A Dual Polarization Massive MIMO Panel Array Antenna at Ka-Band with Beamforming Capability

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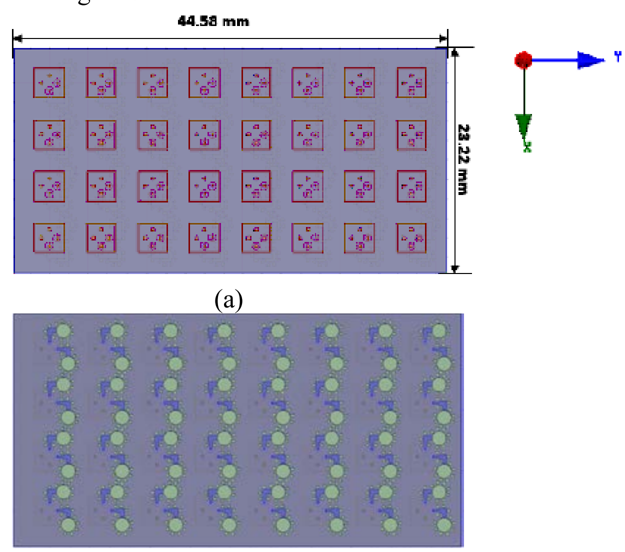
Abstract— **In this paper, we are presenting a dual polarization massive multiple input multiple output (MIMO) panel array antenna with beam steering capability. This design includes a Ka band (31.8 GHz to 33.46 GHz) 4x8 microstrip patch planar array with good isolation between the polarizations which is a desired parameter for a massive MIMO antenna systems. We are controlling input excitations and phases of the individual radiating elements in an array to generate adaptive beamforming characteristics which includes variable gain radiation patterns and beam steering performance. This can be implemented using digital beam forming (DBF) or software defined radio (SDR) technique.**

I. INTRODUCTION

For a radio system to work efficiently, we need both transmitter and receiver to work simultaneously. With dual polarization antennas, we can establish two independent paths (uncorrelated to an extent) for simultaneous transfer of data from both transmission and reception modes of a communication system in the same frequency band. Further, in the modern wireless era, every communication system is expected to provide high data throughput and a reliable link. One such ways of achieving this, is by using massive Multiple Input Multiple Output (MIMO) systems where large antenna systems are desired [1-2]. For achieving high data throughputs, either one can transmit and receive signals as in conventional spatial MIMO systems or one can form high directional radiated beams at specific angles, in both elevation and azimuthal planes, as in beam steering antennas, while utilizing one polarization for the transmit and another polarization for the receive mode. To achieve above, we can make use of Software Defined Radio (SDR) or Digital Beam Forming (DBF) [3] technique which allow to construct radiated beams in virtual domain at both transmitter and receiver sides. By individually controlling the excitation and phase of a set of antenna ports, we can achieve both variable gain patterns and beam steering with specific polarization in the desired plane. For the sake of brevity, we would include only selected results here while remaining one will be presented during the conference.

II. 4X8 ARRAY ANTENNA GEOMTERY

Overall 4x8 antenna array dimension (Fig. 1) is around 24 mm x 45 mm. Each radiating element is individually fed at two orthogonal positions to achieve dual polarization. In total, we have 32 radiating elements and 64 ports which can be classified into two sets. Exciting a set of ports would bring in a specific polarization. Hence, we can achieve either horizontal or vertical polarization by exciting the corresponding set of ports. Patch is on the top most layer. Feedline is designed with microstrip stripline approach. Adjacent radiating elements in both X and Y axes have a patch center to center spacing of 0.585λ which is chosen so that we can maximize beam steering performance approaching 60^{o}.



(a)

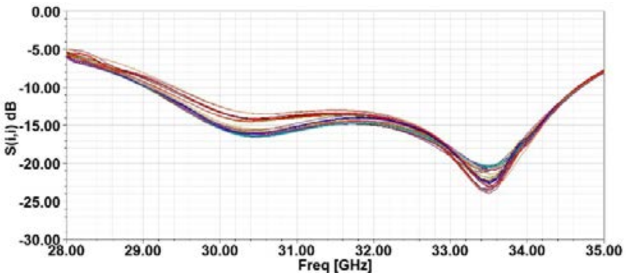
(b)

Fig. 1: (a) Top view and (b) Bottom view of the 4x8 microstrip patch array with dual polarization excited by k-connectors.

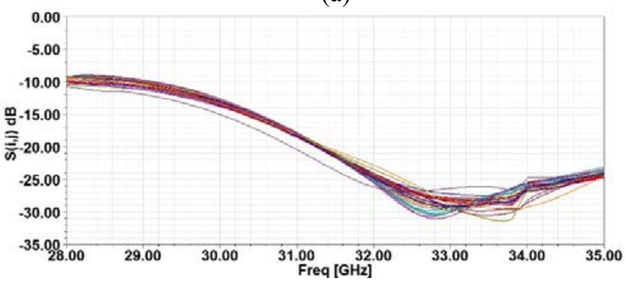
III. IMPEDANCE AND RADIATION PATTERN PERFORMANCE

Magnitude of reflection coefficients for X polarization (S_{ii}, i= odd integers from 1 to 63) ports is shown in Fig 2(a). From the figure, we can observe that the matching band (S_{ii}= -10dB) is from 29.1 GHz to 34.6 GHz, which is wider than our desired band between 31.8 GHz to 33.4 GHz. This is one of the 5G bands released by FCC recently [5]. We find similar behavior for Y polarization ports but not shown here. However, isolation between dual ports of same patch is below -15dB from 30.45 GHz to 34.6 GHz (Fig. 2(b)). Isolation between the adjacent X polarization ports along X axis (Fig. 2(c)) is found to be below -15dB. Similar response was found for Y polarization ports but not shown here.

First we would present variable gain radiation patterns by selectively exciting the array radiating elements for the X-polarization for Phi=0^{o} and 90^{o} cut planes (Fig. 3(a-b)). This is only one possible combination of the radiating elements while other fixed beam combinations will be presented during the conference. It can be seen that, as expected from the array theory [4], the radiation patterns are achieving higher gain values or narrower beamwidths as we increase the number of radiating elements from single radiating element to 1x2, 1x4, 1x6 and 1x8.



(a)



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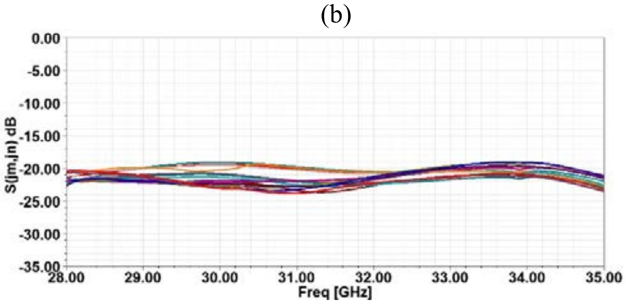
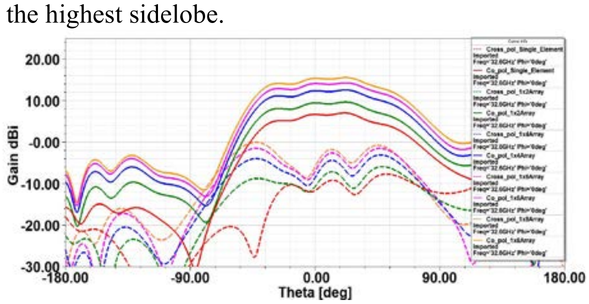


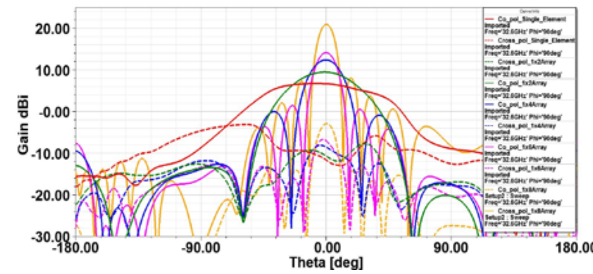
(c)

Fig. 2: (a) Reflection Coefficients of X polarization ports (**Sii**), (b) Isolation between dual ports of each patch (**Sij**), and (c) Isolation between adjacent X-pol ports along X axis **S(im, in)**.

The beam steering performance is shown for phi= 0˚ and 90˚ cuts for the X polarization only while for the Y-plane will be shown during the conference. Beam steering is achieved up to $\theta = 30.5^\circ$ and $\theta = 47^\circ$ in phi=0˚ and 90˚ planes, respectively, as shown in Figs. 4(a-b). These results are shown for 32.6 GHz. There is 6dB separation between the main beam and the highest sidelobe.

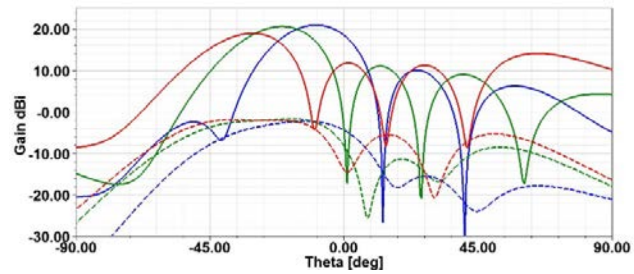


(a)

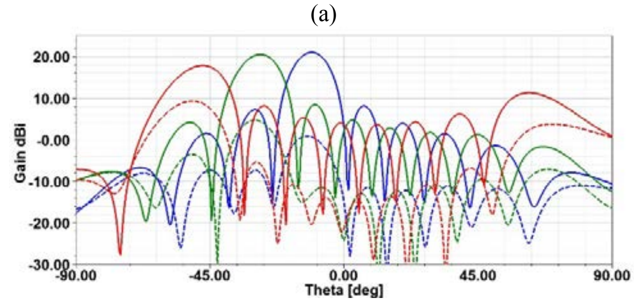


(b)

Fig. 3: Gain radiation patterns at 32.6 GHz for the X-polarization for single, 1x2, 1x4, 1x6 and 1x8 radiating element excitations, (a) Phi=0º cut plane and (b) Phi=90º cut plane.



(a)



(b)

Fig 4: Beam steering performance at 32.6 GHz of the array for X polarization in (a) Phi= 0º cut plane, and (b) Phi= 90º cut plane.

IV. Conclusions and Future Study

In this paper, impedance matching, port to port isolation for the patches, isolation between patches for X-polarization, variable gain/beamwidths radiation patterns and beam steering performance of a dual polarized 4x8 planar array antenna is discussed. For future study, we will be working on fabrication and measurement of the proposed antenna aperture and implementation of the beamforming capability.

References

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