Th3B-1

mmIDs Enter the 3rd Dimension: A Camera Inspired Broadbeam High-Gain Retrodirective Backscatter Tag

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Outline

- Motivation of 5G IoT Infrastructure
- State-of-the-art of 5G-enabled mmIDs
- Camera-inspired 3D lens-based mmID
  – Design of 28 GHz 3D Lens
  – RF ‘Array Design
- Characterization of Angular Coverage
- Long range interrogation of 3D lens-based mmID
- Future work and conclusions

Promise of 5G/mm-Wave IoT

- 5G/mm-Wave IoT promises high-speed data rates, localized sensing for smart city, smart building architecture [1-6].
- The wireless infrastructure needs to be battery-less and highly scalable for ubiquitous sensing.
- Reading range and continuous coverage is a challenge in urban environments with widely dispersed based-stations and sensors.

Fig. 1. Complex urban environment of 5G/mm-Wave IoT infrastructure for Smart Cities.

State-of-the-art of 5G-enabled mmIDs

- Semi-passive Van-Atta mmID presents a cross-polarized wireless architecture and was read at 80 m.
- Re-transmission architecture reduces the differential RCS of mmID.
- Only retro-directive in 1 axis.

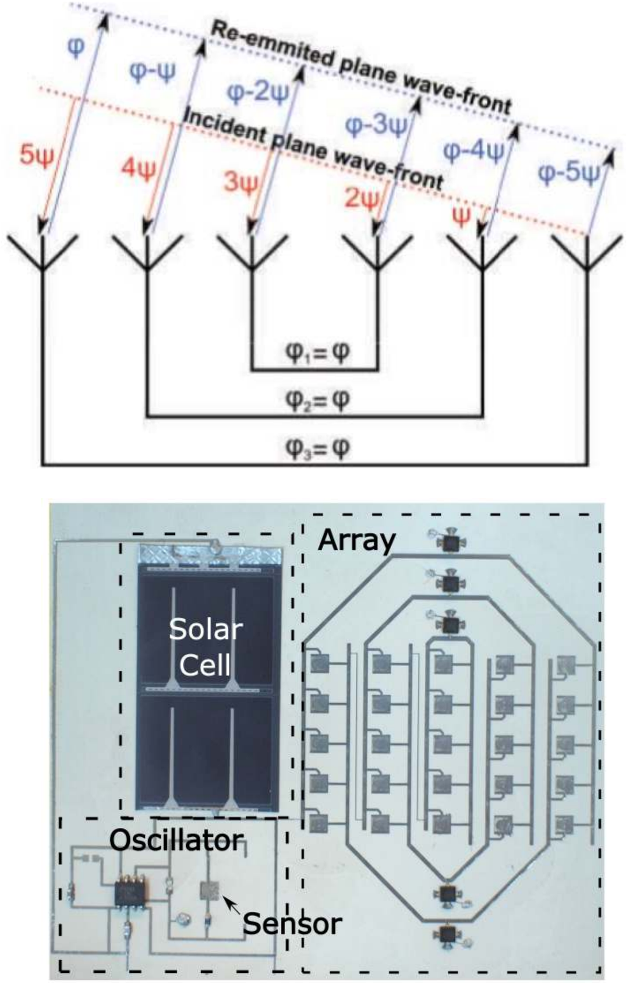


Fig. 2. Energy autonomous semi-passive 28 GHz Van-Atta mmID [1].

State-of-the-art of 5G-enabled mmIDs

- Semi-passive Rotman Lens-based mmID enables ‘RF combining’ to achieve higher differential RCS than Van-Atta.

- Suffers from self-interference with the co-polarized design.
- Only retro-directive in 1 axis.

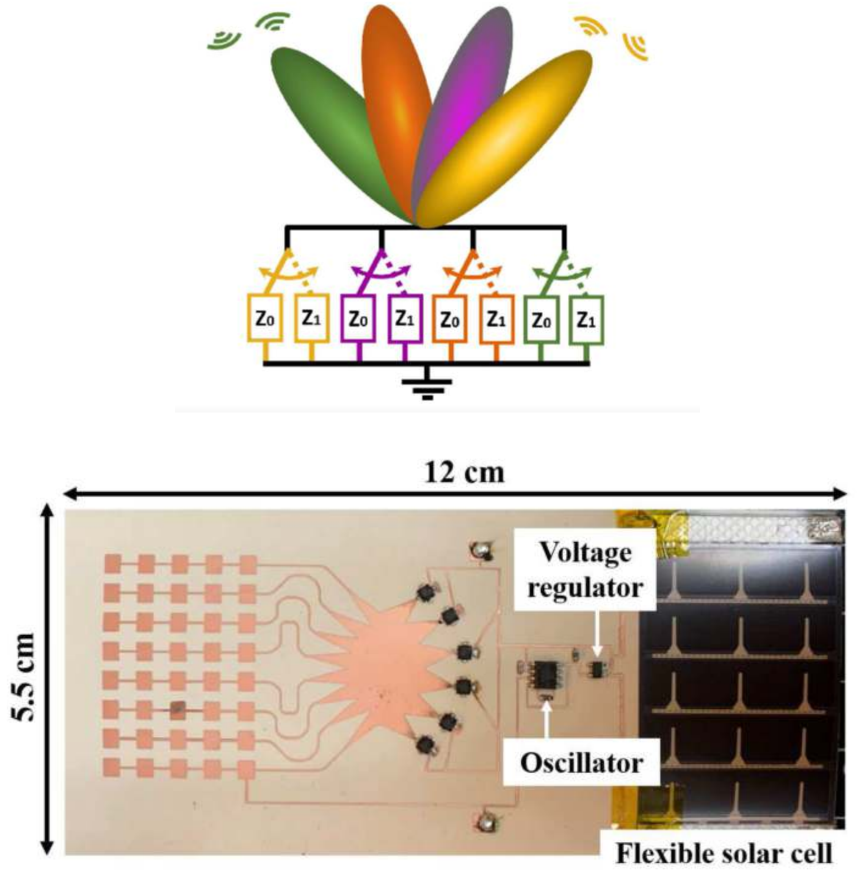


Fig. 3. Energy autonomous semi-passive 28 GHz Rotman Lens-based mmID [5].

Camera Inspired 3D lens-based mmID

- Two retro-directive axis provide an improved solid angle of coverage.
- Enables cross-polarized interrogation to increase reading range.
- Each RF ‘pixel’ can have its own modulation scheme.

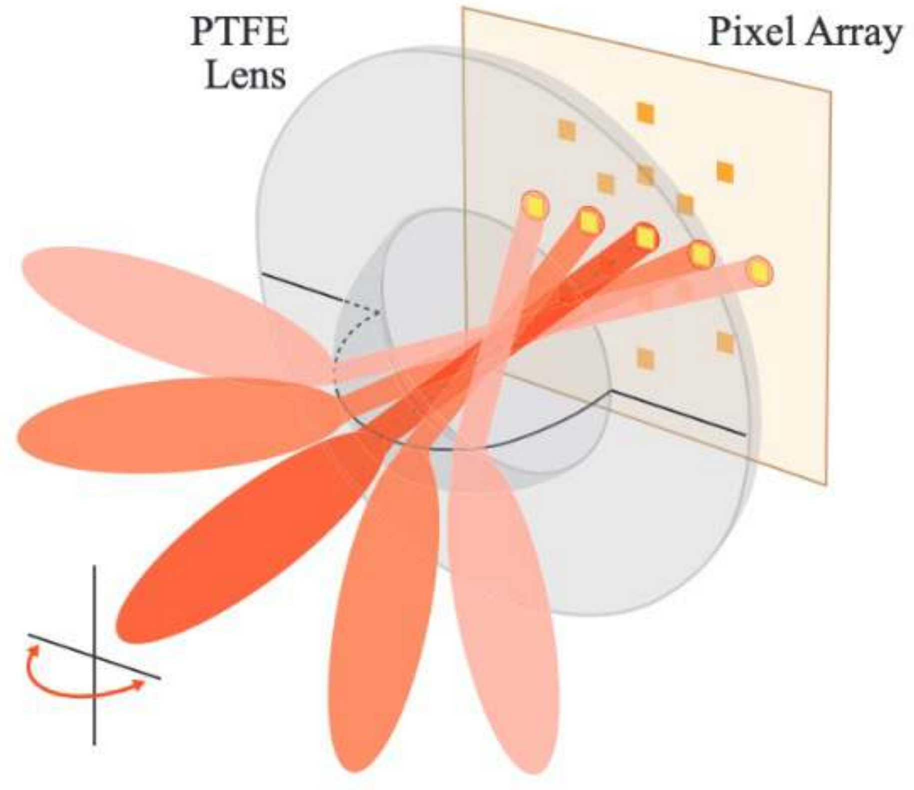
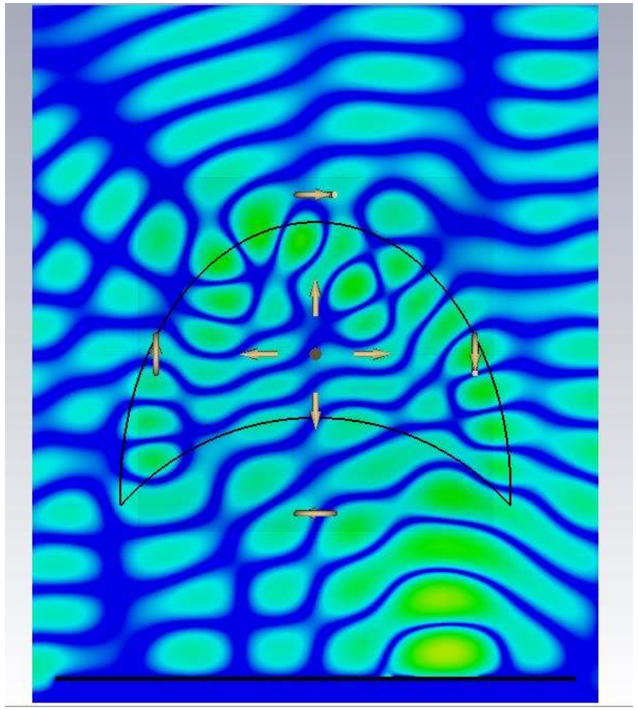


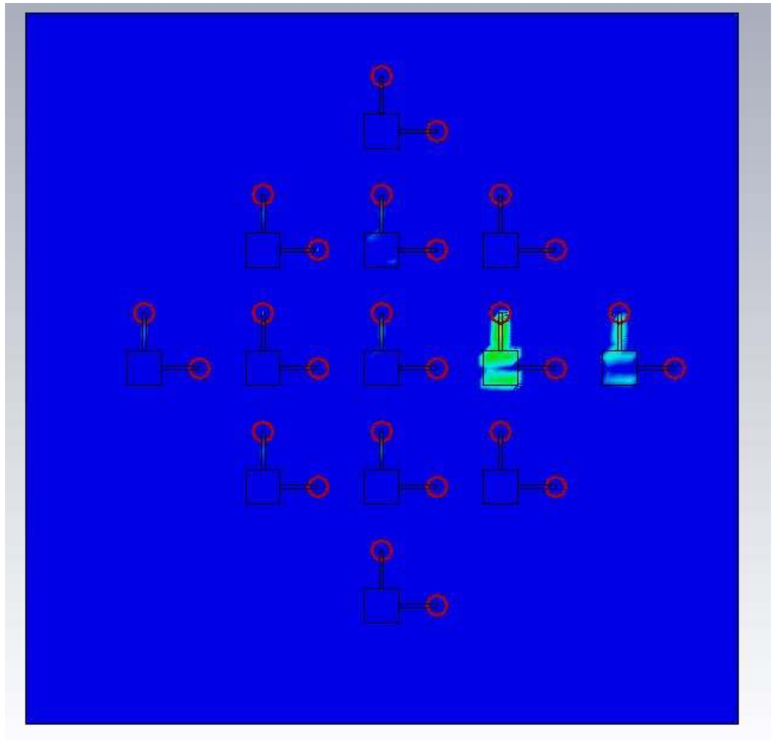
Fig. 4. Diagram of the horizontal axis of coverage enabled by the 3D lens-based mmID.

Focalizing onto the RF 'Pixel'

Focalization onto each individual elements based on the angle of incidence to the 3D dielectric lens.



Plane wave at 17° angle of incidence.



Plane wave focalized on RF 'pixel' top view.

3D Lens Design

- Single elliptical lens design made of PTFE (ε_r=2.1, $\tan\delta$=0.0002) was designed in CST.

- A sweep in diameter with a constant focal length of 3.7 cm was done for optimal dimensions of the lens.

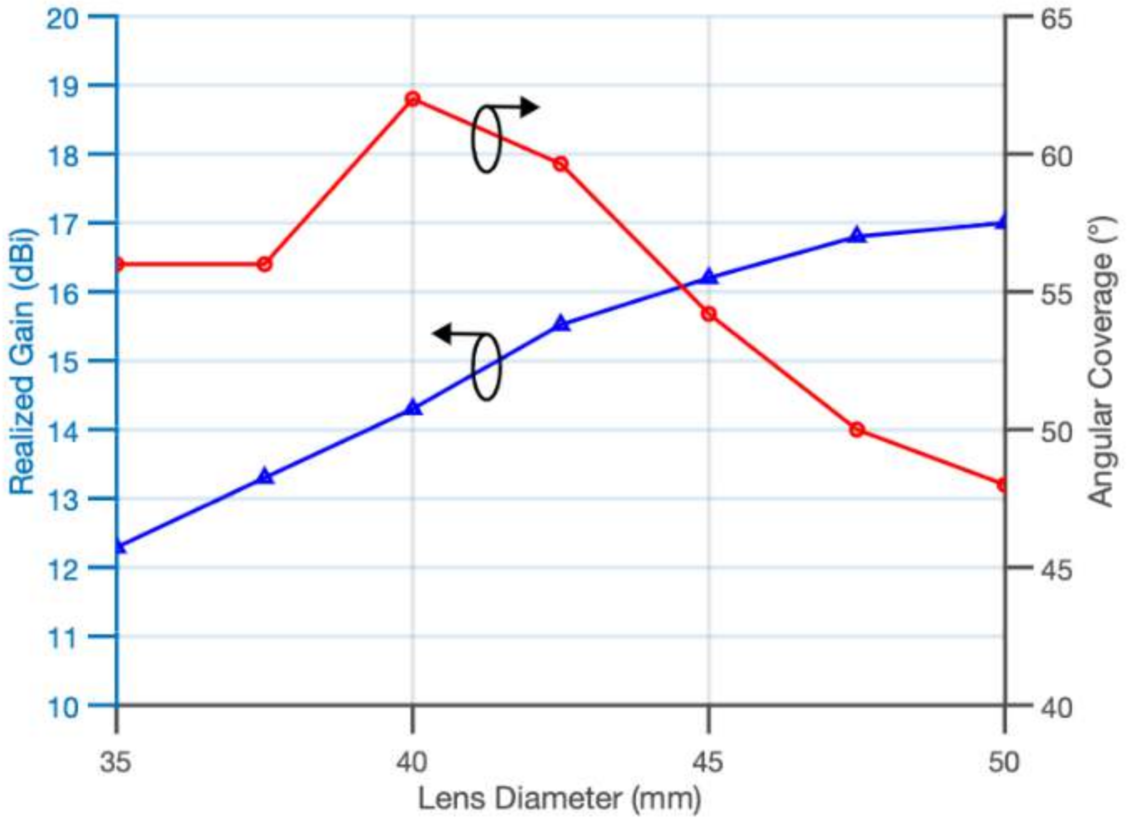


Fig. 7. Simulation results for the peak realized gain and 3 dB angular coverage of the system as a function of the diameter of the PTFE elliptical lens.

RF 'Pixel' Design

- Using a low-cost FET-based (CE3520K3 from CEL) switch enabling low-power sub-carrier generation.
- S_{21} simulated and measured states are match well.

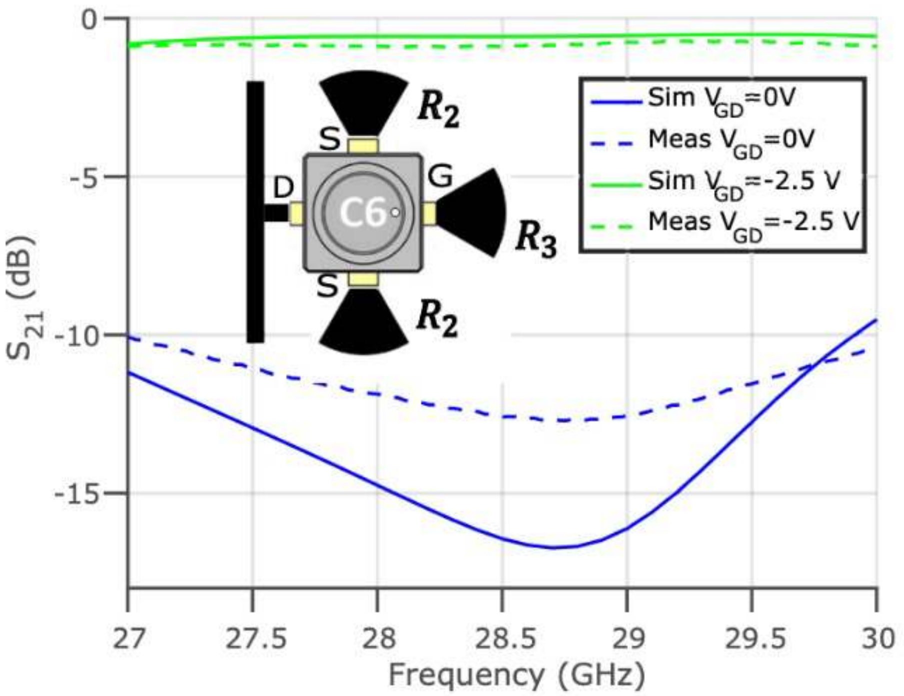


Fig. 8. Measured S_{21} of the biased and unbiased states of the ultra-low-power FET-based switch with R2 = 1.14 mm, and R3 = 1.55 mm labeled.