

## EFFECT OF SURFACE ROUGHNESS ON ANTENNA ARRAY FOR AUTOMOTIVE RADAR APPLICATIONS



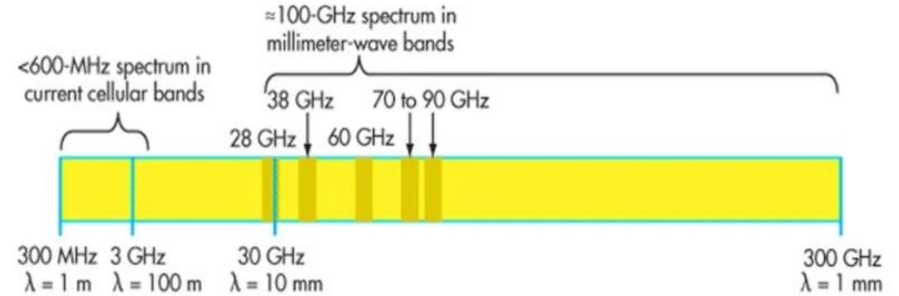
- Smit Baua                      Application Engineer
- ACES virtual conference

Altair Engineering, Inc.

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# Agenda

1. Introduction
  - Millimeter wave frequency applications
  - Surface roughness
2. ACC Radar: Antenna array
3. Effect of Surface roughness
4. Conclusion



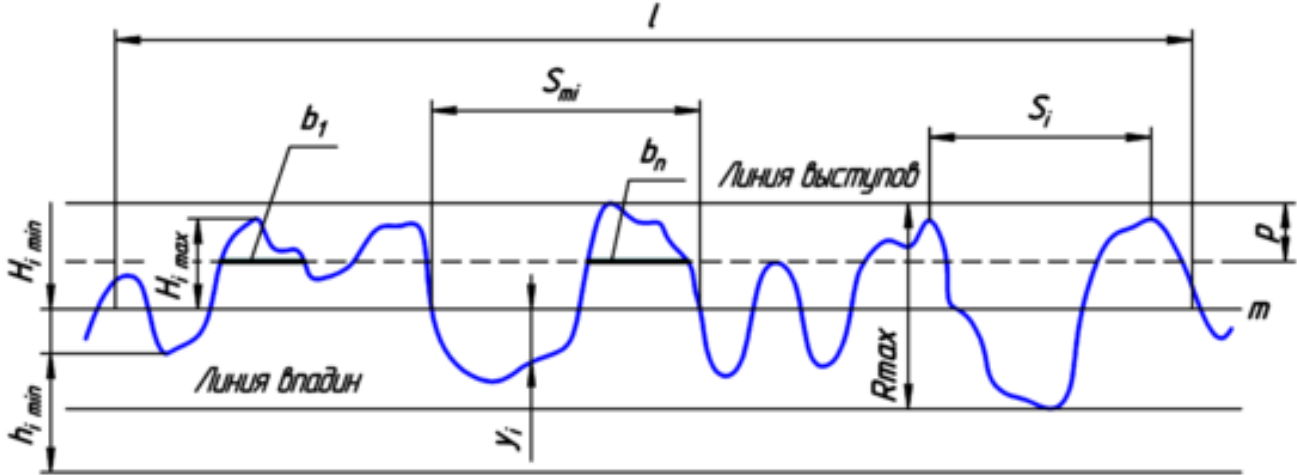


## Millimeter-Wave Applications

- Imaging
- Remote sensing
- Telecommunication
- Automotive
- Many more..

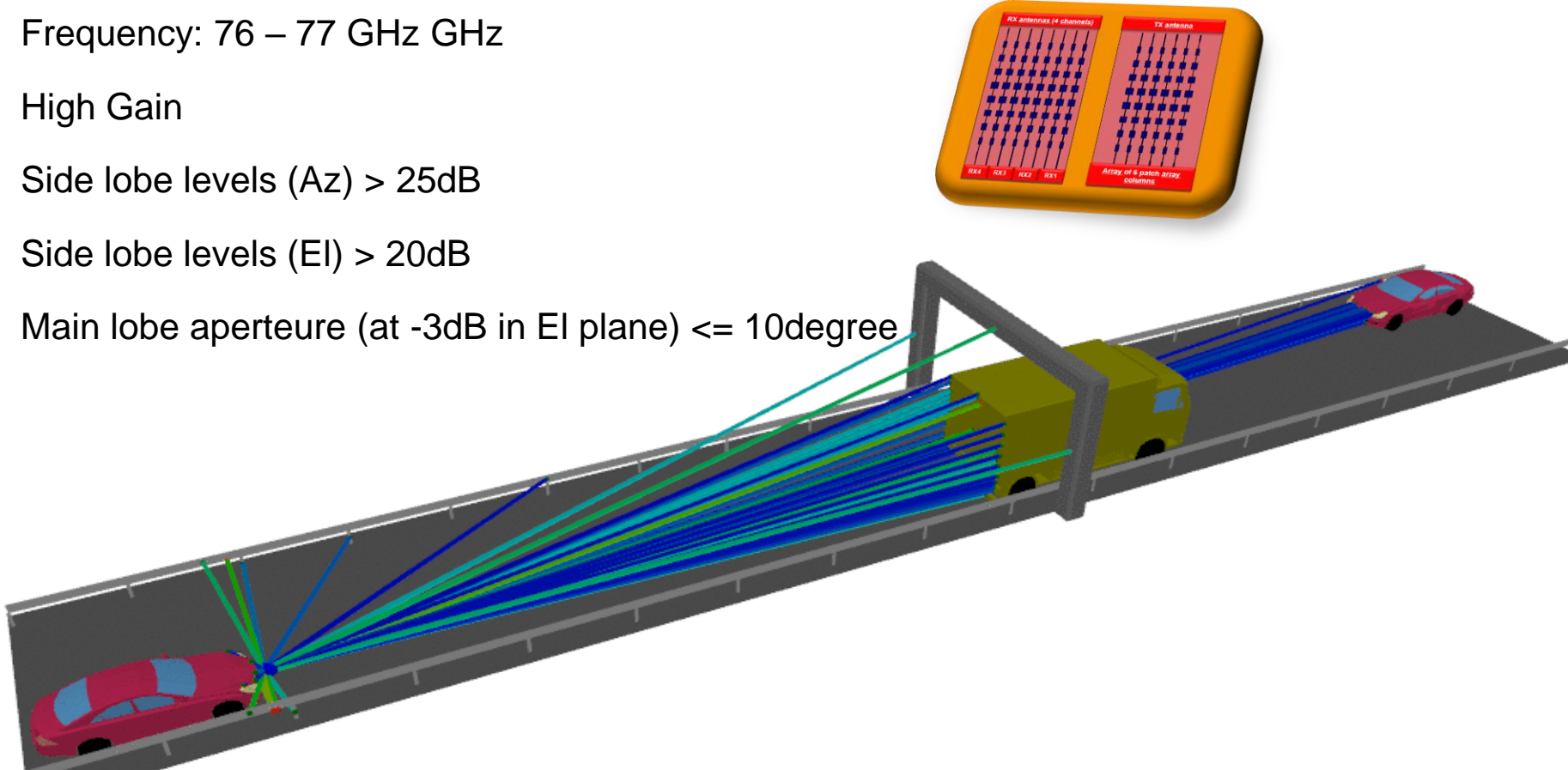


# Surface Roughness



# ACC Radar

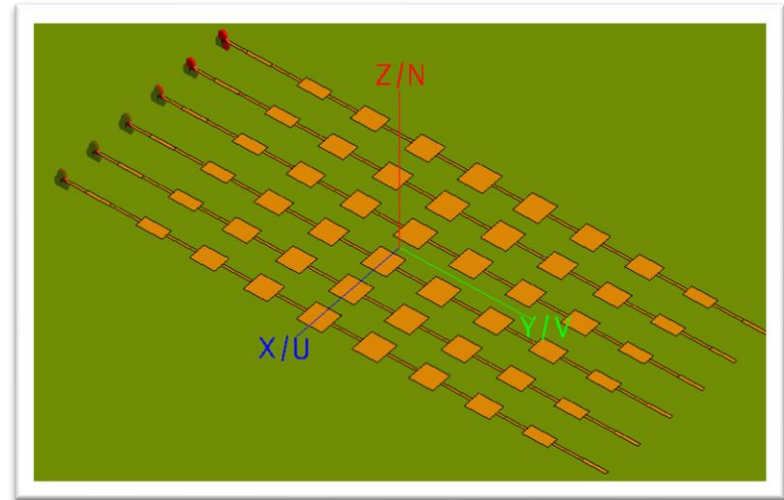
- Frequency: 76 – 77 GHz
- High Gain
- Side lobe levels (Az) > 25dB
- Side lobe levels (Ei) > 20dB
- Main lobe aperture (at -3dB in Ei plane)  $\leq 10$  degree





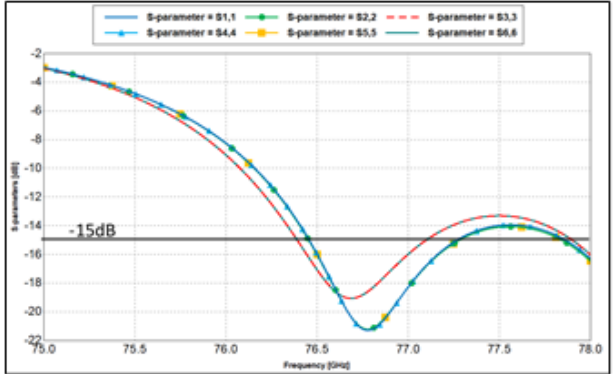
# Array Design

- Microstrip antenna array
- Transmitter of 6 columns
- Substrate – Relative permittivity 2.35  
Dielectric loss tangent 0.004
- Dimensions optimized for 50 ohm reference impedance

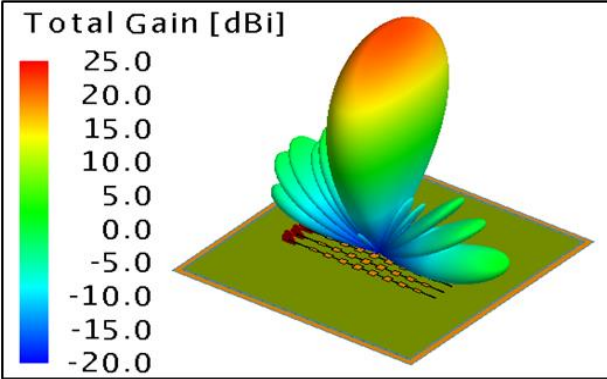


# Antenna Array performance with Perfect Electric Conductor (PEC)

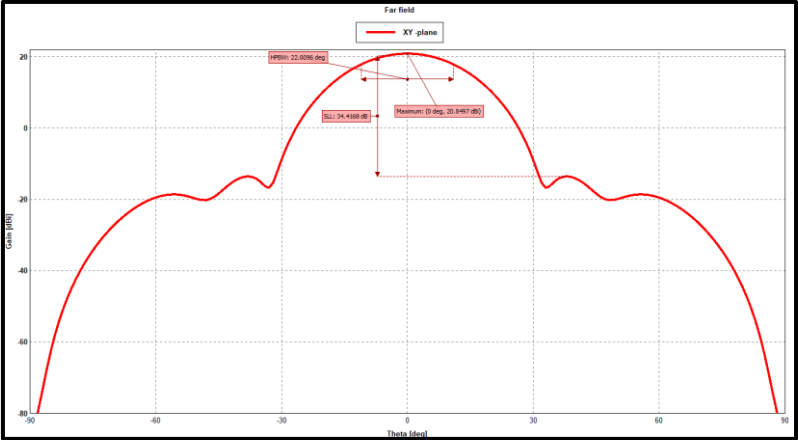
Return loss of individual array columns in the radar



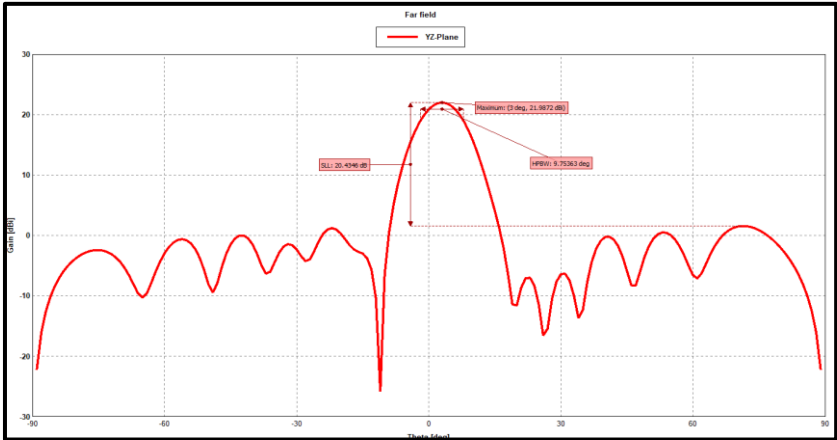
3D Farfield results (Gain)



Azimuth cut plane (Gain)



Elevation cut plane (Gain)



# Surface roughness values with Copper

- Copper Conductivity: 5.813 E+07 S/m
- Thickness of copper trace: 35  $\mu\text{m}$

Sr. No	Surface roughness (RMS in $\mu\text{m}$ )
1	0
2	0.0559
3	0.1118
4	0.2235
5	0.447
6	0.8941
7	1.7602
8	3.4925
9	6.985
10	13.97
11	27.94



# Results with varying Surface Roughness

- Results with Copper and zero surface roughness also computed.
- Gain, Efficiency, losses due to varying surface roughness compared
- The table shows the gain, efficiency, and losses due to varying surface roughness.
- Efficiency reduces as the value of surface roughness is increased. But after a point, the efficiency remains constant.
- The same is observed for conductor losses.
- The gain also shows a similar trend.

Sr. No	Surface roughness (RMS in $\mu\text{m}$ )	Losses (mW)	Efficiency	Gain	
				XZ plane	YZ plane
1	0	8.89	64.11	18.64	19.98
2	0.0559	9.09	63.20	18.56	19.92
3	0.1118	10.59	56.07	17.95	19.35
4	0.2235	11.98	48.72	17.21	18.6
5	0.447	12.55	45.37	16.83	18.31
6	0.8941	12.75	44.15	16.69	18.18
7	1.7602	12.81	43.75	16.64	18.13
8	3.4925	12.83	43.61	16.62	18.12
9	6.985	12.84	43.56	16.61	18.11
10	13.97	12.84	43.54	16.61	18.1
11	27.94	12.84	43.54	16.61	18.1

# Conclusion

- Surface roughness can significantly reduce the efficiency and hence the gain of the array.
- ACC radar design need to take this into account.
- For critical applications that need precise values of these parameters, designers should evaluate the effect of surface roughness before prototyping the design to estimate the degradation.
- Such a study can also aid in selecting the appropriate manufacturing grade based on applications to ensure balance between cost and accuracy of the designed product.

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**THANK YOU!**