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doi:10.15199/48.2024.04.25

Design and Analysis of Three Thin Patch Antenna for Wireless Application

Abstract *A thin flexible monopole printed antennas has been designed on three different substrates for local area network (WLAN) wireless mode. The first design is thin monopole printed on fast-film substrate antenna which operates at frequency of 5.5 GHz and produced a gain of 2.834 dB, then the second design is printed monopole on Silicon substrate antenna that operates at frequency of 6.8 GHz and achieved a gain of 4.841 dB, while the third design will be printed monopole on Teflon substrate which operates at frequency of 5.5 GHz and results a gain of 3.078 dB, all the designs has same substrate and patch dimensions of (24 X 30) mm and (15 X 19) mm respectively with unified thickness of 0.13mm. In this paper design some shapes are used to improve antennas performance like notches, edges, reflectors and circular in the middle with similar thickness dimensions of 0.035 mm. This study shows some antennas properties such as, radiation pattern, gain, and coupling coefficient which expressed in terms of the scattering parameter S11 are provided which are simulated using CST Microwave Studio.*

Streszczenie. *Cienka, elastyczna antena z nadrukiem jednobiegunowym została zaprojektowana na trzech różnych podłożach do pracy w trybie bezprzewodowym sieci lokalnej (WLAN). Pierwszy projekt to cienki monopolista wydrukowany na antenie z szybkowarstwowym podłożem, która działa na częstotliwości 5,5 GHz i zapewnia zysk 2,834 dB, następnie drugi projekt to wydrukowany monopol na antenie z podłożem krzemowym, która działa na częstotliwości 6,8 GHz i osiąga zysk wynoszący 4,841 dB, podczas gdy trzeci projekt zostanie wydrukowany jako monopol na podłożu teflonowym, które działa na częstotliwości 5,5 GHz i powoduje wzmocnienie o 3,078 dB, wszystkie projekty mają takie same wymiary podłoża i plamy wynoszące (24 x 30) mm i (15 x 19) mm odpowiednio o ujednoliconej grubości 0,13 mm. W tym projekcie papierowym zastosowano pewne kształty w celu poprawy wydajności anten, takie jak wycięcia, krawędzie, odbłyśniki i okrągły środek o podobnych wymiarach grubości wynoszących 0,035 mm. To badanie pokazuje, że niektóre właściwości anten, takie jak charakterystyka promieniowania, wzmocnienie i współczynnik sprzężenia wyrażone w postaci parametru rozpraszania S11, są symulowane przy użyciu CST Microwave Studio.* (***Projekt i analiza trzech anten cienkich do zastosowań bezprzewodowych***)

Keywords: Antenna, Compact Antenna, Fast-Film Substrate, Monopole antenna, Wireless Application.
Słowa kluczowe: Antena, antena kompaktowa, podłoże szybkofilmowe, antena jednobiegunowa, zastosowanie bezprzewodowe

Introduction

Recently the evolution of antenna development and variable designs were enrolled specially in 21th century due to wireless communication systems need, while the whole word become like a small village in term of helping the humanity to be communicate, sending and receiving data. In general, there are allot of invented antenna type in deferent prospective like shape, size, cost and material designed and fabricated according to its need. WLAN technology mainly required for the integration in IEEE 802.11 WLAN standards specially for the frequency response of 2.4 GHz in the range of (2400 – 2484 MHz), and 5.2 GHz in range of (5150 – 5350 MHz) bands[1]. In order to comply with the recently fast evolving technology, the compact, robust and high efficiency antennas are in need. Nowadays there are several of single and dual band antenna [1]–[5] as a compact fabricated printed antenna in deferent prospective in term of flexibility to be applicable for medical and soft mobile communication systems. The coverage of WIFI (2.4 GHz) and other WLAN frequency band (5.2 GHz) reported [6], [7].

An ultra-light thin and flexible antenna are required recently to be integration for wireless connectivity to be integrated, at the same time many designs were proposed such as [8]–[14] As a flexible like fast-film, silicone and Teflon are proposed for this article to be design and simulated to be analysis to be applicable for WLAN communication system.

This article proposed three designs printed antenna for the mentioned substrate material types to be configure in 5.5 GHz to comet the revolution of the new generation in telecommunication system by using CST (computer system technology according to its high-quality results comparing to the reality.

The analysis of these proposed design are done base on the response of the frequency response parameters such as return-loss, gain and bandwidth and its relation to the used substrate, the last part of this research article is the conclusion to determine the best proposed design based on the previous mentioned parameters.

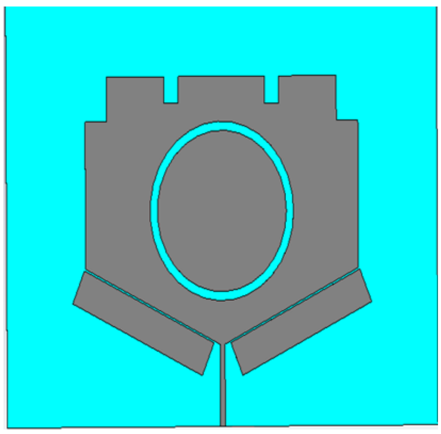


Figure 1: The proposed design of flexible fast-film substrate printed monopole antenna

Design Concept

Fast-Film Substrate

This design concept of partial ground plane with dimension of (4 X 30) mm as the basic layer of the antenna with thickness of 0.035mm, then the substrate as a second layer with dimension of (24 X 30) mm and thickness of (0.13) mm. After that, the proposed design shape as patch with dimension of (15 X 19) mm and thickness of (0.035) mm. The Cylinder concept of inner radius 4.5 mm, and outer radius 5 mm sequentially. Then we adjust two notches on the top of the patch with dimension of (1.5 X 1) mm, and also two edge notch on the end’s top as (2.5 X 1.5) mm. there are two triangle cut from the bottom of the not with dimension of (x=9.5, y=4.3, z=10.43) mm, to adjust two reflector instead of it to increase the directivity of the antenna. The feeding line to the antenna as (5 X 0.35) mm with SNR cable. Figure 1 below shows the design shape.

Table 1: Fast-film substrate antenna dimensions

Element (mm)	Width (mm)	Length (mm)	Thickness (mm)
Ground	30	4	0.035
Substrate	30	24	0.13
Patch	19	15	0.035
cylinder	(Router) 5	(Rinner) 4.5	0.035
Notch	1	1.5	0.035
Edge	1.5	2.5	0.035
Triangle	(x) 9.5	(y) 4.3	(z) 10.43

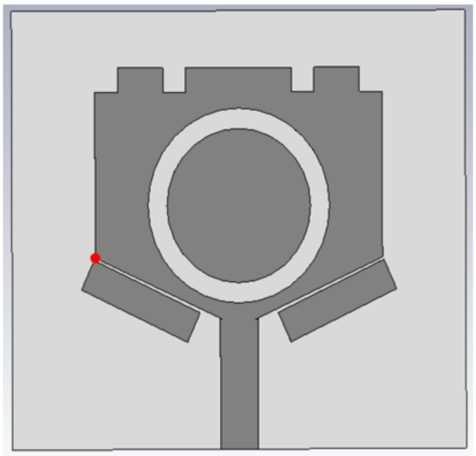


Figure 2: The proposed design of flexible Silicon substrate printed monopole antenna.

Table 2: Silicon substrate antenna dimension

Element	Width	Length	thickness
Ground plane	30mm	8mm	0.035 mm
Substrate	30mm	27mm	1.5 mm
Patch	20mm	15.5mm	0.035 mm
cylinder	(Router) 6mm	(Rinner) 4.75mm	0.035 mm
Notch	1.5mm	1.5mm	0.035 mm
Edge	1.5mm	1.5mm	0.035 mm
Triangle	(x) 10mm	(y) 4.3mm	(z) 10.88 mm

A. Silicon substrate

This design concept of partial ground plane with dimension of (8 X 30) mm as the basic layer of the antenna with thickness of (0.035) mm, then the substrate as a second layer with dimension of (27 X 30) mm and thickness of 1.5 mm. After that, the proposed design shape as patch with dimension of (15.5 X 20) mm and thickness of 0.035 mm. The Cylinder concept of inner radius 4.75 mm, and outer radius 6 mm sequentially. Then we adjust two notches on the top of the patch with dimension of (1.5 X 1.5) mm, and also two edge notches on the end’s top as (1.5 X 1.5) mm. there are two triangles cut from the bottom of the notch with dimension of (x=10, y=4.3, z=10.88) mm, to adjust two reflector instead of it to increase the directivity of the antenna. The feeding line to the antenna as (2.25 X 8) mm with SNR cable. The Figure 2 shows the design:

B. Teflon Substrate

This design concept of partial ground plane with dimension of (4 X 30) mm as the basic layer of the antenna with thickness of 0.035mm, then the substrate as a second layer with dimension of (24 X 30) mm and thickness of 0.13mm. After that, the proposed design shape as patch with dimension of (15 X 19) mm and thickness of 0.035mm. The Cylinder concept of inner radius 4.7 mm, and outer radius 5.25mm sequentially. Then we adjust two notch on the top of the patch with dimension of (1.5 X 0.75) mm, and also two edge notch on the end’s top as (3.5 X 1) mm. there are two triangle cut from the bottom of the notch with dimension of (x=9.5, y=4.3, z=10.43) mm, to adjust two reflector instead of it to increase the directivity of the antenna. The feeding line to the antenna as (8 X 4.75) mm with SNR cable. The Figure 3, shows the design:

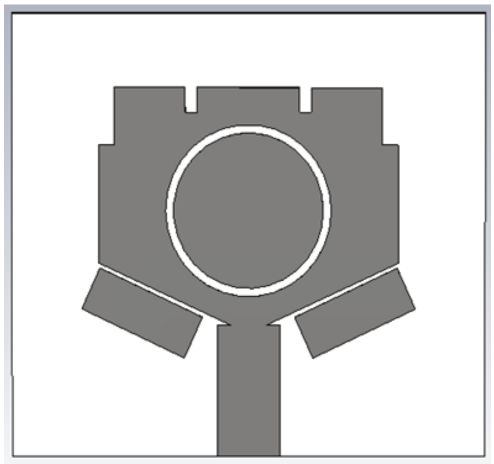


Figure 3: The proposed design of flexible Teflon substrate printed monopole antenna.

Table 3: Teflon substrate antenna dimension

Element	Width	Length	thickness
Ground plane	30 mm	4 mm	0.035 mm
Substrate	30 mm	24 mm	0.13 mm
Patch	19 mm	15 mm	0.035 mm
cylinder	(Router) 5.25mm	(Rinner) 4.75 mm	0.035 mm
Notch	0.75 mm	1.5 mm	0.035 mm
Edge	1 mm	3.5 mm	0.035 mm
Triangle	(x) 9.5 mm	(y) 4.3 mm	(z) 10.43 mm

Results

A. Fast-Film Substrate

The characteristic result simulated from the design of Fast-Film substrate flexible antenna shows the return loss (S 1, 1) parameters at frequency range from (0- 10) GHz are 5.5GHz with -26.8 dB, as in Figure 4.

The Far-field characteristics on frequency of 5.5 GHz is given a gain of 2.834dB, and radiation efficiency of -0.02027 dB with total efficiency of -0.02950 dB, from Figure 5, shows the realized gain of 2.855 dB as the same value for the directivity of 2.855dBi. The Far-field characteristics on frequency of 6.8 GHz is given a gain of 4.843dB, and radiation efficiency of -0.1293 dB with total efficiency of -0.131 dB, from Figure 5, shows the realized gain of 4.841 dB as the same value for directivity 4.841dBi.

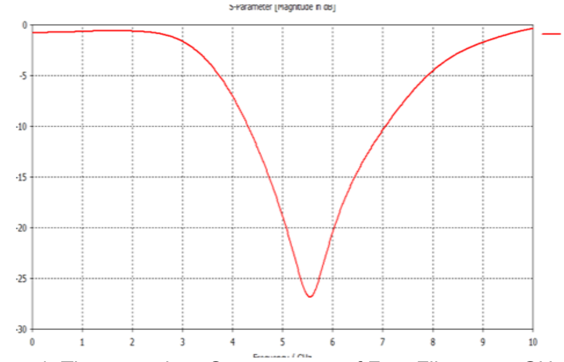


Figure 4: The return loss S-parameters of Fast-Film at 5.5 GHz.

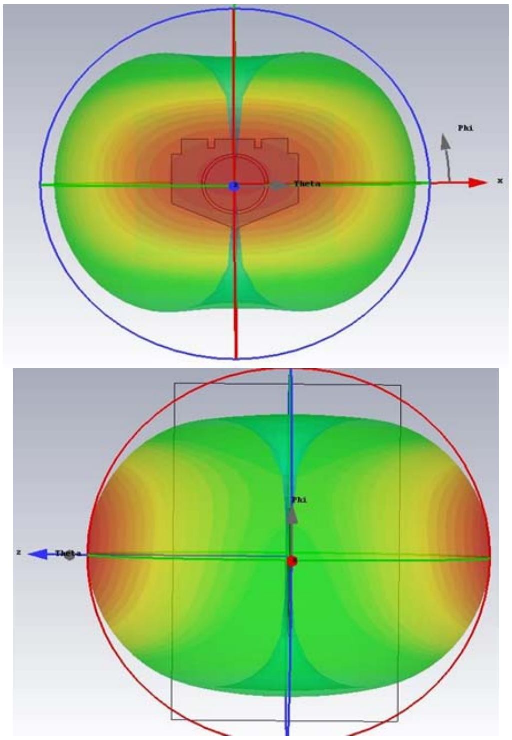


Figure 5: Far-field pattern on freq. 5.5 GHz from two view angle.

B. Silicon Substrate

The characteristic result simulated from the design of silicon substrate flexible antenna shows the return loss (S 1, 1) parameters at frequency range from (0- 10) GHz are 6.8GHz with -36.6dB, as Figure *6*.

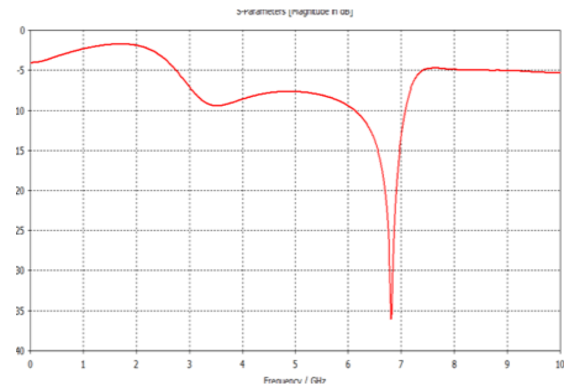


Figure 6: The return loss S-parameters of Silicon at 6.8 GHz.

The Far-field characteristics on frequency of 5.5 GHz is given a gain of 3.078 dB, and radiation efficiency of -0.3562 dB with total efficiency of -0.3564 dB, Figure 7, shows the realized gain of 3.078 dB as the same value for directivity 3.075dBi.

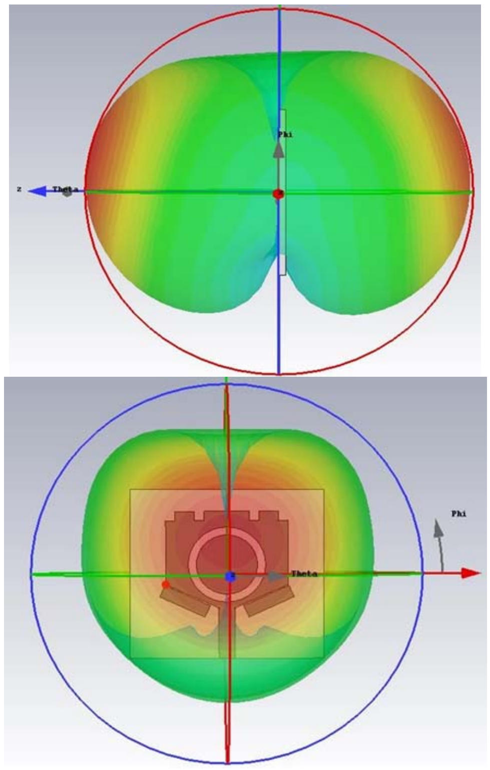


Figure 7: Far-field pattern on freq. 6.8 GHz from two view angle

C. Teflon Substrate

The characteristic result simulated from the design of silicon substrate flexible antenna shows the return loss (S 1, 1) parameters at frequency range from (0- 10) GHz are 5.5GHz with -71.2 dB, as in Figure *8*.

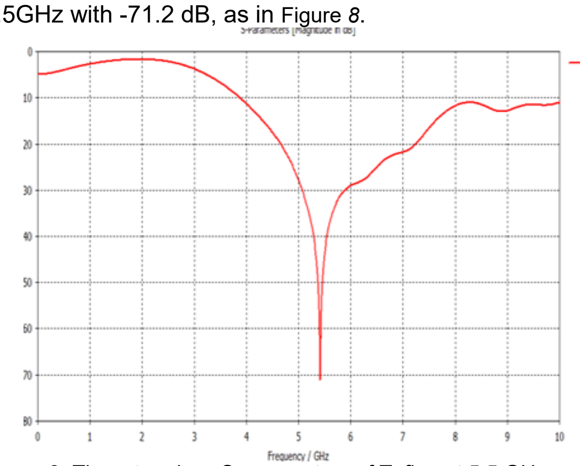
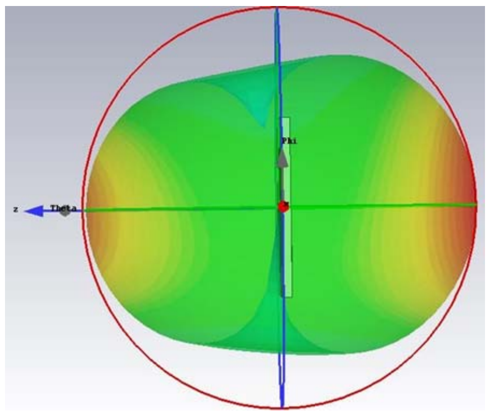


Figure 8: The return loss S-parameters of Teflon at 5.5 GHz.



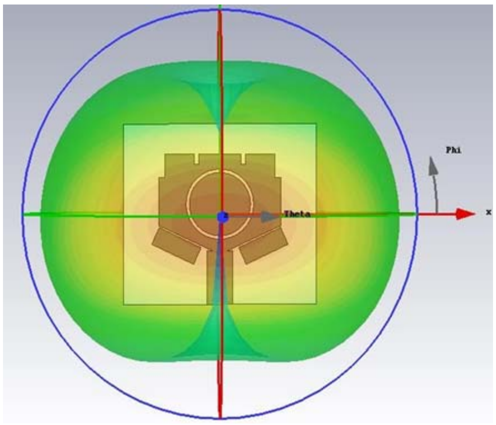


Figure 9: Far-field pattern on freq. 5.5 GHz from two view angle.

Conclusion

A practical design of thin flexible printed monopole antennas using three different substrates has been presented, these substrates are: Fast-film, Teflon and Silicon substrates. Each of these substrates worked at certain frequency band, the highest gain results at a 4.841 dB while using substrate of Silicon with the highest frequency band of 6.8 GHz, while the least gain produced by Fast-film substrate with 2.834 dB, two of three substrates worked at frequency of 5.5 GHz which are Teflon and Fast-film substrates. The shown antennas have similar shape design that analyzed and optimized by CST Microwave studio which based in the finite integration technique to achieve acceptable gain characteristics. Finally, the proposed designed antennas should be useful for integration into flexible technologies for wireless local area network applications.

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