Simulation of Reconfigurable Log-Periodic Microstrip Antenna

M.F. Ismail [1], M.K.A. Rahim [2], S.H.S. Ariffin[3], S.K.S. Yusuf[4], M.R. Kamarudin[5]
Faculty of Electrical Engineering, University Technology of Malaysia, Malaysia.
[1] ismail86mf@yahoo.com, [2] mkamal@fke.utm.my, [3] sharifah@fke.utm.my, [4] kamilah@fke.utm.my,
[5] ramlee@fke.utm.my

1. Introduction

The reconfigurable antennas have drawn lots of attention in the wireless communication systems especially for cognitive radio application, radar system, and multi-frequency communication. As a front component in wireless communication system, the tunable wideband frequency and good radiation pattern are required [1]. The advantage of a reconfigurable antenna is can reduce any unfavourable effects resulting from co-site interference and jamming [2]. The reconfigurable antenna might be having diversity in frequency [2, 3], polarization [4], radiation pattern [5] and sometimes two or more diversities with the same antenna [6]. The reconfiguration can be implemented through the PIN diode switches [2, 4], MEMS [6] or varactor diodes [3]. However, electronic tunability using PIN diode is more frequently used because of its efficiency and reliability especially in dynamic bandwidth allocation.

2. Reconfigurable Antenna Design

The concept of a reconfigurable antenna in wide band frequency antenna is investigated to select the frequency from a wideband range by changing the switches to ON or OFF mode which controlled by the PIN Diode switches for wireless communication application. This proposed antenna is designed from the combination of thirteen elements using log-periodic technique with a scaling factor of 1.05. This antenna can perform a wideband frequency range from 3 GHz until 6 GHz with three different sub bands. In this paper, the Computer Simulation Technology (CST) software is used to carry out the simulation process for the reconfigurable antenna. The antenna is analyzed based on several parameters such as return loss, radiation pattern, gain, polarization and bandwidth.

Figure 1 shows the proposed log-periodic microstrip antenna with frequency reconfigurable. Thirteen square patches that are connected with a single transmission line in a single substrate. The patches are printed on a FR-4 substrate with a thickness of 1.6 mm, dielectric constant of 4.5 and loss tangent of 0.017. The design principle for log-periodic wideband microstrip antenna requires scaling of dimensions from period to period so that the performance is periodic with the logarithm of frequency. The patch length (*lp*), the width (*wp*) and the inset feed (*I*) are related to the scaling factor ($\boldsymbol{\tau}$) by equation 1 [7]. The dimension of the fist patch (higher frequency) is 11.7 mm x 11.7 mm. The space between each patch (*La*) is a half wavelength apart thus giving a forward fire radiation pattern and reducing mutual coupling effect. The dimension of ground plane is 240 mm x 100 mm.

$$\tau = \frac{L_{m+1}}{L_m} = \frac{W_{m+1}}{W_m} = \frac{I_{m+1}}{I_m} \quad (1)$$

The reconfigurabilty is achieved when the RF PIN diodes were integrated with the feeding line to act as a switch and to control the ON/OFF mode. For simulation, the switch in RF systems is represented by a open and short of the transmission line. Therefore, metal stripes 3mm x 1mm have been used to represent a switch and located at the transmission line of patch. Hence, the ON state is representing by that metal stripe and the absence of the metal stripe is representing the OFF state. The thirteen patches require thirteen switches PIN diode. The wideband operation is achieved when all switches are in ON state. By controlling the switch at the transmission line of patch, the required frequency band could be achieved. For this paper, three sub-band is achieved which is low band, mid band and high band by controlling a group of switch. The high band operation is achieved by switching ON the first five patches while the rest is OFF state. The other sub bands operations are shown in Table 1. In simulation process, the ohmic losses are assumed to be zero by using the ideal substrate and perfect electric conductor [7].

3. Result

The proposed log-periodic microstrip antenna has been simulated using CST Microwave studio to carry out the results of the antenna performances. Figure 2 (a) shows the return loss of the wideband operation while figure 2 (b) shows the return loss for three different sub band. The log-periodic microstrip antenna operates from 3 GHz until 6.2 GHz or over 70% bandwidth. Three different sub bands show 30% bandwidth for each band. Figure 3 (a) shows the simulated gain, directivity and efficiency of the antenna for wideband operations while the simulated gain for sub bands are represented at figure 3 (b). The gain at all frequency bands are approximately about 5dB and the directivity of the antenna is about 9 dB.

For reconfigurable antenna, it is noted that the gains at all bands are approximately 5 dB. Since the log periodic technique enables one patch radiated at single frequency hence, the gain is equally to a single patch. The radiation patterns of the antenna are shown in figure 4. The patterns are taken at each band which is 3.5 GHz, 4.5 GHz and 5.5 GHz. The maximum beam angle for high band, mid band and low band are 19 º, 16 º and 5 º respectively while the half power bandwidth are 65 º,60 º and 73 º respectively. The increased of the active region length at high frequency cause the increase of beam angle at high frequency [8].

4. Conclusion

A frequency reconfigurable antenna using log-periodic technique has been design and simulated. It has been demonstrated that the required frequency band could be achieved by controlling the PIN diode switch. For each frequency band, a good return loss, gain and radiation pattern have been obtained.

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Table 1: Simulation Result for All Band

Switch Mode	**Mode 1 (High Band)**	**Mode 2 (Mid Band)**	**Mode 3 (Low Band)**	**Mode 4 (Wide Band)**
Patch	1-5	5-9	9-13	1-13
Frequency	4.6GHz – 6.3GHz	3.6GHz – 4.7 GHz	3GHz – 4GHz	3GHz - 6.2GHz
Bandwidth	31.58 %	26.74 %	28.87 %	74.2 %
Gain	6 dB	5 dB	5 dB	5 dB
HPBW	65º	60º	73º	-

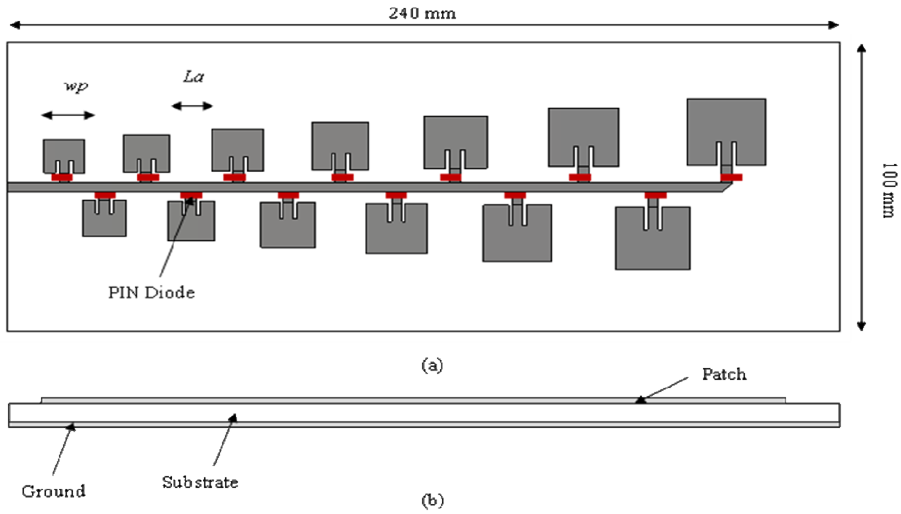
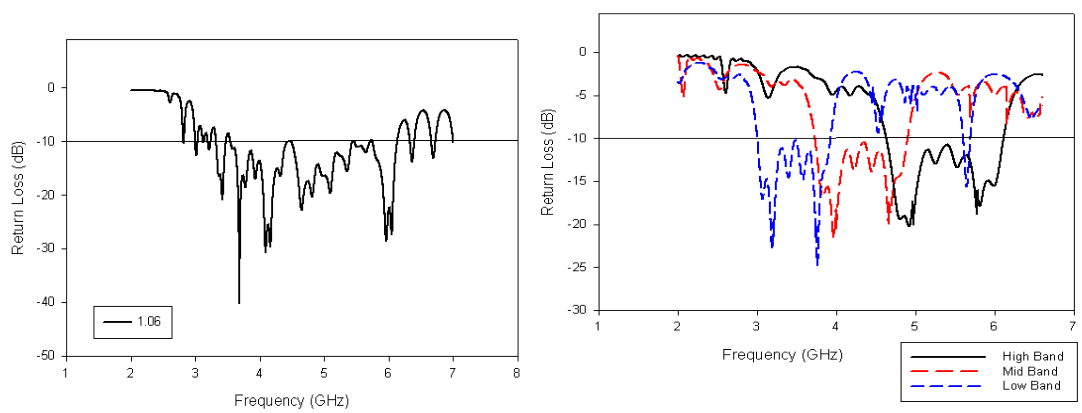
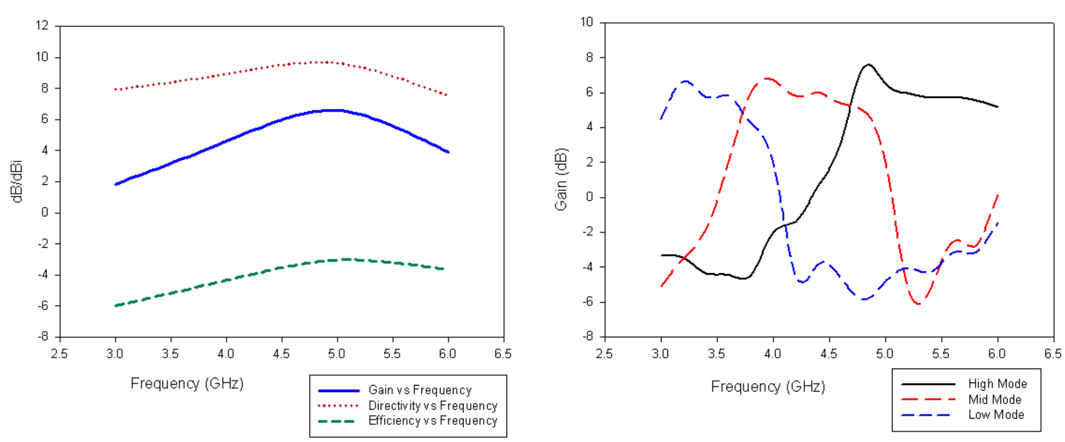


Figure 1: Geometry of proposed antenna (a) Top view (b) Side view



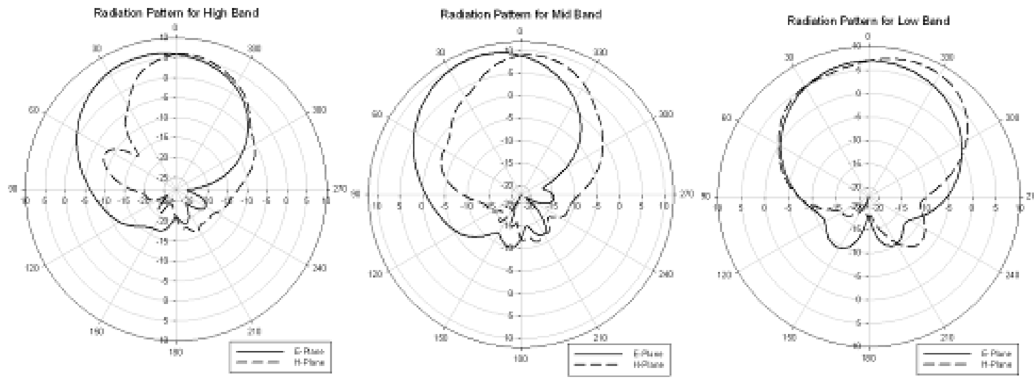
(a) (b)

Figure 2: (a) Simulated return loss for log-periodic microstrip antenna
(b) Simulated return loss for each band



(a) (b)

Figure 3: (a) Simulated gain, directivity and efficiency for wideband log-periodic microstrip antenna (b) Gain for each band for reconfigurable antenna



(a) (b) (c)

Figure 4: Radiation pattern for each band (a) High band (b) Mid band (c) Low band

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