

Design of Miniature Patch Antenna Around the Frequency 3.5 GHz for WIMAX Technology

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Abstract

This work aims to study a miniature rectangular patch antenna $\lambda / 8$ fed by coaxial probe with the transmission line method (TLM). The design and simulation of this antenna is around the frequency of 3.5GHz, for WIMAX technology. The results obtained (input impedance, reflection coefficient, VSWR and bandwidth) are given by the program in the software MATLAB.

Keywords: Patch antenna, Wireless Communications, Wireless Metropolitan Area Network, Wimax, Design.

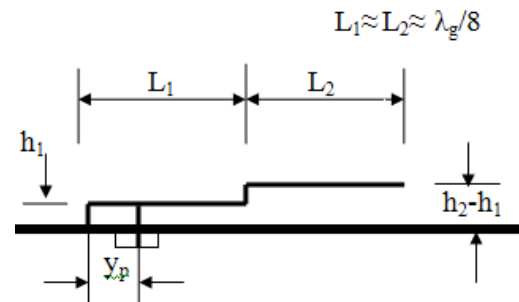


Fig 1 Structure of the patch antenna $\lambda / 8$

1. Introduction

In the first part, this paper deals the modeling of the rectangular patch antenna $\lambda / 8$ fed by coaxial probe with the TLM model.

The second part of this paper is devoted to the simulation of this antenna in the frequency of 3.5 GHz for WIMAX applications, to determine the parameters necessary for the antenna's design.

The key parameters of these simulations are: the input impedance, the resonance frequency, the reflection coefficient and the standing wave ratio (VSWR), with and without compensation of inductif effect caused by the coaxial probe inductance used to feed the patch antenna $\lambda / 8$.

Its equivalent circuit with the TLM method is shown in the figure 2:

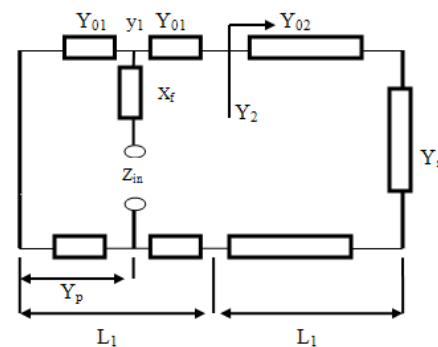


Fig 2 Equivalent circuit of the patch antenna $\lambda / 8$ with the TLM method

2. Modeling of Patch Antenna $\lambda / 8$

Either, the patch antenna $\lambda / 8$ represented in the below figure:

Z_{in} : Impédance d'entrée de l'antenne.

X_f : Réactance inductive

Y_{01} : Characteristic admittance of the line.

Y_{02} : Characteristic admittance of the line L_2 ($L_1 = L_2$).

Z_1 : Impedance of the antenna without that of the coaxial probe.

Z_{in} : Input impedance of the antenna.

X_f : Inductive reactance.

3. Design of the Patch Antenna $\lambda / 8$

3.1 Resonant Frequency and Input Impedance

A design around the frequency of 3.5 GHz for industrial applications in telecommunications namely WMAX, the dimensions of the patch are: The substrate dielectric permittivity $\epsilon_r=2.1$, the length of the inferior patch

is $L_1 = 14$ mm and the upper patch is $L_2 = 14.5$ mm. The widths of the patches W_1 et W_2 are equal and worth 18.7mm. The height of the inferior patch is $h_1 = 2.78$ mm and that of the upper patch $h_2 = 5.4$ mm.

The coaxial probe position from the edge of the short circuit is $x = 2.2$ mm. This gives a resistive part of the input impedance of 49.98Ω in the resonant frequency 3,5 GHz. The coaxial probe radius is 0.32 mm; the inductance in the resonant frequency is 25.14 nH.

The figure 3 shows the real part of the input impedance, the curve peaks indicates the input resistance of the antenna.

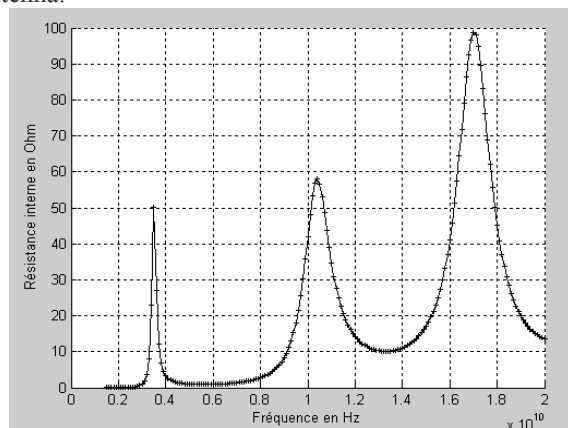


Fig 3 Input resistance of the patch antenna $\lambda / 8$ as a function of the frequency.

I can conclude from the figure 3, that resonance frequencies of the patch near 3.5 GHz, 10.4 GHz and 17.2GHz respectively corresponding to the lengths of the patch $L_{1eff} = \lambda / 8$, $L_{1eff} = 3\lambda / 8$ and $L_{1eff}=5\lambda/8$ (L_{1eff} is the effective length of the patch) . The fundamental mode of propagation is 3.5 GHz; the other frequencies (10.4GHz and 17.2GHz) are other higher order modes.

The figure 4 below allows us to determine precisely the value of the resonant frequency, that 3.5 GHz which gives the maximum value of the resistive part of the input impedance that is 49.98Ω at the adaptation point.

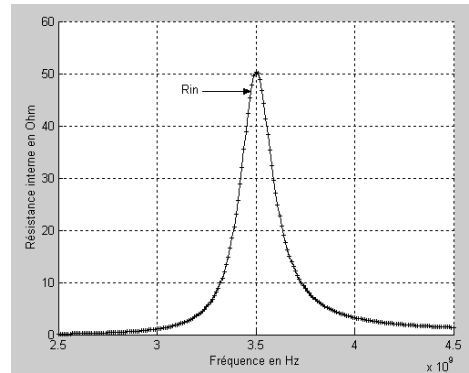


Fig 4 Input resistance of the patch antenna $\lambda / 8$ as a function of the frequency that determine precisely the value of the resonant frequency, in the maximum value of the resistive part of the input impedance at the adaptation point

The patch length determines the frequency desired. This length is the sum of the patch length L and the extension of the field lines Δl that gives the resonance frequency.

3.2 Impedance and reactance of the antenna input patch.

It can be seen in figure 5, that the input resistance is represents the real part of the input impedance that is 49.98Ω is (always positive), which corresponds to a resonance frequency of 3.5 GHz.

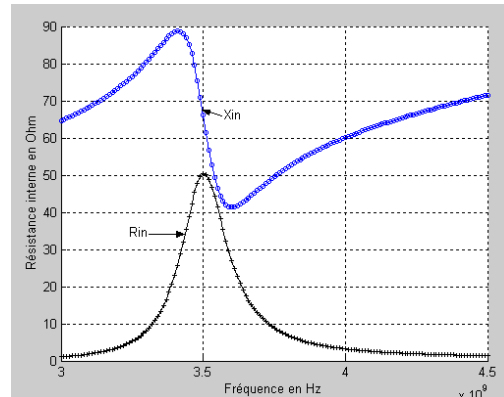


Fig 5 Input resistance of the patch antenna $\lambda/8$ as a function of the frequency.

For this frequency there is a imaginary part (reactance) of the input impedance of this antenna that due to the coaxial probe inductance, and represents the metal losses and reflection losses at contact point between the coaxial probe and the patch $\lambda/8$.

This reactance has an influence on the adaptation of this antenna. This influence appeared in the reflection coefficient of the antenna as a function of the frequency.

3.3 Reflection Coefficient

The following curve shows the reflection coefficient as a function of the frequency:

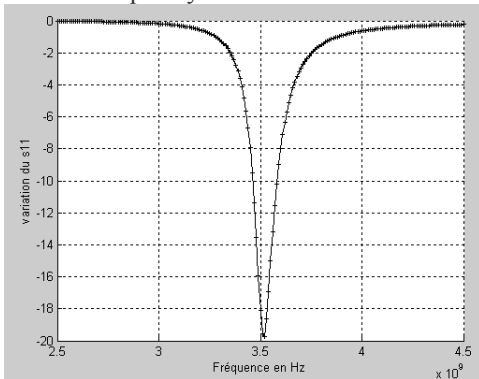


Fig.6: Reflection coefficient as a function of the frequency of the patch antenna $\lambda / 8$ before adaptation

Observed on the figure 6, that the reflection coefficient has a value of -19.6 dB at a resonant frequency of 3.52 GHz. It is a low value that shows the mismatch patch antenna caused by the reactance. And the value of the bandwidth of the patch antenna is very small, that is 124 MHz (3.5% of center frequency).

3.4 Standing Wave Ratio

The standing wave ratio as a function of frequency is given by the figure 7:

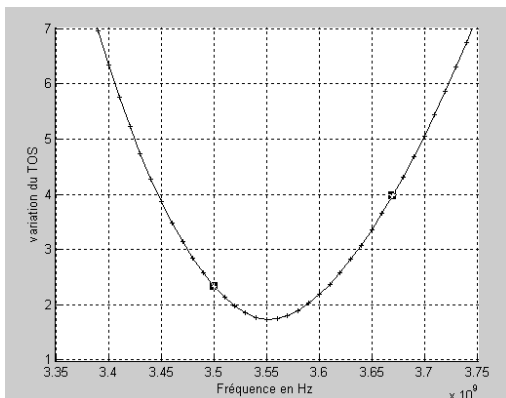


Fig7. Standing wave ratio as a function of frequency of a patch antenna $\lambda / 8$ before adaptation.

The SWR has a value of 1.62 at the resonant frequency of 3.55 GHz, is used to calculate the bandwidth for patch antenna but it is low, this due always to the mismatch impedance caused by the reactance.

4. Adaptation of the patch antenna $\lambda / 8$ with a capacitive reactance.

Let now a capacitor in the middle of the coaxial probe as shown in the figure 8.

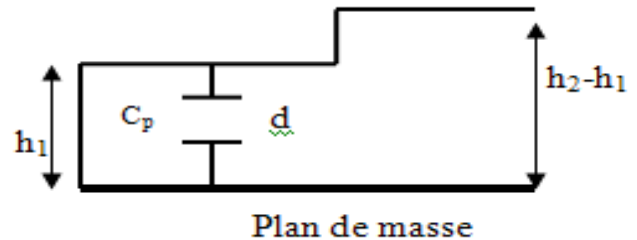


Fig 8 Geometry of the patch antenna with the capacitor.

The equivalent circuit find by the TLM method of this structure is:

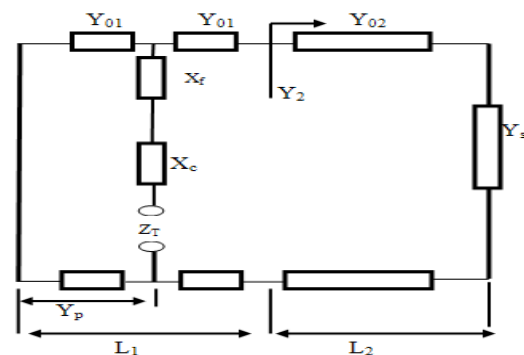


Fig.9 Equivalent circuit of the patch antenna $\lambda / 8$ after the addition of capacitor.

The input reactance of this antenna is the sum of the coaxial probe reactance and the reactance that has been added.

We will study the effects of Adding this capacitor on the reflection coefficient and the SWR at the resonant frequency.

4.1 Input impedance of the antenna patch

The figure 10 shows the simulation of the patch antenna $\lambda / 8$ with the addition of capacitor.

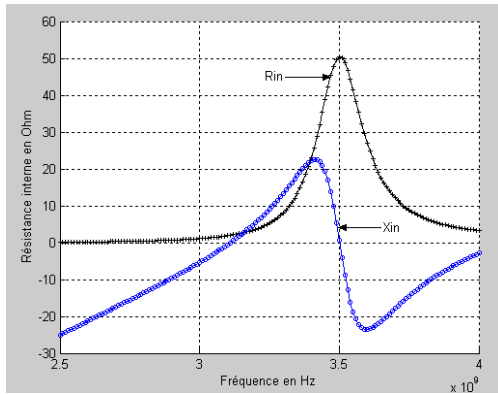


Fig 10 The input resistance and reactance of patch $\lambda / 8$ after adaptation.

The figure 10 shows that the input resistance remains the same at the resonant frequency, but the input reactance is almost zero at the resonant frequency, because of the cancellation of the probe coaxial inductive reactance caused by the capacitive reactance.

4.2 Reflection coefficient

We observe in the figure 11, an increase of the reflection coefficient with a value of -42.5 dB at the resonant frequency of 3.5 GHz.

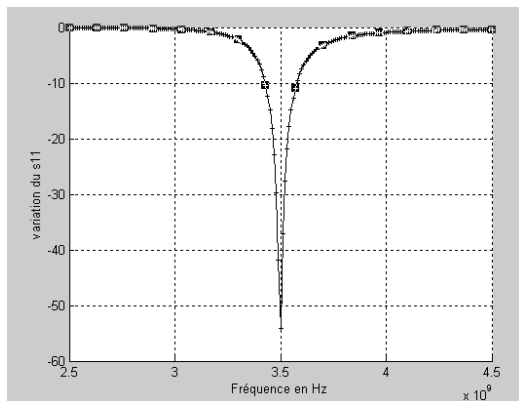


Fig 11 Reflection coefficient as a function the frequency with the addition of capacitor.

Note, that the addition of a capacitor reactance which cancels the effect of inductive reactance causes the decrease of the reflection coefficient of the value -19.6 dB to achieve the value of -54.4 dB at the resonant frequency of 3.5 GHz, this to calculate the bandwidth of the patch antenna.

4.3. Standing Wave Ratio (SWR)

The value of the SWR is 1.1 at 3.5 GHz frequency, which shows that our antenna has been adapted (Figure 12).

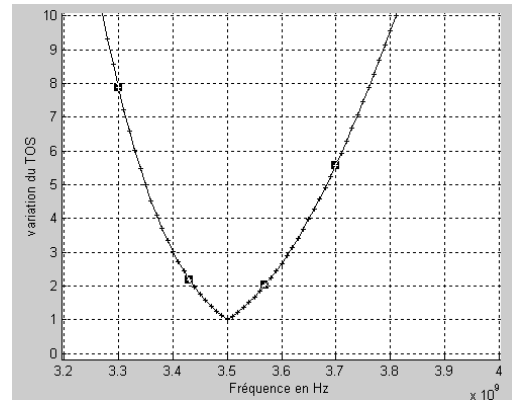


Fig 12 SWR as a function of frequency after the addition of capacitor.

Since the SWR and reflection coefficient at the resonance frequency are respectively less than 2 and -10 dB, then we can calculate the value of the bandwidth of the patch antenna. The value of the bandwidth after the adaptation capacitor is 160 MHz (4.4% of center frequency).

5. Conclusion

We conclude that the simulation of the patch antenna $\lambda / 8$ at frequency of the WIMAX technology is necessary to improve the reflection coefficient and standing wave ratio. To compensate the reactance due to the inductive effect of the coaxial probe, it can be done by adding capacitor to the dielectric substrate. This increases the bandwidth from 3.5% to 4.4%.

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- NGN-'10, Marrakesh, United Kingdom, 8-10 July 2010.
- NETAPPS2010) 22-23 September 2010, MALAYSIA.
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