Dual-Polarized Array Radiating Elements Based on Electromagnetic Dipole Concept

Ridhwan Khalid Mirza[1], Yan (Rockee) Zhang[1], Dusan Zrnic[2] and Richard Doviak[2]
[1]Intelligent Aerospace Radar Team, Advanced Radar Research Center, School of ECE, University of Oklahoma
[2] National Severe Storm Laboratory, NOAA
School of Electrical & Computer Engineering

Introduction

Dual-polarized radiating element is a critical component in the Multi-functional Phased Array Radar (MPAR) system and has direct impact on the dual-polarized array pattern performance. Theoretically, an ideal radiating element consists of co-linear electric and magnetic dipoles, which ensures the orthogonality of co- and cross-pol E-fields in all spatial directions. Initial implementation of such dipole elements has been made by the industry, but much more work remains to be done to achieve a realistic, low-cost and well-performing engineering design.

The research team at OU in collaboration with NSSL proposed a novel dual polarized radiating element design based on EM dipole concept. This work reports the progress and efforts to realize such antenna elements.

Element Designs

1. Loop as Magnetic Dipole

- Loop antennas have advantage of smaller size over its rectangular counterparts and a careful design can achieve good antenna efficiencies.
- Design Based on cavity theory model and operated in fundamental TM_{11} dominant mode. Feed point is located on trial and error method.
- Simulation based on Ansoft HFSS. Inner radius=16.902 mm, Outer Radius=33.804 mm, Rogers 5880 Dielectric Material.

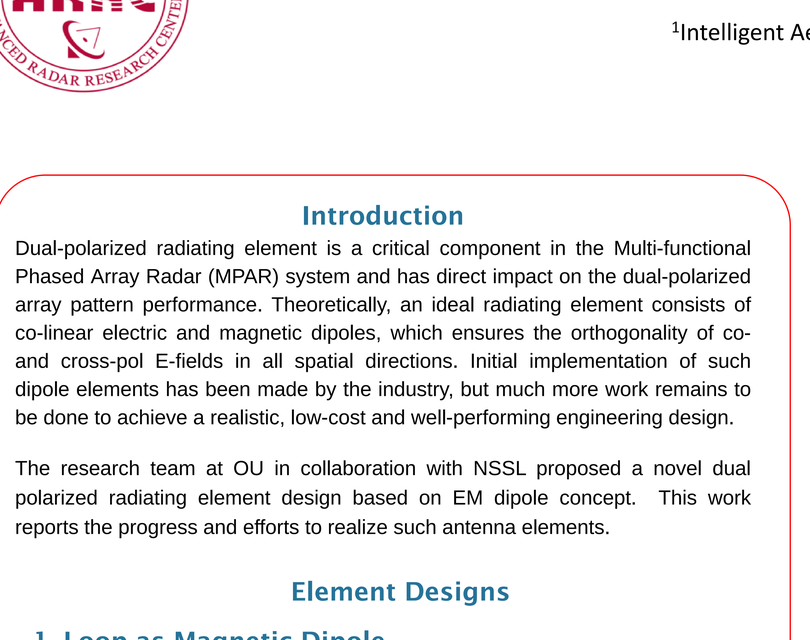

Figure 1: (a)Proposed Single Layer Ring with Coax Feed (b) Return Loss(dB) (c) Total 3-D radiation pattern (d) Radiation Pattern E Plane (Y-Z) (e) Radiation Pattern H plane (X-Z)

- Similar approach is extended to design a stacked ring using full wave spectral domain analysis with accurate probe feed location.
- Has better matching, return loss, uniform surface current distribution and 200 MHz bandwidth.
- Inner radius1=10mm, Outer radius1=29mm, Inner radius 2=14mm, Outer radius2=31mm, ε_r1=2.2, ε_r2=1.07.

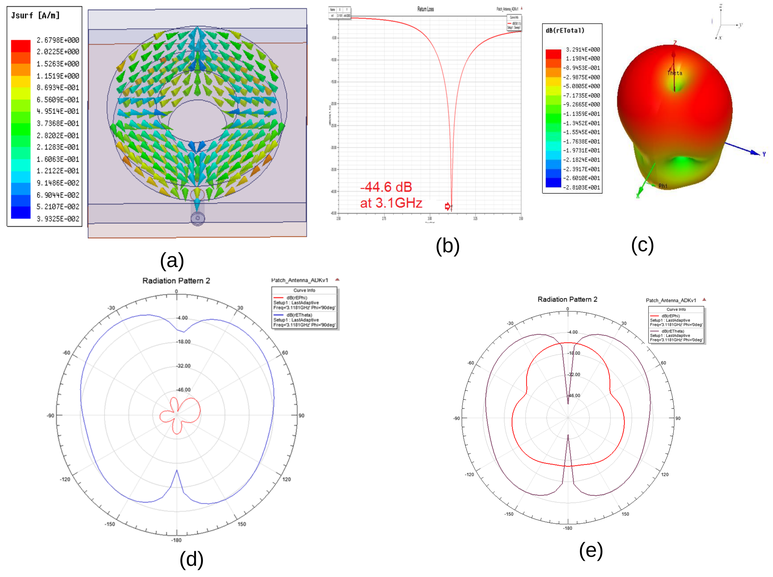

Figure 2: (a)Proposed Stacked Ring with Coax Feed (b) Return Loss(dB) (c) Total 3-D radiation pattern (d) Radiation Pattern E Plane (Y-Z) (e) Radiation Pattern H Plane (X-Z)

- The next candidate design is loop with periodical capacitive loading and parallel strip line.
- The parallel strip line helps to maintain 50Ω impedance and capacitive loading of comprising of several arc strip line sections at 45 degree each allows the current along the loop to remain uniform and in phase.
- The constant current along the loop allows it to be considered close to a magnetic dipole at far field with horizontally polarized omnidirectional pattern.

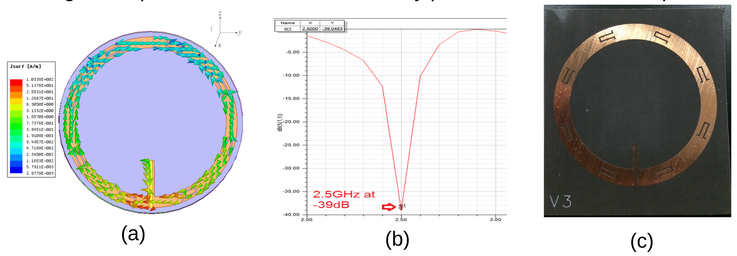

Figure 3: (a) Loop with using differential feed (b) Return Loss (dB) (c) Fabricated Prototype

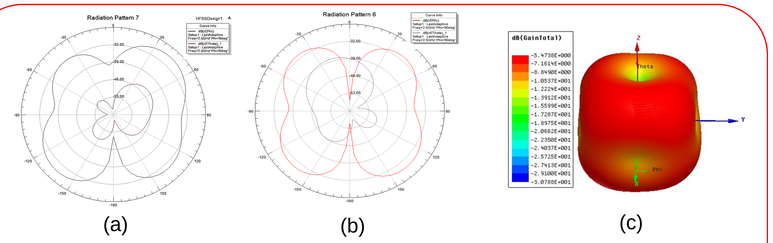

Figure 4: (a) Radiation Pattern E Plane (XZ) (b) Radiation Pattern H Plane (YZ) (c)Total 3D Radiation Pattern

2. Electric Dipole Element Designs

- The Investigation of E dipole led to various implementations of half wave length dipoles. Among all we chose the planar dipole which allows us to avoid 3-D geometry structure.
- The current focus is quality of pattern rather than antenna bandwidth.
- For the sake of brevity only results of Planar E dipole are shown below. The dipole arms are fed at the center as seen in figure 5.

Figure 5: E Dipole Element Design and their simulated Results

3. Combined EM Dipole as A Radiating Element

- These element designs can be combined in such a manner to ensure the orthogonality of co-pol and cross- pol fields in all spatial directions.
- According to the basic theory [4], $E_{loop}=H_{dipole}$ and $H_{loop}=E_{dipole}$ when certain conditions are met.

Summary

The main challenge of combined EM dipole is the magnetic dipole performance and controlled interaction between E and H dipoles. The current goal is to achieve a realistic, low-cost and well performing engineering designs. The research team at OU is working towards testing the initial designs in the anechoic chambers as a part of a larger array test bed called Configurable Phased Array Demonstrator (CPAD) at the Radar Innovations Laboratory (RIL).

CONTACT: rockee@ou.edu **Tel: (405)-325-6036**

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