Folded patch design

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INDEX TERMS antenna, antenna design, patch, folded patch, resonance, radiation, microwave

I. INTRODUCTION

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Parameter	Value	
Feed coefficients $[A]$	$\begin{bmatrix} C_{-2} \\ C_{-1} \\ C_0 \\ C_1 \\ C_2 \end{bmatrix} = \begin{bmatrix} 9.6 \\ 29.8 \\ 41.2 \\ 29.8 \\ 9.6 \end{bmatrix}$	
Tapering efficiency	$\eta_T = 79\,\%$	
Beamwidth	Tchebyshev $50.6°$	Uniform $34.8°$

TABLE 1: Parametri materiali

vehicula.

II. TCHEBYSHEV ARRAY FACTOR DESIGN

The design of the Tchebyshev array factor will be made with five elements and a lobe/side lobe ratio of **R = 41.58 dB**. In order to minimize the beamwidth, let's look for the optimal inter-spacing:

$$d_{\max} = \lambda \left[1 - \frac{1}{2\pi} \arccos\left(\frac{3 - x_1}{1 + x_1} \right) \right] \quad \text{with} \quad d_{\max} \in \left[\frac{\lambda}{2}, \lambda \right] \tag{1}$$

III. RECTANGULAR FOLDED PATCH DESIGN

A. MESH DENSITY REFINEMENT

A FR4 substrate thickness of $h_{sub} = 0.8\,mm$ has been selected so it could be considered as a thin one:

$$\lambda_{sub} = 0.0652\,m \quad \rightsquigarrow \quad \frac{h_{sub}}{\lambda_{sub}} \cong \frac{1}{81}$$

In case of thin substrates ($h/\lambda \leq 1/50$), the `Antenna Toolbox` suggests to mesh the antenna using dielectric in auto mode. The other two available substrate thicknesses ($1.0\,mm$ and $1.6\,mm$) have not been adopted because the `Antenna Toolbox` reference doesn't give any information about accuracy of the results in case of $h_{sub} \in \left(\frac{\lambda}{50}, \frac{\lambda}{10}\right)$.

B. PATCH PARAMETERS

$$L + W - w_{SC} = \frac{\lambda}{4} + h_{sub} \tag{2a}$$

$$W = \frac{\lambda_0}{2} \sqrt{\frac{2}{\varepsilon_r + 1}} \tag{2b}$$

$$BW_E = 2 \arccos \sqrt{\frac{7.03\,\lambda_0^2}{4\,(3\,L_e^2 + h^2)\,\pi^2}} \tag{3a}$$

$$BW_H = 2 \arccos \sqrt{\frac{1}{2 + k_0\,W}} \tag{3b}$$

$$\ell_{\text{feed}} = \frac{L}{\pi} \arccos \sqrt{\frac{R_{in}}{R_r}} \tag{4}$$

C. OVERALL ARRAY PERFORMANCE EVALUATION

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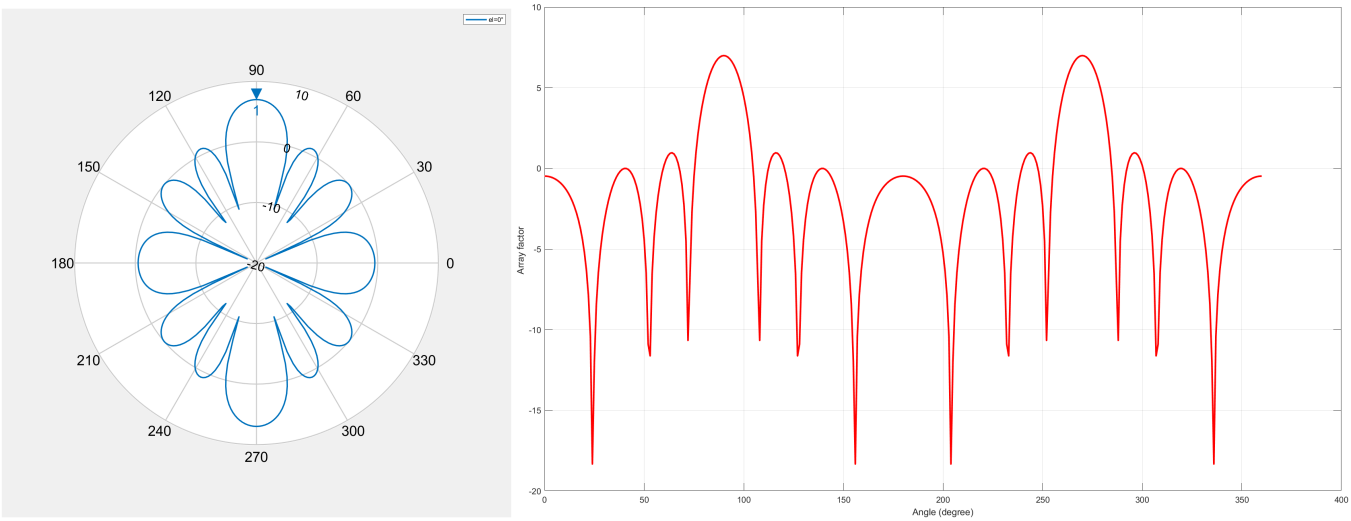

(a) (b)

FIGURE 1: Array factor polar (a) and rectangular (b) diagrams

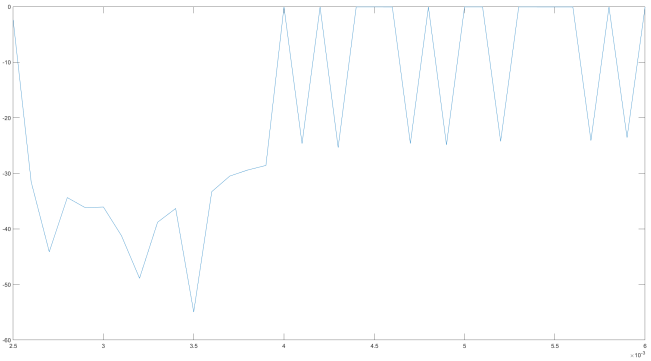

FIGURE 2: Minimum of the reflection coefficient Γ [dB] in the frequency range $2.0 \div 2.2$ GHz depending on the varying mesh density level

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  See [29].

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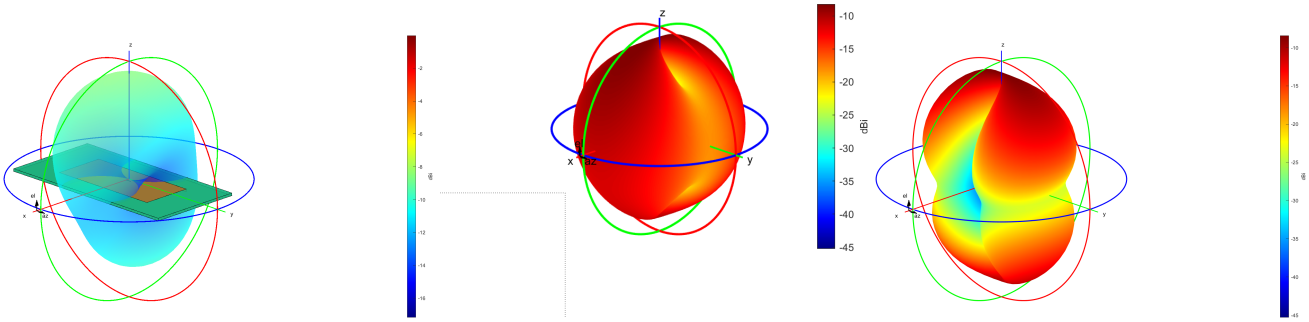
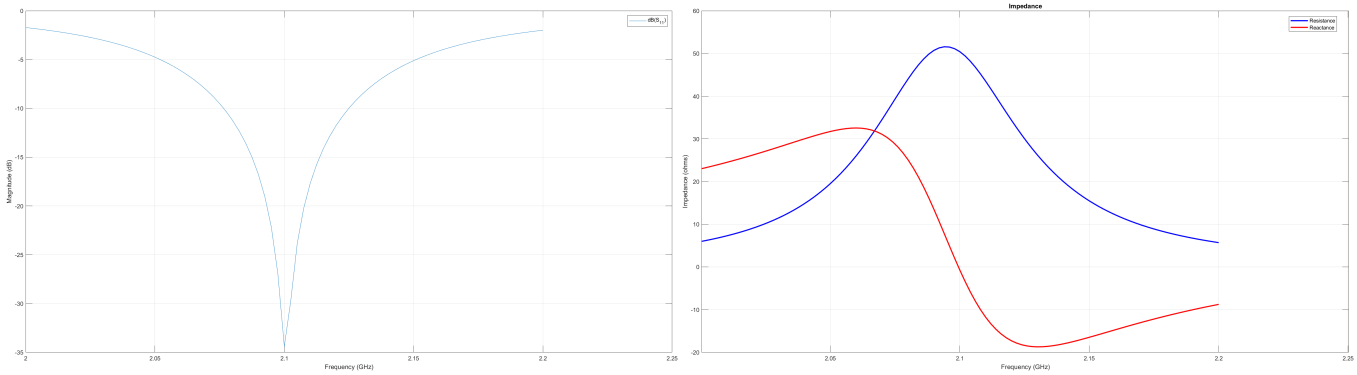


(a) (b) (c)

FIGURE 3: Gain pattern (a), gain pattern with vertical polarization (b) and with the horizontal one (c)



(a) (b)

FIGURE 4: Reflection coefficient (left) and impedances (right) plots depending on $f \in 2.0 \div 2.1\,\text{GHz}$

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