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Body Phased Array Antenna for Body Area Network

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Abstract — This paper presents design of body phased array using optimized dual frequency patch antenna for C band focusing on 5 and 8 GHz frequency band. Inclusion of slots with near about symmetrical distribution on conducting plane and notches in both plane and defected ground structure and also changing feed position for impedance matching. Rat race coupler or hybrid coupler will work as a phase shifter. Simulation is done using IE3D for antenna and using Serenade for complete design for various parameters. Return loss of final design is -16.34 dB for 5 GHz frequency and VSWR of 1.37 and -15.49dB and VSWR of 1.43 for 8GHz frequency. Proposed antenna gives dual band operation and shows good bandwidth and simulated results for two frequency bands.

Index Terms — Body Patch antenna, slot, DGS, feedline, notch, Body area Network

I. Introduction

For the design of the proposed body phased antenna array information and knowledge from different books and research papers are studied. it is found that for phase shifting phase shifter is required at each body antenna element. Proposed array is a combination of body antenna; power divider for feed network and phase shifter this design of the proposed receiver is broke broadly into design of phase shifter, the antenna, power divider network and at last combination of these elements. Let us start with phase shifter include its basic design and operation also selection of phase shifter includes cost, simplicity in design, planar structure etc. phase shifting can be done by using diode phase shifter or planar phase shifter. In diode phase shifter harmonic noise distortion may be introduced. Planar structure like branchline coupler or hybrid coupler can provide phase shift between output ports. Branchline coupler provides shift of 90 degree while hybrid coupler provides shift of 180 degree between output ports. Hybrid coupler has two output ports that are 180 degree out of phase so no chance of mixing and they are isolated from each other at the same time with one coupler two antenna can be fed. In case of conventional phase shifter each antenna element has individual phase shifter. This option is size as well as cost efficient. The diplexing function can be implemented using junction that helps in combination as well as isolation between the two inputs. Wilkinson power divider is the best choice [1].

For making or division of power and forming a network like corporate feed network configuration of a matched power divider/combiner Wilkinson power divider is used. For making 4 ways, three powers divider is required. Here power in input port is equally divided between two output ports. The property of Wilkinson is that power is divided in in-phase signals and can be in same or unequal magnitude depending on power division at output end. This device gives a theoretical bandwidth of approximately 1.44: 1 for an input VSWR of 1.22 and isolation of 20 dB between the two output ports [2]. Phased array allows electronic scanning, focusing and deflection. It requires multiple body elements with variable geometry [12].

Rat-race coupler or hybrid coupler or hybrid ring coupler, is one type of key passive components for applications, such as mixers, power amplifiers, phase shifters and body antenna feeding networks. The main reason behind this is its good isolation between two inputs as well as phase difference between outputs. The design of conventional hybrid coupler is composed of one $3\lambda/4$ and three $\lambda/4$ arms, where, λ is the guided wavelength at its central frequency, and its total circumference is 1.5λ. Bandwidth can be improved using different techniques [1,12]. Magic Tee in conventional design and hybrid coupler in planar design splits equally between ports 2 and 3, but the signal at output are 180 degrees out of phase. Ring Hybrid junction is basically a four-port network where it provides 180 degree phase shift between two output ports [1,2,12]. Rat-race couplers are generally used in microwave circuits. They provide in-phase and out-of phase power division. Major drawbacks of conventional rat-race couplers are size and narrow bandwidth. This can be overcome with different techniques [1,12].

In case of phased array antennas there are multiple radiating elements each connecting to a phase shifter.

Operation of phase shifting allows the radiation pattern to be “steered” towards a certain direction. The radiating lobe is increased upward means beam can be steer in desired location without actually moving the element. Also combination of beam produces high gain. It can produce multiple lobes allowing multiple targeting at the same time. Drawback includes high cost because of phase shifter. This cost can be reduced by using planar structure providing phase shift. If hybrid coupler was used then it gives phase shift of 180 degree between each element. Here no active or passive component is required so cost reduction [1,11].

II. DESIGN

A. Microstrip Antenna

Width=30.6mm and length= 27.40mm .

Here modification is done in two different plane i.e. on top plane and ground plane separately. For top plane four square slots of size 5mm x 5mm are made on upper portion of the rectangular patch antenna. Along with that notch line of 1mm thickness is drawn throughout the plane in cross pattern.

Ground plane is made defected giving U type structure. Here ground plane is shifted beneath the microstripline feed with dimension of 30.6 mm width and 26.525 mm length. Here also small notches are made of 1mm x 5 mm dimension. A rectangular defected structure of dimension 10 mm width and 18 mm length is made in the ground plane.

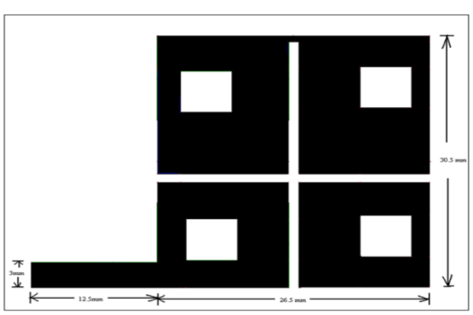

Fig. 1. Detail diagram showing different dimensions of top conducting plane.

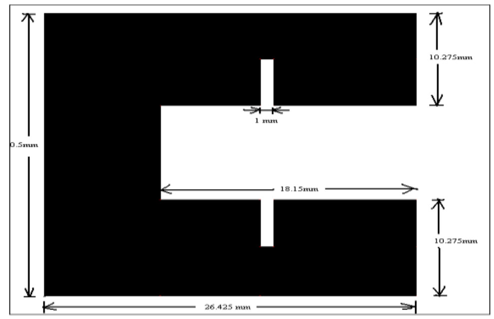

Fig. 2. Dimensions of defected ground structure for the proposed antenna

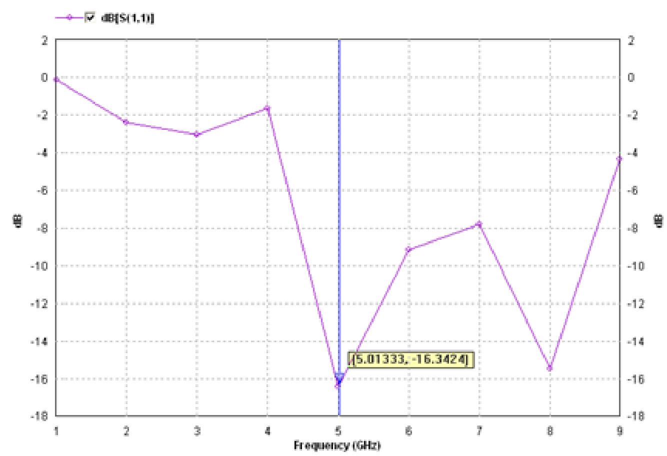

Fig. 3. Simulation of return loss for proposed body antenna

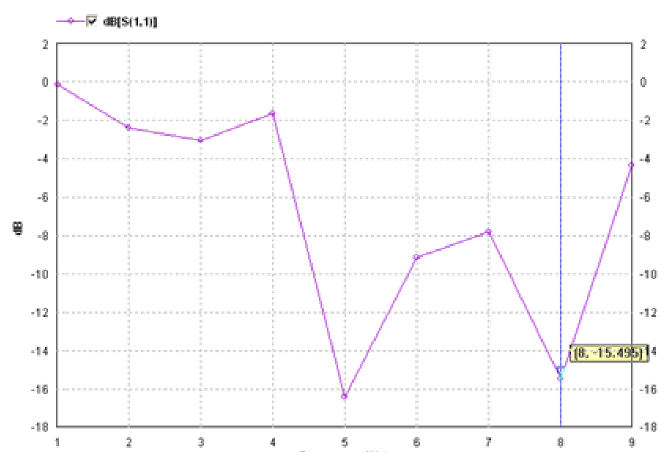

Fig. 5. Simulation of return loss for proposed body antenna

Return loss at 5 and 8 GHz was found to be -16.34dB and -15.49dB respectively.

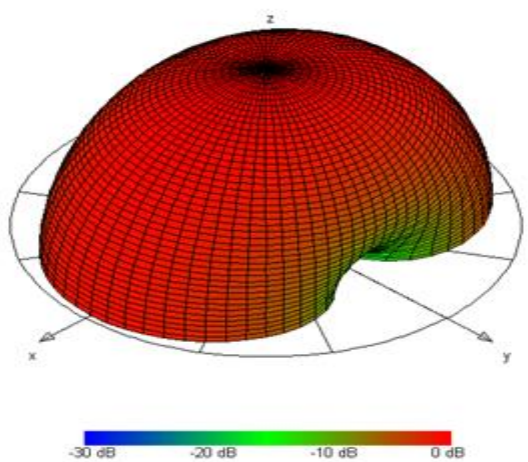

Fig. 6. Radiation pattern of body antenna

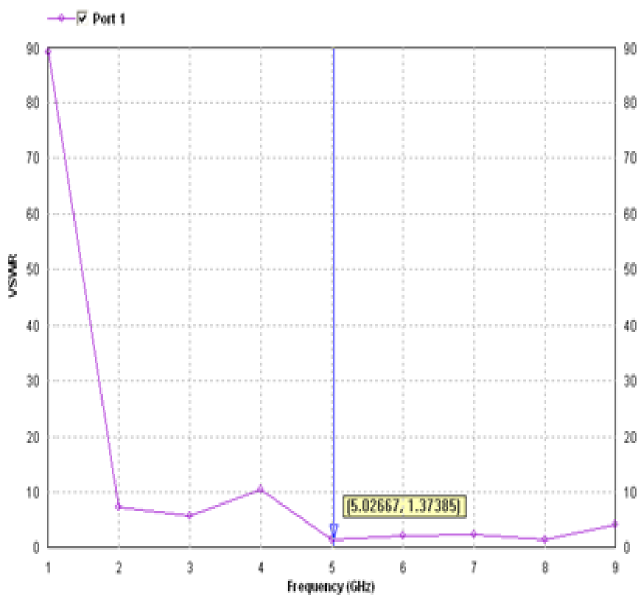

Fig. 7. Simulated VSWR of proposed body patch antenna at 5GHz

Bandwidth of first band was 1.28 GHz starting from 4.6GHz to 5.88 GHz. Similarly for second band bandwidth was 1.19 GHz starting with 7.29 GHz to 8.48GHz. More than 1 GHz bandwidth for two bands was achieved implying wideband applications.

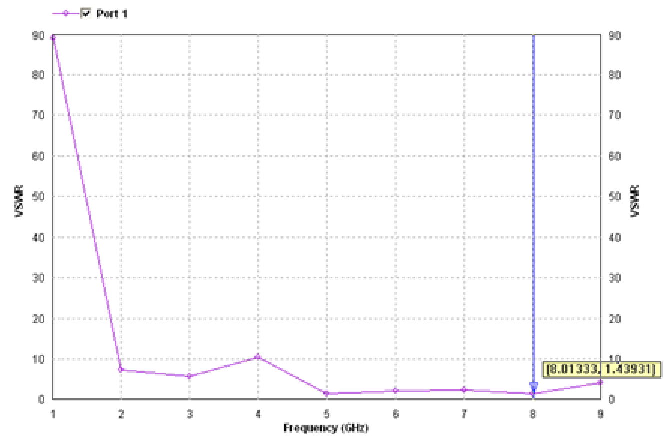

Fig. 8 Simulated VSWR of proposed body patch antenna at 8 GHz

Simulated value of impedance is found to be 55.5 ohm and 40.26 ohm for 5 and 8GHz respectively. This value is close to 50 ohm characteristic impedance of transmission line. Thus in turn proposed body antenna design provides better impedance matching.

B. Hybrid Coupler as Phase Shifter

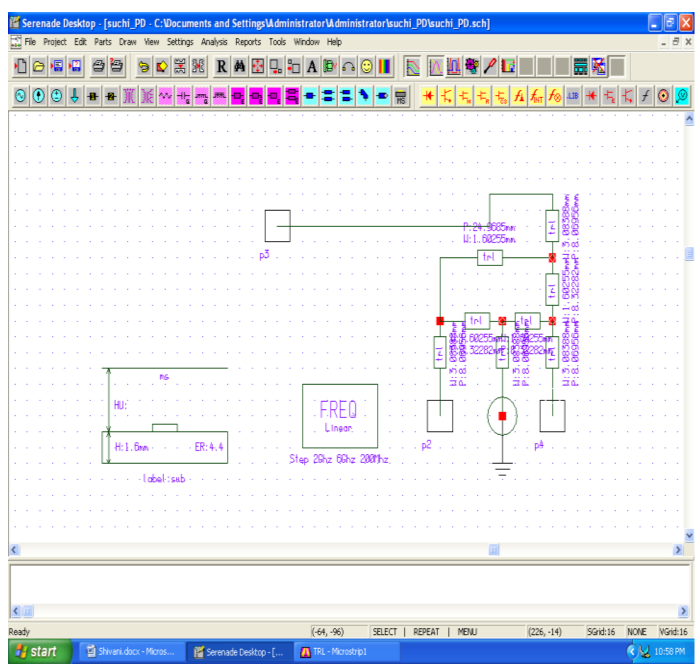

Fig. 9 Screenshot for hybrid coupler

TABLE I

VARIOUS PHASE DIIFERENCE FOR COUPLER

FREQ [GHz]	Ang(S12) [deg]	Ang(S13) [deg]	Ang(S23) [deg]
4.00	-4.49	146.25	173.56
4.20	-23.47	107.17	156.67
4.40	-41.03	75.36	139.25
4.60	-57.90	47.85	122.19
4.80	-74.49	22.74	105.51
5.00	-90.99	-1.32	89.01

TABLE II

VARIOUS ANGULAR PHASE FOR COMPLETE ARRAY

FREQ [GHz]	Ang(S12) [deg]	Ang(S13) [deg]	Ang(S23) [deg]
4.00	74.25	165.15	152.82
4.20	53.46	121.44	116.82
4.40	33.43	85.71	84.29
4.60	13.73	54.89	54.60
4.80	-5.96	26.84	26.83
5.00	-25.84	0.00	0.00

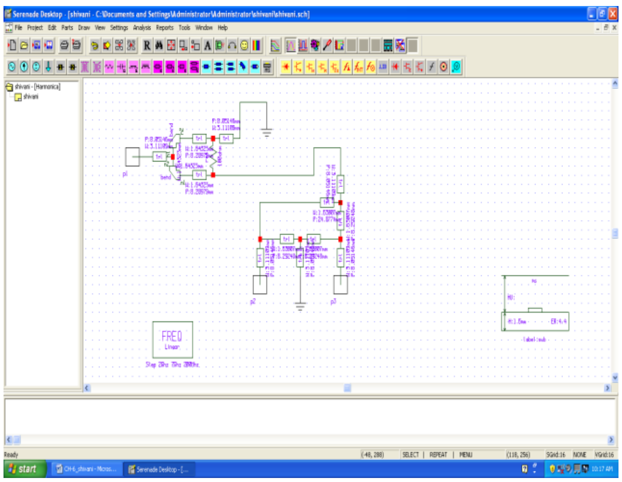

Fig. 10 Screenshot for complete phased array

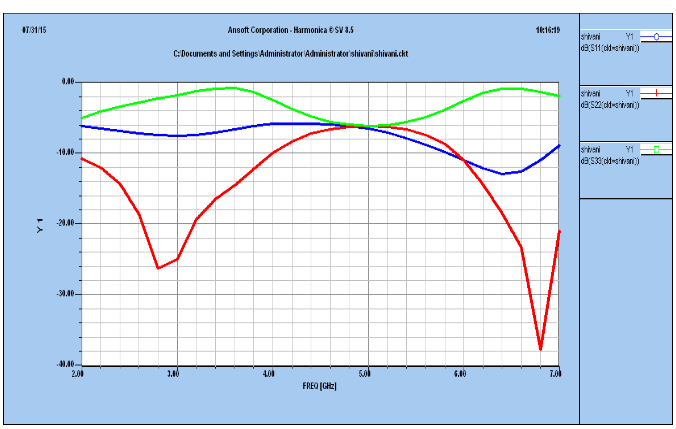

Fig. 11 Return loss at three ports

III. MEASUREMENT RESULTS

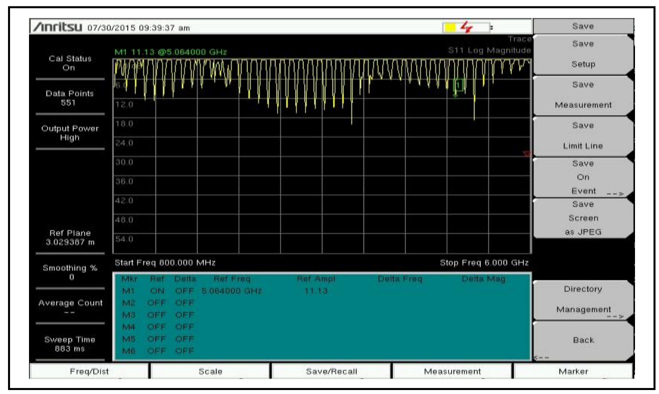

Fig. 12 Measured return loss at input port for 5 GHz array

Return loss is found to be 11.13 at 5 GHz. This is the input port of hybrid coupler.

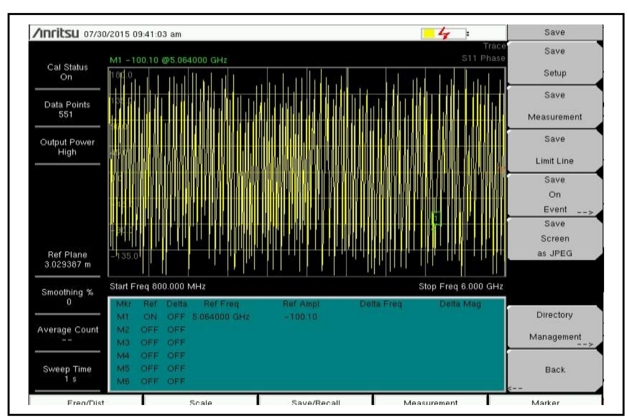

Fig. 13 Measured phase difference at first antenna of array

Fig. 14 Measured phase difference at second antenna of array

IV. CONCLUSION

Measured phase difference is found to be -100 degree. Phase difference of 102.31 degree found for second antenna for 5 GHz antenna array. Simulated value is 90 degree and -89 degree. This value is close to measured value. There is phase difference of almost 180 degree. It means there are very less chances of signal coupling between two ports and thus hybrid coupler can be used for providing phase difference in phased array.

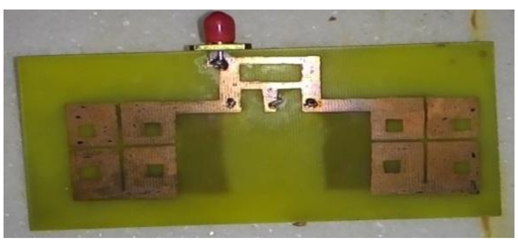

Fig. 15 Photograph for fabricated proposed phased array

FIG. 16 PHOTOGRAPH OF GROUND PLANE OF ARRAY

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