

## Documents

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**mmWave Four-Element MIMO Antenna for Future 5G Systems**  
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**Abstract**

This paper presents an S-shape four-port Multiple Input Multiple Output (MIMO) wideband mmWave antenna with bandwidth of 25 GHz to 39 GHz. The antenna is designed on 0.254 mm ultra-thin RO5880 with permittivity of 2.3. The dimensions of proposed S-shape antenna are 10 × 12 mm for single element and 24 × 24 mm for four-port MIMO configuration. A decoupling network is introduced to further compress mutual coupling among MIMO elements. The peak gain achieved is 7.1 dBi and MIMO assembly delivers diversity scheme. The proposed MIMO antenna is fabricated, and simulated results are found to be in excellent agreement with simulations. Through the results obtained, the proposed MIMO antenna system can be considered as a potential candidate for future mmWave devices. © 2022 by the authors. Licensee MDPI, Basel, Switzerland.

**Author Keywords**

ECC diversity; four port; gain; MIMO; mmWave

**References**

- Yang, Q., Gao, S., Luo, Q., Wen, L., Ban, Y.L., Ren, X., Wu, J., Liu, Y.  
**Millimeter-wave dual-polarized differentially fed 2-D multibeam patch antenna array**  
(2020) *IEEE Trans. Antennas Propag*, 68, pp. 7007-7016.
- Park, S.J., Shin, D.H., Park, S.O.  
**Low side-lobe substrate-integrated-waveguide antenna array using broadband unequal feeding network for millimeter-wave handset device**  
(2015) *IEEE Trans. Antennas Propag*, 64, pp. 923-932.
- Abdullah, M., Kiani, S.H., Iqbal, A.  
**Eight element multiple-input multiple-output (MIMO) antenna for 5G mobile applications**  
(2019) *IEEE Access*, 7, pp. 134488-134495.
- Kiani, S.H., Altaf, A., Abdullah, M., Muhammad, F., Shoaib, N., Anjum, M.R., Damaševičius, R., Blažauskas, T.  
**Eight element side edged framed MIMO antenna array for future 5G smart phones**  
(2020) *Micromachines*, 11, p. 956.

- Guo, J., Cui, L., Li, C., Sun, B.  
**Side-edge frame printed eight-port dual-band antenna array for 5G smartphone applications**  
(2018) *IEEE Trans. Antennas Propag*, 66, pp. 7412-7417.
- Zhu, Q., Ng, K.B., Chan, C.H., Luk, K.M.  
**Substrate-integrated waveguide-fed array antenna covering 57–71 GHz band for 5G applications**  
(2017) *IEEE Trans. Antennas Propag*, 65, pp. 6298-6306.
- Kamal, M.M., Yang, S., Ren, X.C., Altaf, A., Kiani, S.H., Anjum, M.R., Iqbal, A., Saeed, S.I.  
**Infinity Shell Shaped MIMO Antenna Array for mm-Wave 5G Applications**  
(2021) *Electronics*, 10, p. 165.
- Rahman, S., Ren, X.C., Altaf, A., Irfan, M., Abdullah, M., Muhammad, F., Anjum, M.R., AlKahtani, F.S.  
**Nature inspired MIMO antenna system for future mmWave technologies**  
(2020) *Micromachines*, 11, p. 1083.
- Sehrai, D.A., Abdullah, M., Altaf, A., Kiani, S.H., Muhammad, F., Tufail, M., Irfan, M., Rahman, S.  
**A Novel High Gain Wideband MIMO Antenna for 5G Millimeter Wave Applications**  
(2020) *Electronics*, 9, p. 1031.
- Murthy, Nimmagadda  
**Improved isolation metamaterial inspired mm-Wave MIMO dielectric resonator antenna for 5G application**  
(2020) *Progress in Electromagnetics Research C*, 100, pp. 247-261.
- Sehrai, D.A., Asif, M., Shoaib, N., Ibrar, M., Jan, S., Alibakhshikenari, M., Lalbakhsh, A., Limiti, E.  
**Compact Quad-Element High-Isolation Wideband MIMO Antenna for mm-Wave Applications**  
(2021) *Electronics*, 10, p. 1300.
- Raheel, K., Altaf, A., Waheed, A., Kiani, S.H., Sehrai, D.A., Tubbal, F., Raad, R.  
**E-Shaped H-Slotted Dual Band mmWave Antenna for 5G Technology**  
(2021) *Electronics*, 10, p. 1019.
- Kiani, S.H., Altaf, A., Anjum, M.R., Afridi, S., Arain, Z.A., Anwar, S., Khan, S., Khan, M.A.  
**MIMO Antenna System for Modern 5G Handheld Devices with Healthcare and High Rate Delivery**  
(2021) *Sensors*, 21, p. 7415.
- Luo, Y., Shen, Y., Cai, X., Qian, F., Xu, S., Cui, H., Yang, G.  
**Substrate integrated coaxial line design for mmWave antenna with multilayer configuration**  
(2022) *Int. J. RF Microw. Comput. Aided Eng*, 32, p. e23090.
- Abdullah, M., Kiani, S.H., Abdulrazak, L.F., Iqbal, A., Bashir, M.A., Khan, S., Kim, S.  
**High-performance multiple-input multiple-output antenna system for 5G mobile terminals**  
(2019) *Electronics*, 8, p. 1090.
- Ojaroudi, M., Ojaroudi, N., Ghadimi, N.  
**Dual band-notched small monopole antenna with novel coupled inverted U-ring strip and novel fork-shaped slit for UWB applications**  
(2013) *IEEE Antennas Wirel. Propag. Lett*, 12, pp. 182-185.

- Mishra, S.K., Gupta, R.K., Vaidya, A., Mukherjee, J.  
**A compact dual-band fork-shaped monopole antenna for Bluetooth and UWB applications**  
(2011) *IEEE Antennas Wirel. Propag. Lett.*, 10, pp. 627-630.
- Dong, Y., Li, Y., Yu, K., Wang, Y.  
**High Isolation Design of a Two-Element Planar UWB-MIMO Monopole Antenna**  
(2017),  
International Applied Computational Electromagnetics Society Symposium: Firenze, Italy

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