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Reconfigurable Antenna for Next Generation Satellite & 5G Communication System

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I. Abstract

❑ We propose high gain pattern reconfigurable Meta-surface based electronic beam-forming antenna for satellite communication and 5G mmWave wireless communication systems.

❑ Satellite tracking antennas currently in the market are extremely expensive due to the presence of phase shifters and costly mechanical tracking mechanism. Proposed antenna provides a cost-effective solution for satellite communication.

❑ In comparison to current antennas for 5G communication system, the proposed antenna provides high gain and beam adaptability which can overcome propagation losses incurred at mmWave frequency bands.

❑ This technology once implemented will be a game changer for the whole satellite communication industry, and will open new horizons in wireless communication.

❑ The key features of proposed design are:

- Multiple radiation patterns with single radio frequency (RF) chain.
- Steering independent beam by using a beam selection mechanism.
- Mitigate interference by channeling antenna radiation pattern towards the desired direction.
- High gain, low cost, lightweight, space efficient and conformal to mounting surfaces.

II. Problem Formulation

❑ About four billion people in the world who do not have internet at present will be served by emerging LEO and MEO satellites. Low cost beam steering antennas are required for cost-effective communication with next generation LEO and MEO satellites.

- Beam steering antennas provide multiple access on a single channel.
- Channel capacity, spectrum efficiency, and coverage range dramatically increase.
- Ground stations equipped with smart antennas support multi-satellite reception and minimize interference.

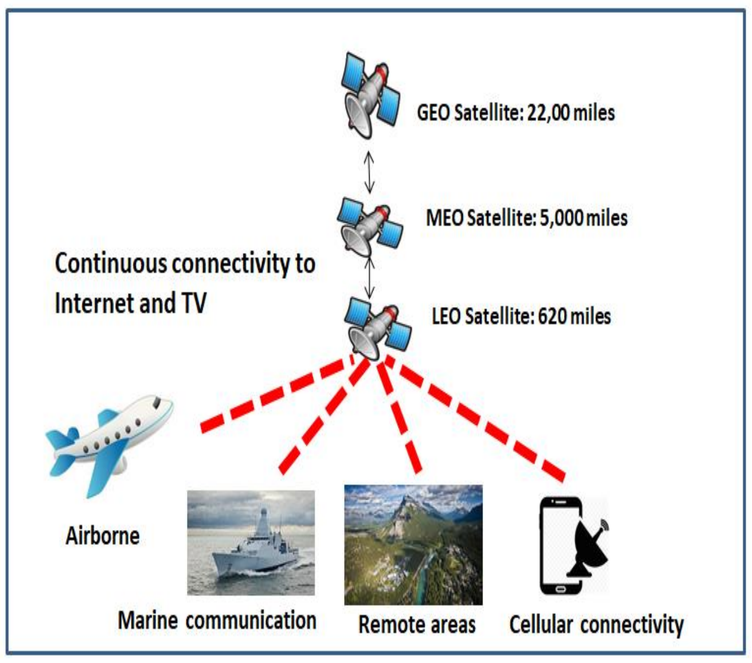

Fig. 1. Satellite Connectivity

❑ Reconfigurable/smart antennas for 5G wireless communication network increase network capacity, data rates and quality. Employing smart antennas can overcome the propagation losses and multipath fading incurred at mmWave frequency bands [1-3].

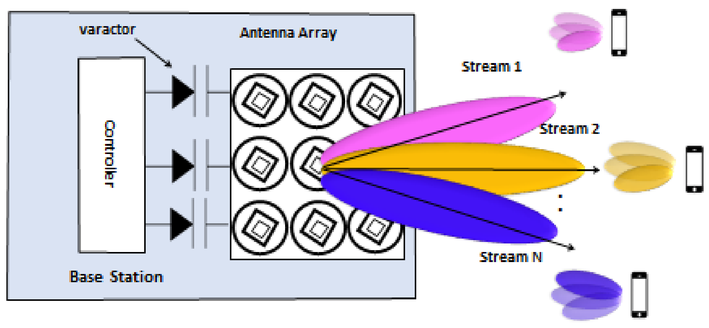

Fig. 2. 5G mmWave communication using proposed antenna

III. Why do we need Meta-surface based antenna?

✓ Low-cost, low-profile and instantaneous beam positioning
✓ User terminals for LEO and MEO satellites
✓ Backhauling for mmWave 5G wireless cellular network
✓ Connectivity to air vehicles from satellite
✓ Cellular / internet connectivity to remote areas from satellite
✓ Internet connectivity for communication-on-move (COTM) using satellite

IV. Proposed Antenna Design

❑ Meta-surface based antenna is made up of an array (28 x 28) of resonant unit cells.

❑ Resonant unit cells are made up of concentric metal rings etched on the substrate.

❑ Multi layer unit cell provides sufficient phase agility.

❑ A 28 x 28 cm meta-surface consists of 784 unit cells.

❑ Two different models have been designed for beam steering which are:

- Meta-surface loaded with voltage controlled varactor diodes. Desired beam characteristics are achieved by varying the capacitance of varactor diodes from 0.3 - 2 pF.
- Meta-surface integrated with multiple feed antennas. Beam steering is achieved by switching between feed antennas.

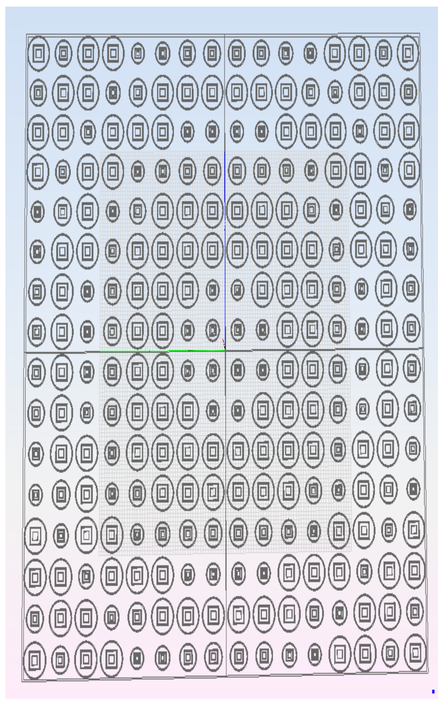

Fig. 3. Designed meta-surface

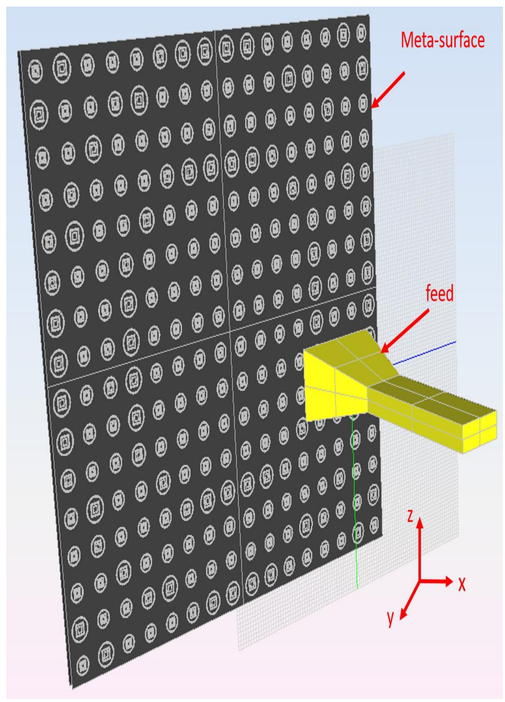

Fig.4. Designed meta-surface antenna

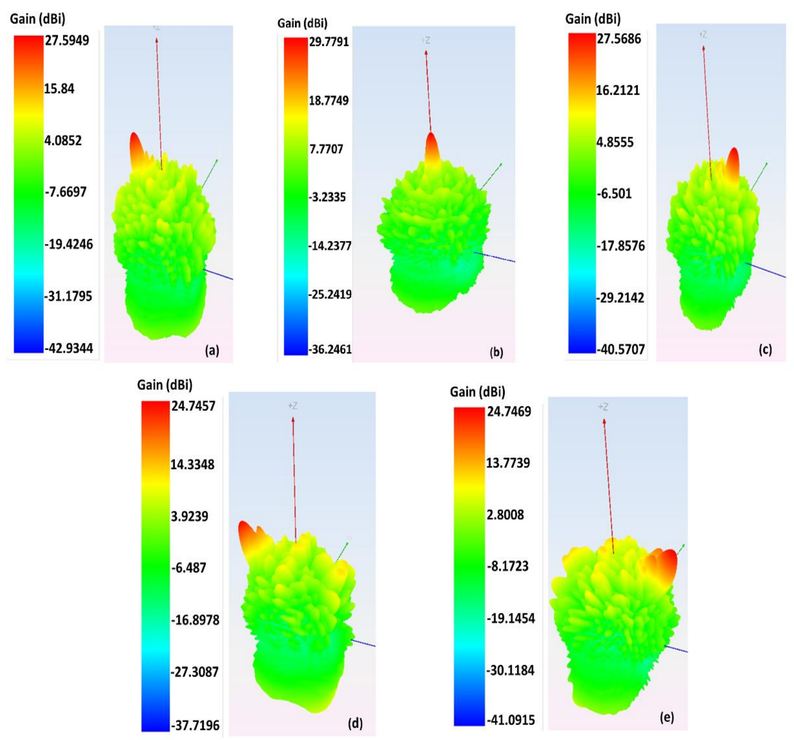

Fig. 5 (a-e). Five beams in 3-D

V. 2-D Plots & Phase Curve

❑ Antenna achieves peak gain of 29.78 dB at center frequency of 18 GHz.

❑ Far field radiation pattern in *H-Plane* shows peaks at -40°, -20°, 0°, +40°and +20°.

❑ Reflection phase is 360° with minimal reflection loss (reflection loss < 0.05 dB).

❑ Concentric square and circular rings enhance reflection characteristics. Multi layer unit cell improves bandwidth and phase characteristics.

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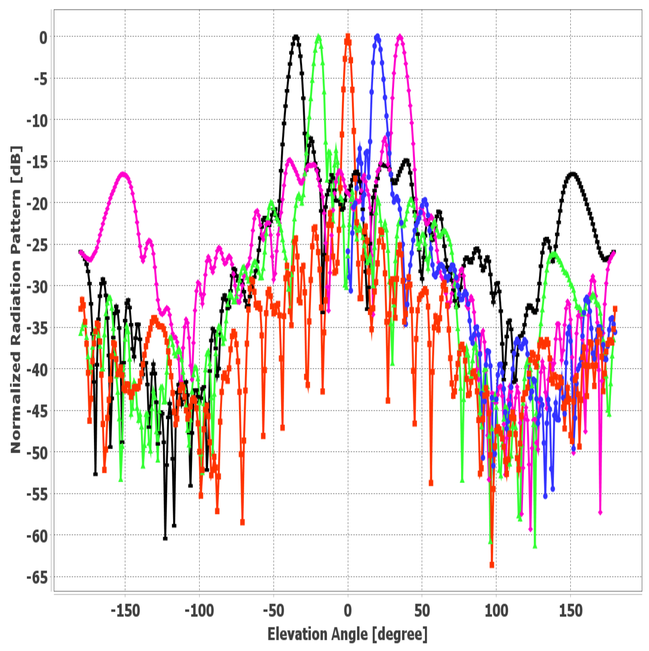

Fig. 6. Five beams in 2-D

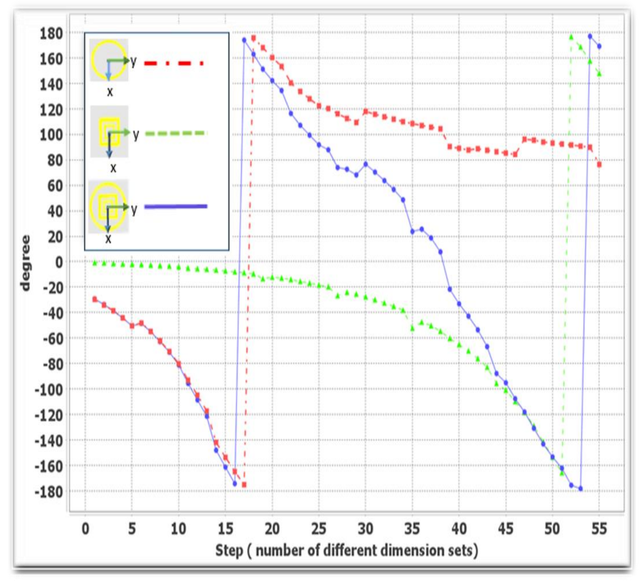

Fig.7. Phase range for proposed design

VI. Conclusion

❑ This research presents the high gain meta-surface based electronic beam-forming antenna for satellite communication and 5G mmWave wireless communication system.

❑ Proposed antenna provides efficient and cost-effective solution for satellite communication. SpaceX and Oneweb are launching mega constellations in low earth orbits. Commercial success of these satellites depend greatly on the availability of electronically steerable antennas.

❑ In comparison to current antennas for 5G communication system, designed antenna provides economically favorable solution with high gain and beam reconfigurabilty which can overcome propagation losses incurred by mmWave frequencies.

❑ Proposed antenna requires single RF chain hence reduces the energy consumption.

References

[1] J. A. E. J. Huang, Reflectarray Antennas, Hoboken, NJ, USA, Wiley, 2008.
[2] A. U. Kausar, H. Mehrpouyan, 'Reconfigurable antennas for millimeter-wave systems that support multiple beams', 20180062257, 2018 (our work includes implementation of the ideas proposed in the patent).
[3] A.U. Kausar , 'Smart Adaptive Beam-Forming Antenna Design for Next Generation Communication Systems' , Boise State University, 2018