2022

Dual-band dual-polarized Microstrip Array for mm-Wave and sub-6 GHz Applications

Neeraj Kumar Maurya
Technological University Dublin, neerajkumar.maurya@tudublin.ie

Max Ammann
Technological University Dublin, max.ammann@tudublin.ie

Patrick McEvoy
Technological University Dublin, patrick.mcevoy@tudublin.ie

Recommended Citation

Kumar Maurya, Neeraj; Ammann, Max; and McEvoy, Patrick, "Dual-band dual-polarized Microstrip Array for mm-Wave and sub-6 GHz Applications" (2022). *Conference papers*. 376.
https://arrow.tudublin.ie/engscheleart/376

Funder: Science Foundation Ireland

Dual-band dual-polarized Microstrip Array for mm-Wave and sub-6 GHz Applications

Neeraj Kumar Maurya*, Max J. Ammann, Patrick McEvoy
Antenna and High Frequency Research Centre
Technological University Dublin
Dublin, Ireland
*D20125890@mytudublin.ie

***Abstract*—In this paper, a compact dual-band and dual-polarized antenna array with integrated crossover for mm-Wave and sub-6 GHz band Wi-Fi applications is proposed. The proposed dual-band antenna is comprised of a 2x2 array operating at 26 GHz and 5.48 GHz (channel 96). The dual-band crossover consists of a microstrip-grounded CPW-microstrip interface transition. The measured design shows inter and intraband isolation better than 25dB with the crossover on the same plane with a maximum gain of 9.2dBi and 11.83 dBi for 26.25 GHz and 5.48 GHz respectively**

***Index Terms*—mm-Wave, crossover, sub-6 GHz, microstrip antenna**

I. INTRODUCTION

Broadband operators are currently using the mm-Wave n258, 26 GHz spectrum for wireless communication. When compared to the lower frequency bands currently used for mobile networks, mm-Wave bands offer substantially wider bandwidths but are vulnerable to much greater propagation losses due to obstacles including walls, buildings, trees, and topography. Fading due to atmospheric conditions such as rain, fog, and other factors introduce further loss for mm-wave communication. As the frequency of operation increases from sub-6 GHz to mm-Wave bands in tropical regions with heavy rains, harsh communication conditions emerge [1]. The wavelength at 5 GHz is 60 mm, whereas at 26 GHz it is 11.5mm, $\lambda/2$ is comparable to the size of a raindrop, which can range from 1mm to 6mm [2]. A compact dual-polarized architecture with 5 GHz (channel 96) and mm-wave 26 GHz band (n258) is proposed to overcome communication problems in such settings. For the mm-Wave frequency range, numerous dual-band and dual-polarized antenna designs have been reported [3] - [7], but none for the mm-Wave and 5 GHz band (channel 96). The proposed design includes a 2x2 array for both the 5 GHz and 26 GHz band with a single layer crossover

The 26 GHz array is enclosed inside the void established by a 5 GHz array. Both antennas have linear vertical and linear horizontal polarization. This antenna can be used for direct communication at 26 GHz and at 5 GHz in the event of network disruption. This also can be used for 26 GHz access points with 5 GHz backhaul as the limited range of mm-Wave radio transmissions, especially when used indoors, opens the door to more geographic spectrum re-use.

II. ANTENNA ARRAY DESIGN WITH CROSSOVER

The antenna array design is comprised of two 2x2 fed dual-polarized antennas as shown in Fig 1. A series-fed design provides flexibility to use the space between the patches for a 26 GHz array design. The design is optimized to achieve greater inter-band isolation along with intraband isolation.

The design is derived in two steps:

1. Series fed 5 GHz and 26 GHz antenna array
2. Dual-band single-layer crossover design.

A. Series-fed 5GHz and 26 GHz antenna array

The microstrip patch for array design is selected over aperture-coupled and proximity-coupled patch antenna design. The microstrip antenna provides flexibility to use only a single layer for feed and radiating patch whereas other designs require more than one layer for the design.

The series feed mechanism is chosen over corporate feed to use the space efficiently and reduce the copper losses

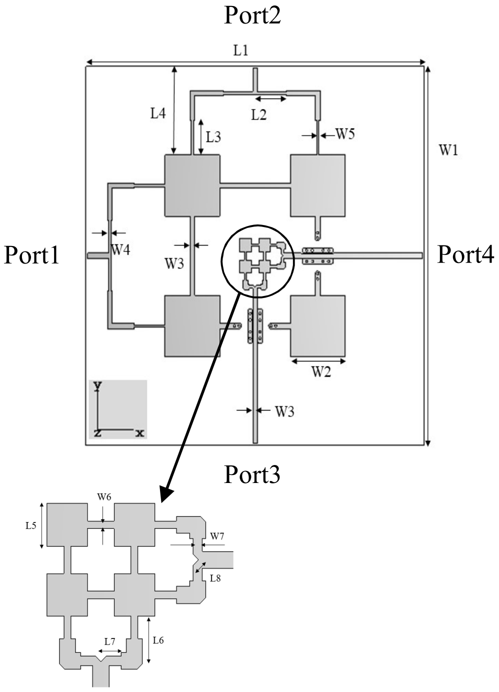


Fig. 1. Dual-band dual-polarized array

Parameter	L1	L2	L3	L4	L5	L6
Value (mm)	110	10.25	10	25.7	3.8	4.75
Parameter	L7	L8	L9	L10	L11	W1
Value (mm)	1.9	0.707	10	9	15	110
Parameter	W2	W3	W4	W5	W6	W7
Value (mm)	17.79	1.5	0.86	0.65	0.65	0.86
Parameter	W8	W9	W10	W11	W12	G1/G2
Value (mm)	1.5	1.3	1.5	1.5	2	1.5/1.9

Table 1: Design Parameters for the proposed architecture

The substrate used for the design is RO5880 which has ε_r= 2.2 and a loss tangent of 0.0009. The substrate has a thickness of 0.535 mm, which comprises a copper thickness of 0.017 mm. The inter-element spacing for 26.25 GHz is 6.25 mm (0.54 λ_o) and for 5.48 GHz is 42.7 mm (0.78 λ_o).

The patch dimensions and other design dimensions are given in Table 1. The 40 GHz end launch castle microwave connectors were used for the prototypes. Ports 1 and 2 are used for 5 GHz and ports 3 and 4 are used for 26 GHz.

B. Dual-band single-layer crossover design

In the proposed design the transmission lines cross over each other using a compact single-layer crossover. One reported crossover design [8] using microstrip can operate up to 6 GHz, but with many vias, makes fabrication more challenging. A mm-wave crossover design developed on a 0.25 mm substrate and employing a grounded-CPW operates up to 40 GHz but is not compatible with connectorized designs [9].

This design is compatible with the 5 GHz and 26 GHz bands. The design uses a 0.5 mm thick substrate enabling simple fabrication on both layers of the substrate. The proposed crossover is shown in Fig 2.

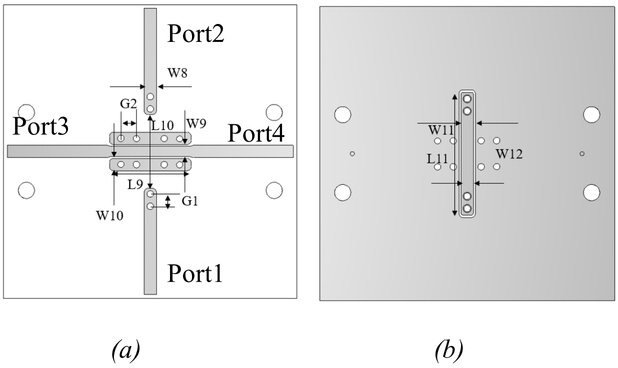


Fig.2. Proposed crossover (a) Topside (b) Bottom side

The crossover design used a grounded coplanar waveguide transmission line for the section of the intersection to reduce the effect of partial ground on the bottom side. The distance between the vias is set so that they function as a shorting wall.

The vias used for CPW ground provide shielding and the gap between the ground and the perpendicular transmission lines increased intraband isolation.

The crossover dimension is provided in Table 1. A 3D EM analysis software, CST Studio Suite, was used to optimize the dimensions of the proposed design.

III. SIMULATION AND MEASURED RESULTS ANALYSIS

A Rohde & Schwarz ZVA40 vector network analyzer was used to measure the S_{11}. The prototype antenna's far-field measurements were taken in an anechoic chamber. A comparison of the simulated and measured results follows.

A. S-Parameters Plot

Figure 3 shows the S_{11} and S_{21} for port 1 and port 2 operating in the 5 GHz band. The measured and simulated S_{11} are better than -10 dB for 5.48 GHz.

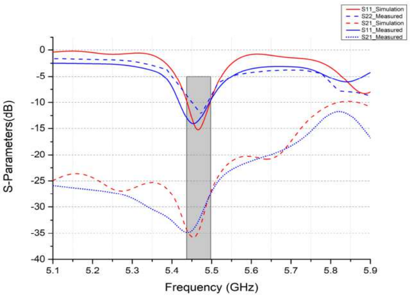


Fig. 3. Simulated and measured S-parameters for sub 6GHz

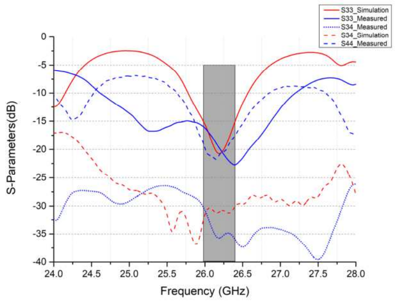


Fig. 4. Simulated and measured S-parameters for 26 GHz

Figure 4 shows the S_{11} and S_{21} for port 3 and port 4 in the 26 GHz band. The measured and simulated S_{11} are better than -15 dB for 26.25 GHz

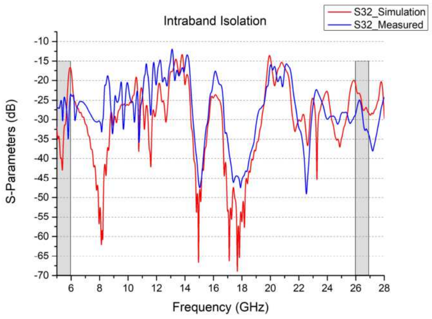


Fig. 5. Simulated and measured S-parameters of the proposed design

Figure 5 shows intraband isolation for ports 2 and 3 across the 5 GHz and 26 GHz bands respectively. The measured and simulated isolation is better than -25 dB and -20 dB, respectively. The S_{23}, S_{32}, $S_{41,}$ and S_{14} are reciprocal as port 1-port 2 and port 3-port 4 are symmetric.

Crossover S-Parameters simulation data

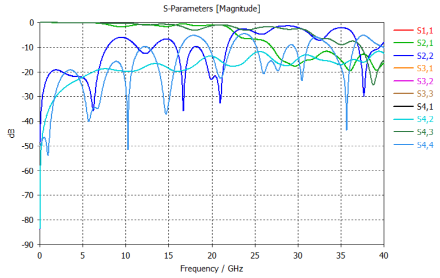
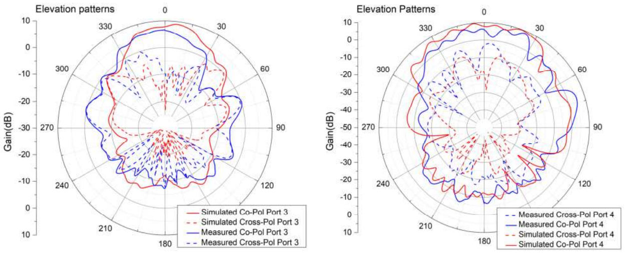


Fig. 6. S-parameters for crossover

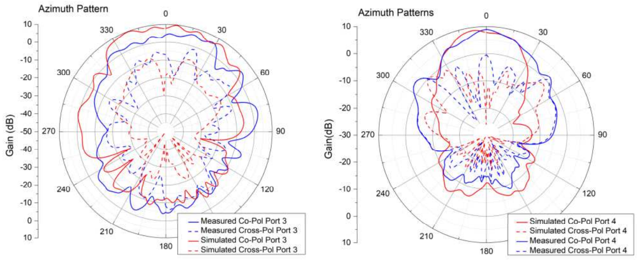
The transmission loss is 0.25 dB at 5.48 GHz and 1.82 dB at 26.25 GHz for the crossover design shown in Figure 6. The normal microstrip transmission line losses at 5 GHz are 0.18 and 0.89 dB. So, the additional 0.7 and 0.93dB loss occurs due to crossover.

B. Radiation properties

The radiation patterns were measured and compared to simulation and are shown in the following plots.

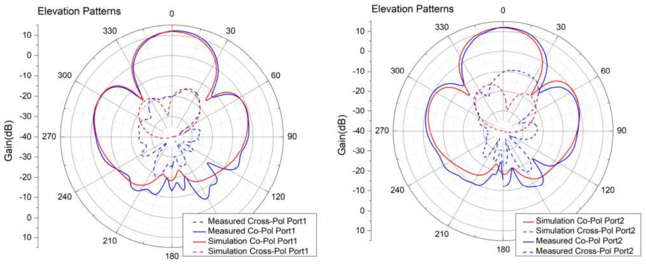


a) Y-Z Plane

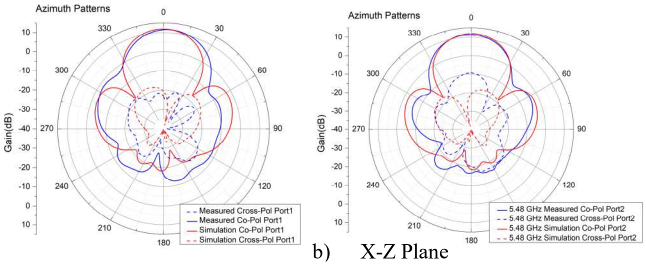


b) X-Z Plane

Fig. 7. Simulated and measured radiation plots at 26.25 GHz for ports 3 & 4



a) Y-Z Plane



b) X-Z Plane

Fig. 8. Simulated and measured radiation plots at 5.48 GHz for ports 1 & 2

The simulated realized gain for ports 3 & 4 at 26.25 GHz was 10.4 dBi and the measured values were 9.21 dBi for port 3 and 8.98 dB for port 4.

The simulated gain in the 5 GHz band for ports 1& 2 was 11.83 dBi with 12.31 dBi and 12.17 dBi for ports 1 & 2 respectively in measurements. comparison. The gain difference in 26.25 GHz is 1.19 dB for port 3 and 1.42 dB for port 4. Figure 9 shows the prototyped antenna.

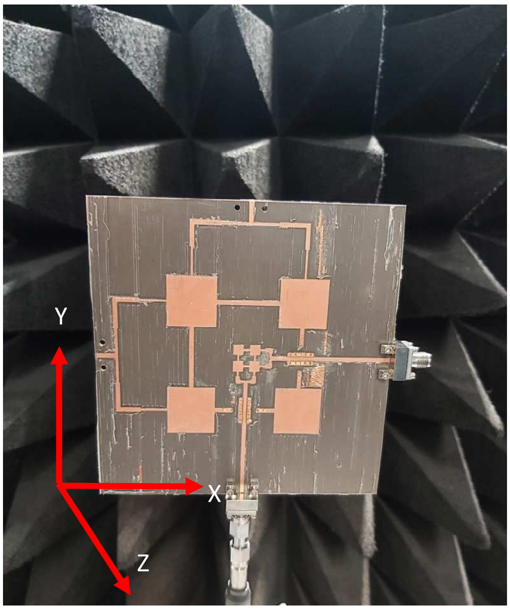


Fig. 9. Prototyped antenna and coordinate system

IV. CONCLUSION

The proposed design shows an innovative approach to use mm-Wave and 5 GHz Wi-Fi in a single structure using a single-layer board. The impact of crossover on 5 GHz and 26 GHz band is not significant The CPW interface at the crossover junction provides a better ground for the transmission line as the bottom layer includes a partial ground There is flexibility to use this for larger arrays for 26 GHz to meet the gain requirements. This design can be used as an access point for fixed wireless communication for the 5 GHz Wi-Fi band and 26 GHz mm-Wave frequency band

V. ACKNOWLEDGMENT

This publication has emanated from research supported in part by a grant from Science Foundation Ireland under Grant number 18/CRT/6222.

VI. REFERENCES

[1] I. Shayea, T. Abd. Rahman, M. Hadri Azmi and M. R. Islam, "Real Measurement Study for Rain Rate and Rain Attenuation Conducted Over 26 GHz Microwave 5G Link System in Malaysia," in IEEE Access, vol. 6, pp. 19044-19064, 2018, doi: 10.1109/ACCESS.2018.2810855.

[2] B. Fong, A. C. M. Fong, G. Y. Hong and H. Ryu, "Measurement of attenuation and phase on 26-GHz wide-band point-to-multipoint signals under the influence of rain," in IEEE Antennas and Wireless Propagation Letters, vol. 4, pp. 20-21, 2005, doi: 10.1109/L

[3] Z. Siddiqui, M. Sonkki, J. Chen, M. Berg, M. E. Leinonen and A. Pärssinen, "Dual-band Dual-polarized Antenna for mm-Wave 5G Base Station Antenna Array," 2020 14th European Conference on Antennas and Propagation (EuCAP),2020,pp.1-4,doi: 10.23919/EuCAP48036.2020.9135795.

[4] Y. Rahayu, L. Fitria, Y. Hakiki and A. Kurniawan, "A new 2×4 array design of dual-band millimeter-wave antenna for 5G applications," 2018 International Workshop on Antenna Technology (iWAT), 2018, pp. 1-4, doi: 10.1109/IWAT.2018.8379210.

[5] T. Elhabbash and T. Skaik, "Design of Dual-band Dual-polarized MIMO Antenna for mm-wave 5G Base Stations with Octagonal Prism Structure," 2019 IEEE 7th Palestinian International Conference on Electrical and Computer Engineering (PICECE), 2019, pp. 1-6, doi: 10.1109/PICECE.2019.8747180.

[6] M. Rao and K. Sarabandi, "A Dual-band Dual-polarized 5G Antenna for Smartphones," 2020 IEEE International Symposium on Antennas and Propagation and North American Radio Science Meeting, 2020, pp. 485-486, doi: 10.1109/IEEECONF35879.2020.9330072.

[7] A. Sharif, H. T. Chattha, M. Haseeb, M. Hayat and A. Raza, "4x4 Dual-band Circular Polarized antenna array for Millimeter Wave Applications," 2018 18th International Symposium on Antenna Technology and Applied Electromagnetics (ANTEM), 2018, pp. 1-2, doi: 10.1109/ANTEM.2018.8573019.

[8] J. Kurvinen, A. Lehtovuori and V. Viikari, "Dual-Band Dual-Polarized mm-Wave Slot Antenna Array for Mobile Handsets," 2020 14th European Conference on Antennas and Propagation (EuCAP), 2020, pp. 1-5, doi: 10.23919/EuCAP48036.2020.9135623.

[9] W. Liu, Z. Zhang, Z. Feng and M. F. Iskander, "A Compact Wideband Microstrip Crossover," in IEEE Microwave and Wireless Components Letters, vol. 22, no. 5, pp. 254-256, May 2012, doi: 10.1109/LMWC.2012.2190270.

[10] A. Tajik, M. Fakharzadeh and K. Mehrany, "DC to 40-GHz Compact Single-Layer Crossover," in IEEE Microwave and Wireless Components Letters, vol. 28, no. 8, pp. 642-644, Aug. 2018, doi: 10.1109/LMWC.2018.2843134.