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Beamforming Network for 5G Application

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Abstract*: A spatial filtering technique called beamforming is used to improve signals coming from a certain direction in relation to a microphone array and to reduce noise and interference coming from other directions. A wireless signal is steered towards a particular receiving device in this sort of radio frequency (RF) control. Beamforming is used in a variety of technologies, including radar, sonar, wireless communications, and acoustics. In 5G technology will be using different frequency bands but we are going to use 3.5GHz frequency (n78 band). The popularity of the n78 band is a result of its widespread availability when contrasted to lower cellular spectrum that is currently being utilised by 3G & 4G networks. The 5G NR standard created the frequency band n78.*

Keywords: Butler without crossover, Antenna, Branch line Coupler, ADS Software

I. INTRODUCTION

Beamforming is the process of sending the electromagnetic signal in a particular direction rather than sending in all direction. Beamforming is one of the essential 5G techniques. It is a type of radio frequency management in which a wireless signal is directed towards a specific receiving device. 5G is the latest iteration of cellular technology. 5G can be called REAL wireless word. The main moto of 5G to used less energy and radio spectrum while delivering speeds faster than current 4G technology.

Low, mid, and high frequency bands are used in 5G; the low band (less than 1GHz) has a larger coverage area but slower speed, while the mid band (1GHz–6GHz) has a smaller coverage area but faster speed. The 26. 28, 38, and 60 GHz millimetre wave bands are a key component of 5G technology. Instead of sending an electromagnetic signal everywhere, beamforming sends it in a specific direction. In wireless communication systems, transmit and receive beamforming is used to send signals from multiple-antenna BSs to user equipment that needs to be covered.

The Butler Matrix is a beam shaping network that combines phase shifters and 90° hybrids. In order to produce 2n orthogonal beams, it uses a spatial Fast Fourier Transform (FFT). These beams are combinations of the array element pattern that are linearly independent. The phases and amplitudes of the stimulation for the smart antenna are controlled by a network called the Butler Matrix. Eight two- step stubs are proposed in a new design to help the branch-line coupler become smaller. The following is a summary of the primary contributions of the suggested method: (1) It applies Butler Matrix's detailed design and decreases the area of the branch-line coupler to its minimum size. (2) The suggested design has decreased the area of the branch-line coupler by up to 30%.

In order to create the next generation of mobile communication, modern communication systems need to be more compact, have greater resolution, and have more bandwidth. Due to their increased mobility, microstrip antennas are used in a variety of applications, including military, radar, satellite communication, and GPS. It benefits from having a reasonable band width, being compact, and being simple to integrate with other planning components. However, some of the restrictions are poor gain, low efficiency, and low impedance bandwidth. Since a decade ago, many microstrip antennas have been developed. A survey of wireless communication systems using microstrip antenna arrays. Microstrip antennas with three distinct geometries can be employed for additional broadband and dual frequency activities. The array antennas are made in various sizes for gap coupling. With the components appropriately aligned, the patch antenna's CP performance improves. By lowering the antenna's total size, a circularly polarised antenna with an arrow slit can be employed for radio frequency applications. An introduction of square slot on the square patch is responsible for producing CP wave.

II. LITERATURE SURVEY

To fulfil this increasing network demand, the fifth-generation (5G) wireless systems' technological advancements will be required. Data speeds of up to 10Gbps, 1-ms latency, and lower power consumption are all features of 5G wireless networks. It is well known that 5G wireless networks will employ frequencies outside of the 3 GHz microwave and millimetre wave (mm-wave) frequency ranges now in use. The main force behind the creation of the 5G wireless technology is this[1].

For 28-GHz mm-Wave 5G wireless applications, this study proposes a Butler matrix-based four-directional switching beamforming antenna system that was realised on a two-layer hybrid stack up substrate. Two layers make up the hybrid stack up substrate, and each of these layers has unique electrical and thermal characteristics. It is created by utilising prepreg to affix two layers, with the ground layers going in the centre and the circuit components going on both exterior planes[2].

Massive multiple-input and multiple-output (MIMO) and steerable antenna array are key architectural elements of 5G wireless network systems. Using switched-beam antenna, such as Butler matrix, Rotman lens, Blass matrix, and Nolen matrix, it is possible to achieve the higher capacity, lower power transmission, and wider system coverage provided by impending 5G technology. [3].

On a double-layer sub-strate, a brand-new 4 3 4 Butler matrix (BM) is given. By utilising a double-layer substrate structure, the multi-layered BM configuration design successfully eliminates the necessity for a crossover component. The microwave circuit of the BM uses much less space now that the crossover has been removed[4].

III. BUTLER MATRIX

A phased array of antenna components is fed by a beam generating network called a Butler matrix. Its function is to regulate the radio transmission of a beam or beams. It is made up of a matrix of fixed-value phase shifters and hybrid couplers. The gadget features output ports (the element ports) where antenna elements are attached and input ports (the beam ports) where power is provided. In order to steer the radio transmission beam in the appropriate direction, the Butler matrix supplies power to the components while gradually changing the phase difference between them.

Power may be switched to the chosen beam port to change the beam direction. A number of beams, or possibly all of them, can be turned on at once. Butler and Lowe originally put out the idea in 1961. It is a development of Blass's 1960 work. The hardware's ease of use gives it an edge over other angular beam generating techniques. on comparison to previous techniques, it uses a lot fewer phase shifters and can be implemented on a tiny strip on a cheap printed circuit board.

The Butler matrix's main properties are:

- There are N inputs and N outputs; N is often 4, 8, or 16.
- Inputs are kept apart from one another.
- The beam is slanted off the primary axis because the phases of the N outputs are linear with respect to location.
- No inputs deliver a broadside beam.
- Which input you pick will determine the phase difference between the outputs.
- Advantages of Butler Matrix
- Simple networks with a few different component kinds can be readily constructed in microstrip or strip lines.
- The beams produced are of the Woodward-Lawson type, having an orthogonal pattern, a short beamwidth, and strong directivity.
- The ideal Butler matrix is the discrete Fourier transform's analogue counterpart.
- Easy design of huge matrices; low pass as minimal insertion in hybrids, phase shifters and gearbox lines.

Disadvantages of Butler matrix

- The Butler matrix creates phased-steered beams that squint with frequency by varying the beam width and beam angle with frequency.
- Large matrices have a complicated connectivity strategy.

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IV. BRANCH LINE COUPLER

- A signal divider called a branch line coupler may divide an incoming signal into two identical signals with a 90- degree phase shift. It has 4 ports: P1 for input, P2 for output 1, and P3 for output 2. For the signal splitter, the fourth port (P4) is separated from the input and terminated at 50 ohms.
- The branch line coupler allows for the use of any one of the four ports as an input port and has a high degree of symmetry.
- Using a transmitter line with a quarter wavelength results in a smaller bandwidth.
- Discontinuities occurring at the junction.
- The bandwidth may be increased by using cascading several sections of branch line coupler.

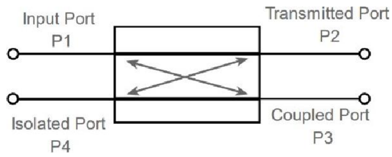

Fig 1.1 Branch line Coupler

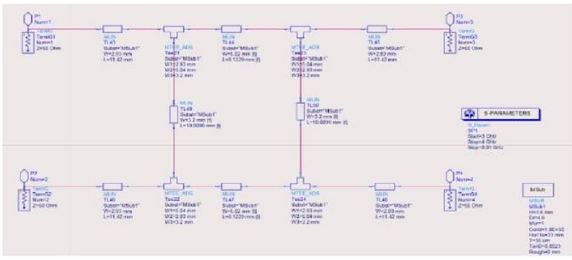

Fig 1.2 Schematic Diagram of Branch Line Coupler

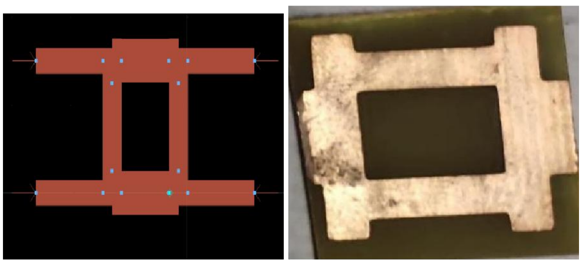

Fig 1.3 Layout of Branch Line Coupler

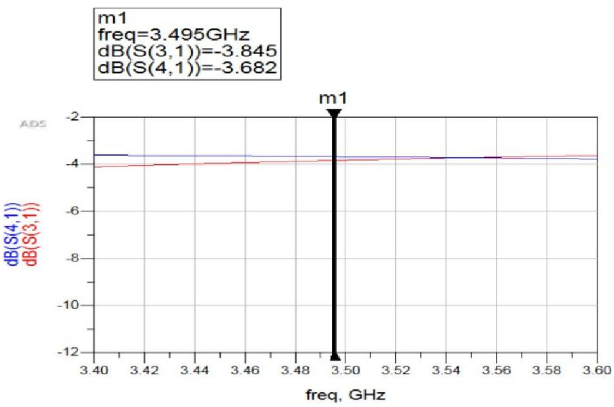

Fig 1.4 Result of Branch Line Coupler

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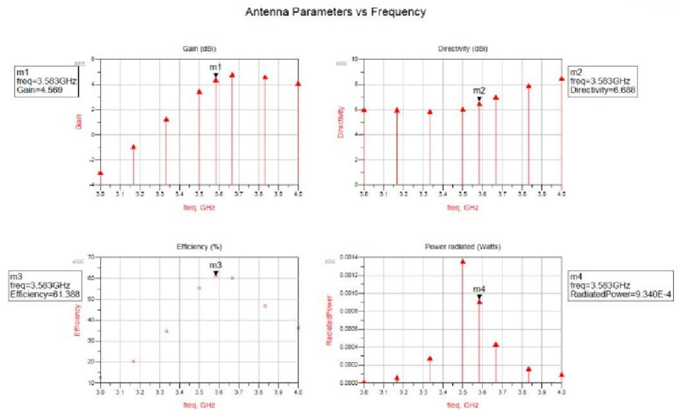

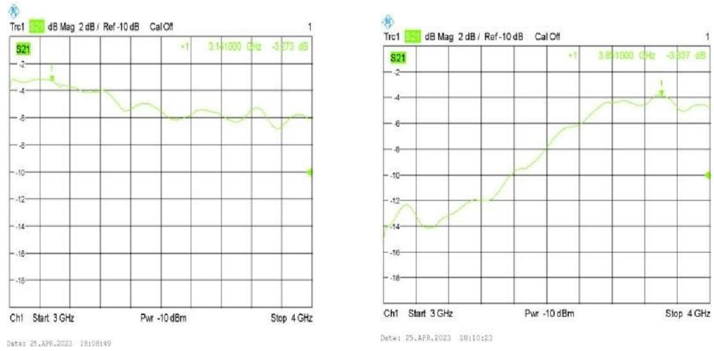

Fig. 1.5 (a) S21 Testing Result of Branch line Coupler Branch Couple
Fig. 1.5 (b) S31 Testing of Branch line Coupler Branch Couple

V. ANTENNA

Because they can be printed directly onto a circuit board, microstrip patch antennas are becoming more and more beneficial. The use of microstrip antennas in mobile phones is expanding rapidly. Patch antennas are inexpensive, have a small profile, and are simple to make.

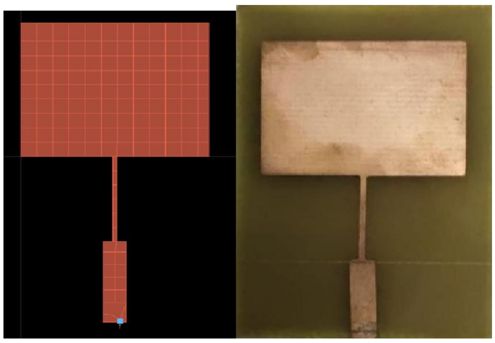

Fig 2.1 Layout& Design of Microstrip Patch Antenna

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Momentum Visualization(MPA_3.5GHz)

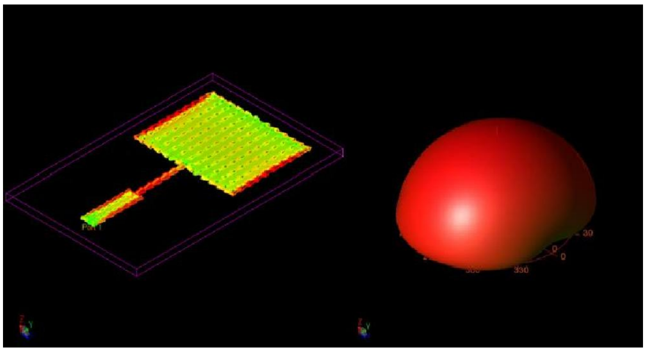

Fig 2.2 3D View of Antenna Radiation Pattern&3D View of Microstrip Patch Antenna

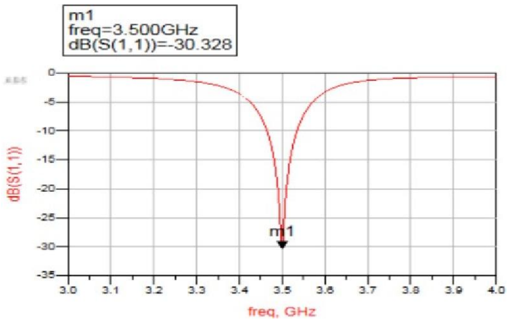

Fig 2.3 Result of Microstrip Patch Antenna

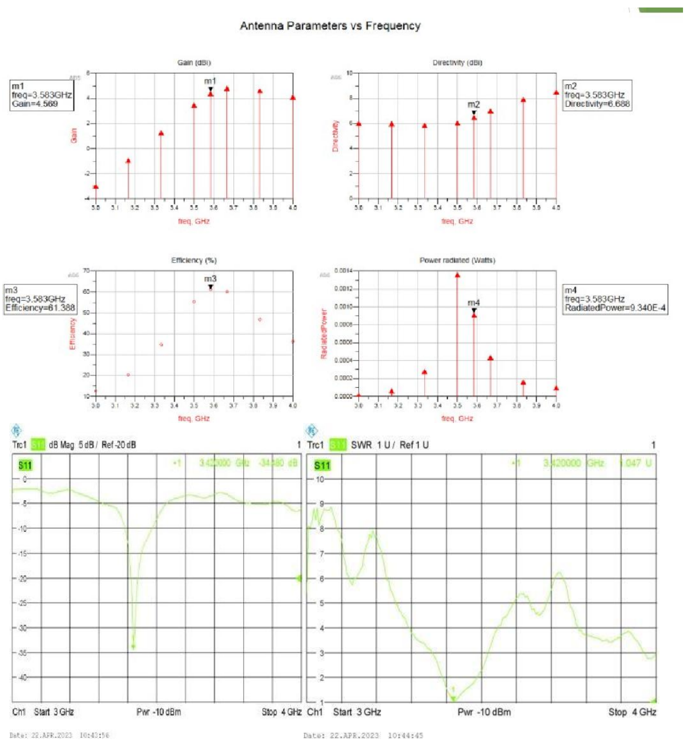

Fig 2.4 (a) S11 Testing result of Microstrip Patch Antenna
Fig 2.4 (b) SWR Testing Result of Microstrip Patch Antenna

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VI. BUTLER MATRIX WITHOUT CROSSOVER

In both the military and the civilian worlds, in multibeam antennas have been extensively deployed. For instance, multibeam antennas are used in the air/space/ground network, unmanned aerial vehicle (UAV) reconnaissance, and tactical status broadcast system. Multiple beams can be created using multibeam antennas, maximising the aperture efficiency of the device. The area of its feed network is smaller and more compact than a standard single beam antenna since it can create numerous beams.

The Blass matrix, Rotman lens, Nolen matrix, and Butler matrix are only a few examples of the numerous multibeam antenna feed networks. The Butler matrix, with its easier architecture and low power dissipation, is the most well-known of them.

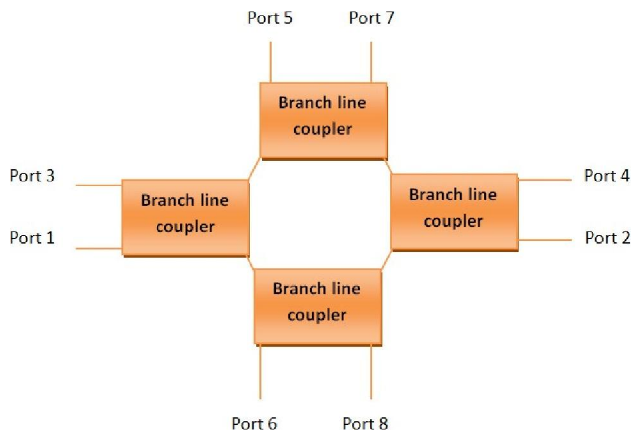

Fig. 3.1 Without Crossover

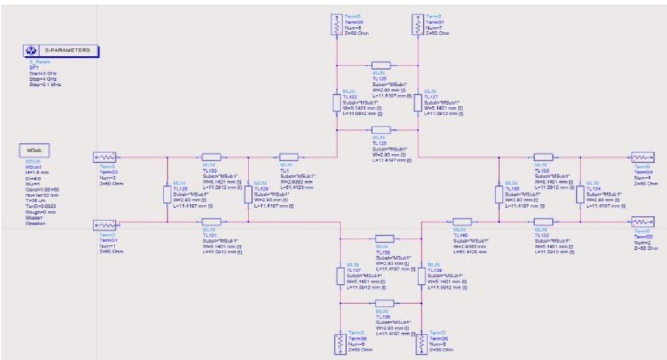

Fig. 3.2 Butler-matrix at 3.5 GHz Frequency

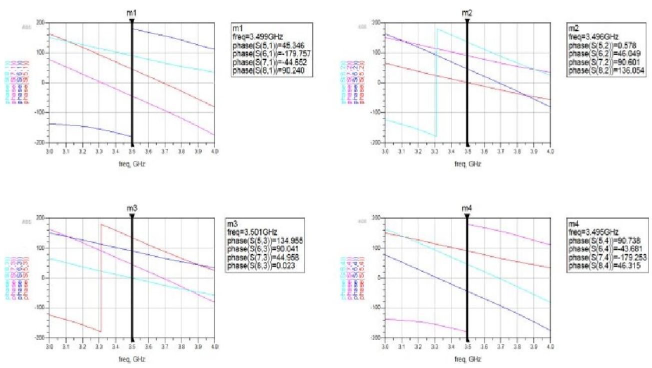

Fig. 3.3 Result of Butler-matrix at 3.5 GHz Frequency

VII. RESULT

Fig. 4.1. Fabricated Branch line Coupler

Fig. 4.2. Fabricated Inset feed Antenna

VIII. CONCLUSION

The Butler Matrix (BM) based Beamforming Networks (BFNs), which are regarded as a crucial component of the phased array antennas (PAAs) in the impending 5G systems, have been thoroughly reviewed in this research. Simple and inexpensive 4*4 BM at 3.5GHz respectively, have been designed in this paper and We have designed and fabricated Microstrip patch antenna, Inset-feed antenna and Branch line Coupler using ADS Software and tested it on Vector network analyzer. Network has been implemented in a single layer without any crossover two different layer layout have been deployed for 4*4 Matrix. They have been proved that they possessed very similar characteristics. The actual bandwidth of network have been determined by measuring by S-Parameter. The experimental results have been compared to theoretical predications, and a good agreement has been observed

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