OPTIMIZING THE DESIGN OF BEAM SQUINTED RLSA AT 5.8 GHZ FREQUENCY BAND

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Abstract

The Radial Line Slot Array (RLSA) Antenna is known for its good characteristics such as low profile, low cost, aesthetically pleasing, ease of installation and simple structure. This research involves the optimization of the design and development of a novel linearly polarized Beam Squinted Radial Line Slot Array (RLSA) Antenna at 5.8 GHz band. The research objective is to study the optimum size of the antenna that can give an acceptable antenna's performance. There are four prototypes with different sizes which have been developed and the measurements obtained indicate a return loss at 17.12 dB, antenna gain of 21 dB and 18.80% antenna bandwidth with 63.10% radiation efficiency for the 400mm diameter antenna design.

Keywords: *Radial Line Slot Array Antenna, antenna performance and Beam Squinted Design*

I. INTRODUCTION

Wireless Local Area Network (WLAN) is currently more popular due to its capability of carrying high speed signals and cost saving. In this system, the antenna plays a significant role in building effective communication between places at different locations. Radial Line Slot Array Antenna (RLSA) has been designed and developed based on IEEE 802.11a standard in the frequency range of 5725 – 5875 MHz for WLAN system applications. Typically, this system uses the standard parabolic dish antenna. However, the use of these antennas has the disadvantage of aperture blockage. To overcome this drawback, a new antenna design is proposed and investigated.

Radial Line Slot Array (RLSA) which is known for its flat, low profile and rugged structure, is considered as one of the options for indoor WLAN application. RLSA was introduced by Kelly K.C. in the 1960s [1]. Takada and several authors proposed the use of RLSA in the mobile satellite communication [2 – 4]. Tharek A.R, Lim T.S, Wan Khairuddin W.A, and Hasnain proposed the linear polarized Beam Squinted RLSA for satellite communication application [5, 6]. The beam squinted technique has been patented under the names of Tharek A.R and Bialkowski M.E. [7-8]. This design applies similar design concept as the design of antenna in the more popular 5.8 GHz range for outdoor point-to-point WLAN applications.

This paper highlights two major issues involved. Section 2 explains the tools and procedures used in the antenna design. In Section 3, it presents the simulation and measurement results and analysis of the Beam Squinted RSLA antenna. The paper ends with the conclusion made on the research undertaken.

II. THE ANTENNA DESIGN

The Linear Polarized Beam Squinted RLSA 5.8 GHz antenna for WLAN and Bluetooth applications is designed based on the small aperture RLSA 5.2 GHz antennas [5]. The RLSA antenna structure consists of a dielectric material, sandwiched by copper plates. The front plate bears the radiating element while rear plate acts as a ground plate with feed element at the center. The dielectric constant, $\varepsilon r > 1$ was chosen to suppress the grating lobes. The radiating elements are arrayed so that their radiations are added in phase along the beam direction. The structure of the investigated single-layer RLSA antenna is shown in Figure 1. The orientation of slots is in such a direction so as to transmit and receive waves of proper polarization, linear, and proper coupling inside the cavity.

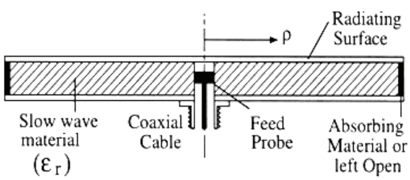

Figure 1: Structure within the radial cavity of RLSA antenna.

The theoretical slot design procedure is similar to what was proposed [6]. Slot pattern has been arranged on the aperture to provide a linear polarization as shown in Figure 2.

A unit radiator is defined as an adjacent slot pair #1, #2, lying along the Φ = constant direction. The following requirements have to be enforced to achieve the requirements of utilizing this slot pairs to produce a linearly polarized radiation [6] [8]:

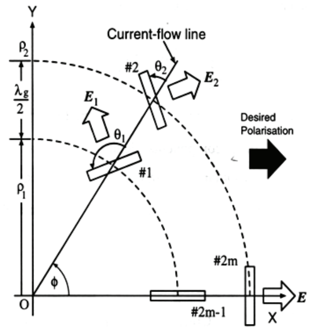

Figure 2: Design of unit radiator of linear polarization.

The co-polar components must be combined in phase while the cross-polar components must cancel out each other. These requirements can be expressed mathematically as follows:

Co-polarization : $\sin\theta 1 \sin(\theta 1+\phi) - \sin\theta 2 \sin(\theta 2+\phi) = 1$

Cross-polarization : $-\sin\theta 1 \cos(\theta 1+\phi) + \sin\theta 2 \cos(\theta 2+\phi) = 0$

The unit radiator can be placed at an arbitrary position on the radiating surface to obtain the desired linearly polarized radiation [6 – 8].

III. SIMULATION AND MEASUREMENT ANALYSIS

Comparison between the simulated and measured radiation patterns were studied at the Wireless Communication Center, Universiti Teknologi Malaysia. Radiation pattern measurements were obtained at 5.8 GHz. Figure 3,4,5 and 6 show the radiation patterns simulated and measured for 600mm, 500mm, 400mm and 300mm prototype antennas. The 600mm, 500mm and 400mm results show a disagreement on the side lobe but a close agreement between the measured and simulated radiation patterns at main lobe is observed. However, the side lobe level is higher than the simulated results. Figure 4 shows a major disagreement radiation pattern between simulation and measured radiation pattern. However for 300mm prototype, a close agreement between measured and simulated radiation pattern is obtained. The angle of squint is also almost at the right point as obtained by the simulation process.

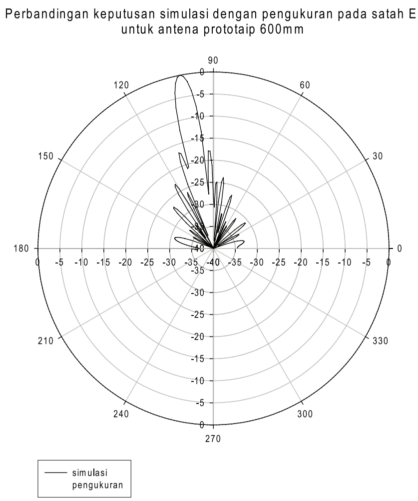

Figure 3: Simulated and measured radiation pattern for 600mm prototype

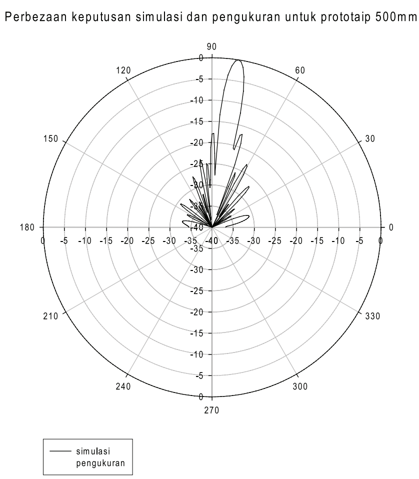

Figure 4: Simulated and measured radiation pattern for 500mm prototype

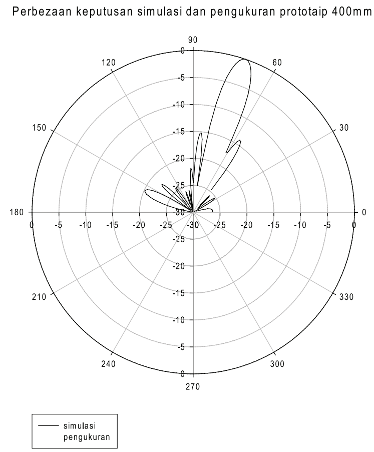

Figure 5: Simulated and measured radiation pattern for 400mm prototype

The summary of the antenna prototypes results is as in Table 1 and 2. The results show that the prototype antennas have a good potential to be implemented in point to point application. The 400mm prototype showed a better VSWR of 1.26 with a return loss of 17.12dB. For point to point application, the gain of the antenna must be high. All the prototype antennas illustrate more than 20 dB gain with 63.1% radiation efficiency except for the 300mm prototype. Beamwidth at E-plane and H-plane is less than 15^o. It is shown that the antenna is suitable for point to point application. The antennas also have a good front to back ratio where more than 15 dB ratio is recorded at the E-plane and the H-plane for all the prototypes. Since the antennas are designed for linear polarization, the cross polar discrimination results provide the verification that the antennas are linear polarized antennas. A constructed prototype has demonstrated more than 20dB ratio for E-plane and H-plane cross polar discrimination.

Table 1: The comparison of simulated and measured return loss

Prototype	S_{11} Sim. (dB)	S_{11} Meas. (dB)
600mm	16.10	-14.55
500mm	16.10	-15.70
400mm	16.10	-17.12
300mm	16.10	-13.52

Table 2: The summary of the results of the prototypes

Antenna Size (mm)	600	500	400	300
VSWR	1.46	1.39	1.26	1.54
Return Loss (dB)	14.55	15.70	17.12	13.52
Directivity Gain (dB)	28	24	23	22.5
Gain (dB)	26	22	21	19
Beamwidth at -3dB				
>E-plane (degree)	8.0	11.5	13	13
>H-plane (degree)	6.0	10.5	11.5	14
Front to Back Ratio (dB)				
>E-plane	20	19	17	21
>H-plane	20	17	26	17
Main to Side Lobe Ratio (dB)				
>E-plane	12	9	9	10
>H-plane	12	15	9	8
Cross Polar Discrimination at 0^o (dB)				
>E-plane	37	26	23	44
>H-plane	45	23	38	44
Bandwidth (%)	12.17	42.74	18.80	33.63
Radiation Efficiency (%)	63.1	63	63.1	44.7

IV. CONCLUSION

The prototypes of RLSA have been successfully constructed for outdoor WLAN point-to-point application. A 300mm prototype shows a close agreement on radiation pattern but poor performance for radiation efficiency. The 600mm and 500mm prototype show a disagreement between measured and simulation for side lobe but good performance for all other aspects. A 400mm prototype shows a bit close agreement of radiation pattern characteristic between the measured and simulation radiation pattern and good performance for all aspects.

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