain of sidelobes
    - main lobe has 3 peaks
    - 1st sidelobe decrease, far-out sidelobes increase

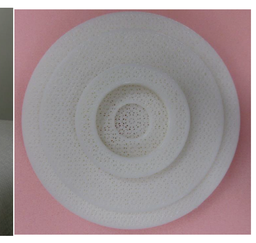


ANTENNA DESIGN

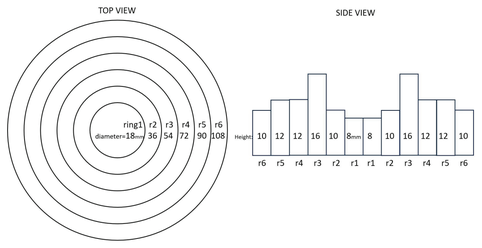


- consists of WR 90 waveguide feed + flare
- **Flare:** varied x & y lengths and flare length
- **Aim:** >8.5dBi peak gain and 45deg 3dB beamwidth
- **Final:** 12.2dBi peak gain, 42deg 3dB beamwidth
- Measured results similar to simulated

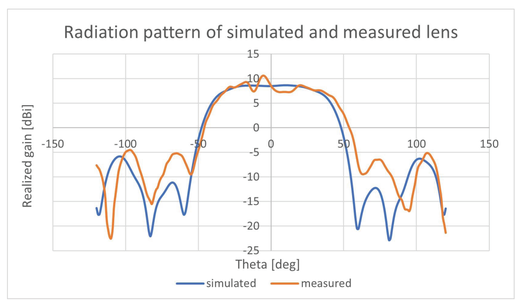




LENS DESIGN



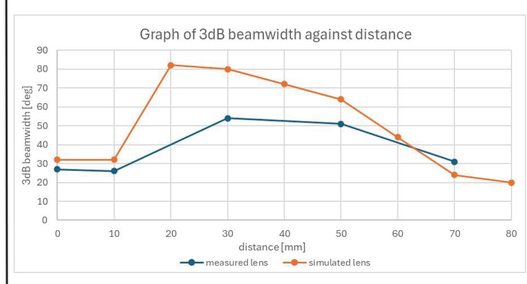
- 6 concentric rings of homogenous material
- **Varied:**
  - heights of each ring: 8-20mm, 2mm increments
  - distance between lens and antenna: 0-100mm
  - dielectric constant of lens: 1.7778-2.8141
- **Final:**
  - distance of 30mm, dielectric constant of 2.1277
  - 0.29dB flatness, 0.75dB/deg rolloff, -11.8dBi sidelobes
- **Measured:** similar to simulated radiation pattern but large abnormal kink present from -16 to -5deg



PRINTED LENS

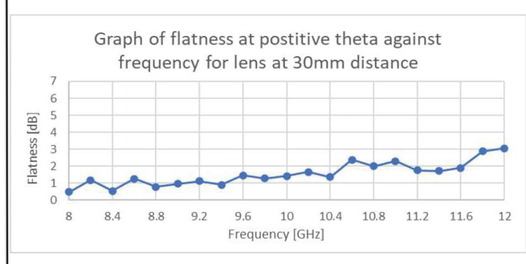
(1) DISTANCE

- as dist increases, gain increases, 3dB beamwidth widens then narrows
- the trends are similar to simulated lens



(2) FREQUENCY

- gain increases, beamwidth narrows
  - due to narrowed 3dB beamwidth, higher gain of horn as frequency increases
- flatness:
  - large abnormal kink present from 9.8-12.0GHz --> affects flatness (difference between the max and min within the span is exaggerated)
  - taking flatness from theta > 0 to avoid kink: less flat as the frequency increases



CONCLUSION

The microwave lens is effective in altering the radiation pattern of a horn antenna to produce a flat top beam with steep rolloff and low sidelobes

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