Active Beamforming Network Design

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Abstract **-** This paper describe the design and implementation of multi beam antenna array using active beam forming network for wireless local area networks (WLAN) operating at 2.4 GHz band frequency. In this paper, four beam patterns generated by incorporated a rectangular patch antenna array with active beam forming network using switch line phase shifter. The radiation patterns measurement of multibeam antenna using active beam forming is compared with passive beam forming network using butler matrix. It shows that the multibeam antenna can be produced using this active beam forming network by switching the RF diode towards the required phase shift of the circuit. The comparison between active and passive beamforming have been made and discuss.

Keywords: Multibeam Antenna, Beamforming network using switch line phase shifter, Microstrip Antenna Array.

1. Introduction

Multiple access wireless communications is being deployed for both fixed and mobile application. In fixed application, the wireless network provides voice and data for fixed subscribers. Mobile networks offering voice and data services can be divided into two classes: high mobility, to serve high speed vehicle-borne user, and low mobility, to serve pedestrian user. Wireless system designer are facing with a number of challenges [1]. In indoor wireless communication environments, however, reflections from walls, the floor, or the ceiling cause many signal propagation paths and delays consequently degrading the received signal quality and receiver performance. One of possible solutions is using the beam forming technique. The antenna's direction main beam will be focused towards the user while nulls towards interference signal or multipath signal directions. The incoming signals from reflection paths are suppressed while increasing the antenna gain for a desired signal direction. Thus, a transmitting power requirement can be also reduced [2]. Multibeam antennas are antenna array that make use of beam forming network to produce multiple independent beams that directed to different directions. By offering independent beams or channels, access point will switch between these channels to select the channel that has the highest received power. This feature assist the antenna system to maximize the power received in the desired directions. Figure 1 illustrates the idea of having four beams coverage pattern produced by multibeam antenna.

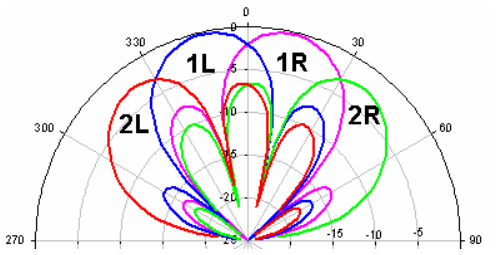


Figure 1 Four beams coverage pattern produced by multibeam antenna

2. Active Beam forming Network Configuration

Table1 shows the phase difference between the ports for the passive beam forming network using Butler Matrix.

Table 1: The specification of passive Beam forming network.

Ports	5	6	7	8	β
1	0º	-45º	-90º	-135º	-45º
2	-90º	45º	-180º	-45º	+135º
3	-45º	-180º	45º	-90º	-135º
4	-135º	-90º	-45º	0º	45º

The active Beamforming network can be designed using the concepts of switch-line phase shifter. In this design, the most important thing is to obtain the coupling in each ports of output with different phases. It can be obtained by using a 90-degree hybrid coupler. The trick of changing the phase of output with 2 inputs and four outputs is by using switch-line phase shifter in the arms of hybrid coupler. For each arm in the hybrid coupler, it ease to achieve by using the switch between two lines as shown in figure 2, where each line has a different length to get a different phase.

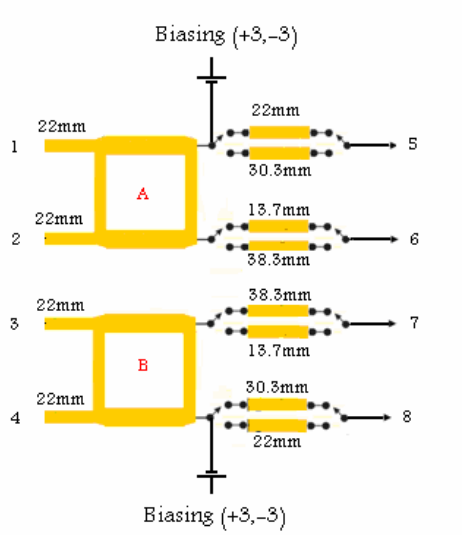


Figure2: Configuration of active Beamforming network

The network was designed in such a way that four different phases with same amplitudes of the excitation current can be coupled. It consists of two 90° hybrid coupler, four switches and eight different transmission lines with different length .The most important thing in this design is the switch; it will give four different phases with different bias state of switch (+3, -3). Table 2 show the simulation result of Beam forming network using switch line phase shifter. The simulation has been done using Agilent Advanced Design System (ADS).

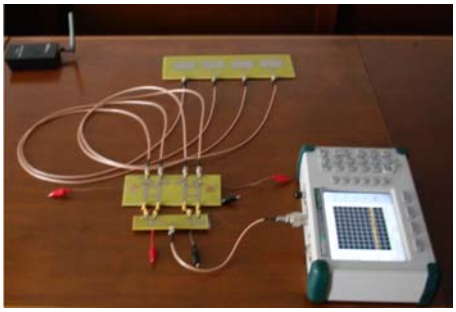
Table 2: Simulation results of the active beam forming network configuration

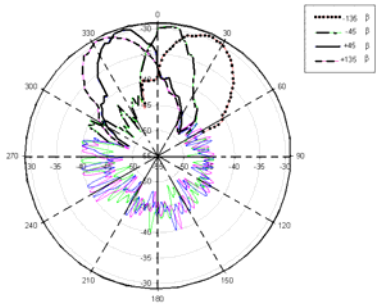
Ports	5	6	Ports	7	8	Bias
1	-1.17º	-46.8º	3	-88.7º	-136.1º	+3 V
1	-91.5º	45º	3	-179º	+135º	-3 V
Ports	5	6		7	8	Bias
2	-45.7º	-179º	4	45.6º	91.5º	+3 V
2	-136º	-88.7º	4	-44.6	-1.17	-3V

The result shows that it has less phase error, approximately about 1.6°. It can be observed that the Beamforming network using switch line phase shifter also provide constant phase increment between its output ports which are 45° for port 1, -135° for port 2, 135° for port 3 and -45° for port4. These results show that the design specification as shown in Table 2 is achieved.

3. Radiation Pattern Measurement Result

The measurement setup of radiation pattern is shown in figure 3(a). Four element of antenna array is connected to the active beam forming network. The phase of the beam forming is obtained by switching the RF diode so that each corresponding beam will be obtained. Figure 3 (b) shows the radiation pattern measurement of the multibeam antenna using the active beam forming network.

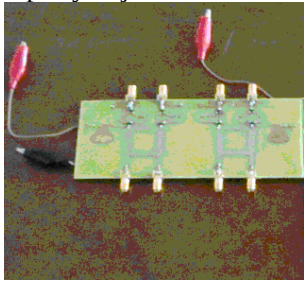


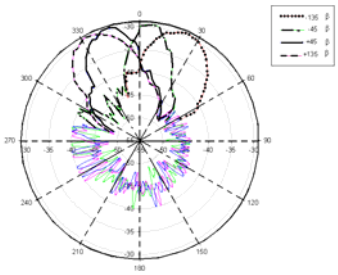


(a) Active beam forming with spectrum analyzer **(b) Radiation pattern measurement**

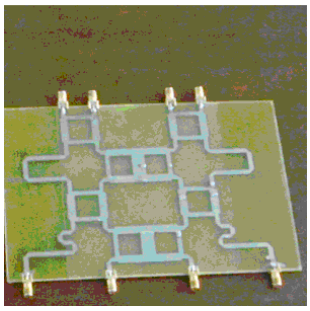
Figure 3: Measurement set up and radiation pattern

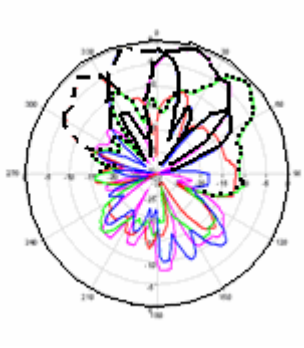
The comparison between the passive and active beam forming network is shown in figure 4. It can be observed that the size of active Beamforming network using "switch line phase shifter" is half size of butler matrix beam forming network. The radiation pattern from the measurement shows that the beam for active beam forming using phase line shifter has narrow beam width compared to the passive beam forming using butler matrix. This is due to the transmission line phase shifter for the beam forming network is not properly adjusted to the correct phase.





(a) Active beamforning network **(b) Radiation pattern for active beam forming**





(c) Passive beam forming network **(d) Radiation pattern for passive beam forming**

Figure 4: Comparison between Active and passive beamforning network

4. Conclusion

The implementation of linear array antenna with active Beamforming network is presented. The active Beamforming network has been designed to excite the four units of antenna array to steer the beams in different directions. The experimental results obtained show that the constructed of active Beamforming network is able to produce four different beams in four different directions. The radiation characteristics of the antenna array are compared between passive Beams forming network. It has shown that active Beamforming has narrow beam width compared to passive Beamforming network. The size of the active beamforming is half of the passive beam forming.

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