Array of folded patches

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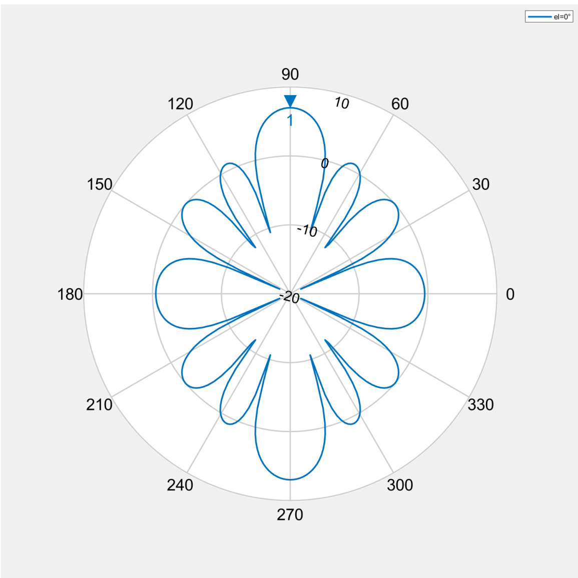
Tchebyshev array factor design

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:

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

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 || Uniform 50.6° || 34.8°



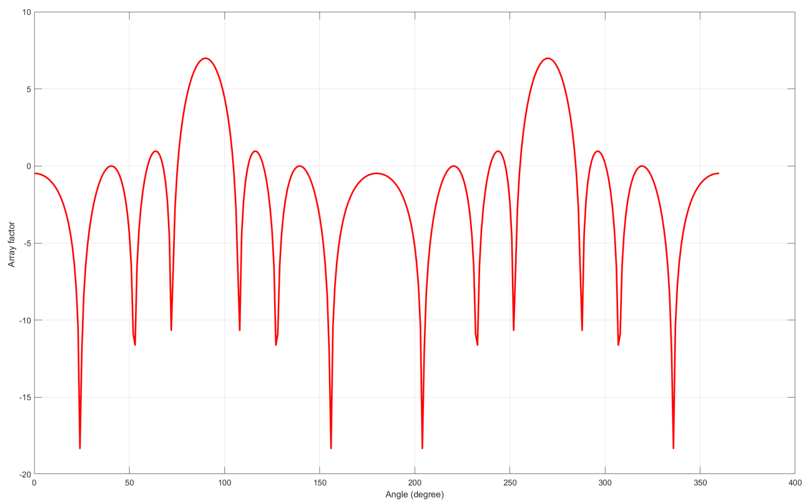


Figure 1: Array factor polar (left) and rectangular (right) diagrams

Rectangular folded patch design

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 $h_{sub} \in \left(\frac{\lambda}{50}, \frac{\lambda}{10}\right)$.

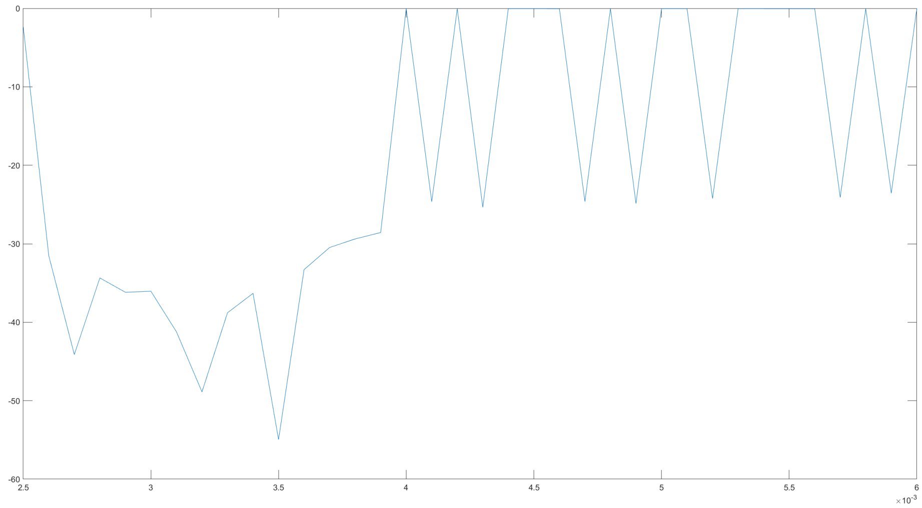


Figure 2: Minimum of the reflection coefficient $\Gamma\,[dB]$ in the frequency range $2.0 \div 2.2\,GHz$ depending on the varying mesh density level

Patch parameters

$$
\begin{aligned}
L + W - w_{SC} &= \frac{\lambda}{4} + h_{sub} \\
W &= \frac{\lambda_0}{2}\sqrt{\frac{2}{\varepsilon_r + 1}}
\end{aligned}
\tag{2}
$$

$$
\begin{aligned}
BW_E &= 2\,\arccos\sqrt{\frac{7.03\,\lambda_0^2}{4\,(3\,L_e^2 + h^2)\,\pi^2}} \\
BW_H &= 2\,\arccos\sqrt{\frac{1}{2 + k_0\,W}}
\end{aligned}
\tag{3}
$$

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

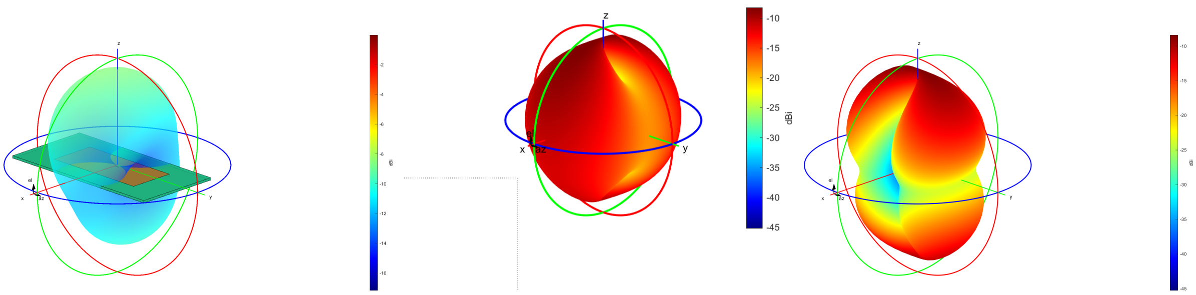


Figure 3: Gain pattern (left), gain pattern with vertical polarization (center) and with the horizontal one (right)

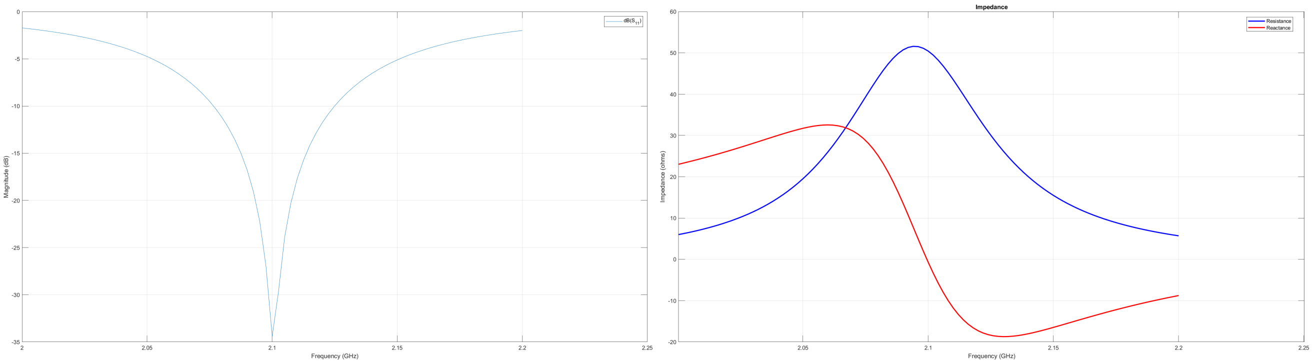


Figure 4: Reflection coefficient (left) and impedances (right) plots depending on $f \in 2.0 \div 2.1\,GHz$

Overall array performance evaluation