

EDISON

Electromagnetic Design of
flexible Sensors



Report 95 CISS for zeros-poles

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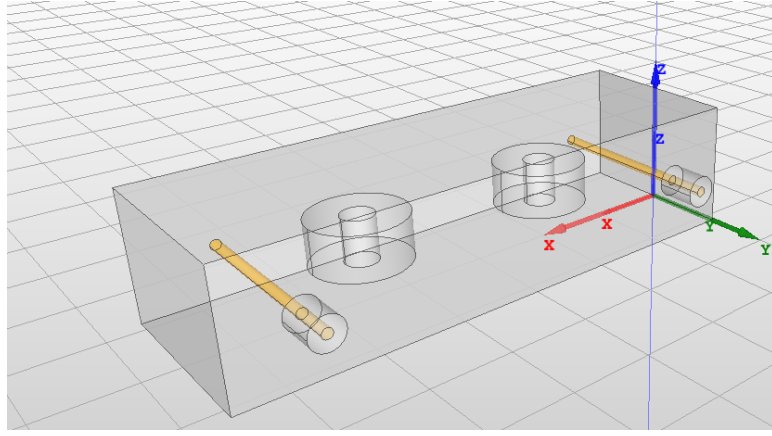


Figure 1: Bandpass filter.

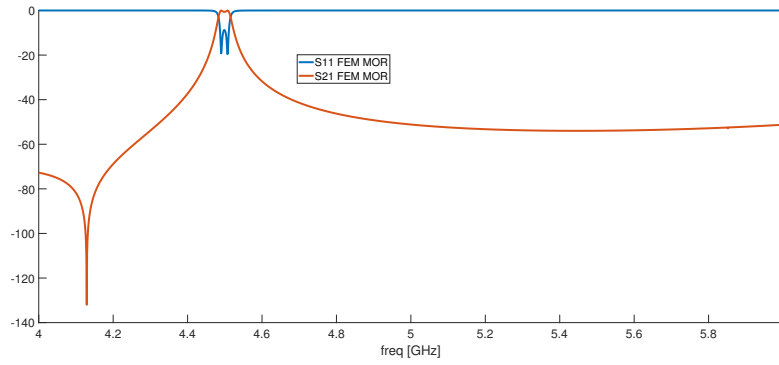


Figure 2: S - characteristics (FOM/ROM).

1 Test Structure

- Bandpass filter.
- Poles and zeros are extracted from the eigenproblem associated with reduced order model.

2 Eigenproblem

Model order reduction system of equations (S-params formulations):

$$\begin{cases} (\mathbf{T}_r - k_0^2 \mathbf{C}_r + ik_0 c \epsilon_0 (\mathbf{B}_r d) \cdot (\mathbf{B}_r d)^T) \cdot \mathbf{x}_r = 2\mathbf{b}_r^j da \\ b = ik_0 c \epsilon_0 (\mathbf{b}_r^i d)^T \mathbf{x}_r - a \end{cases} \quad (1)$$

which can be transformed to the matrix form (assuming $b = 0$):

$$\left(\begin{bmatrix} \mathbf{T}_r & -2\mathbf{b}_r^j d \\ 0 & -\delta_{ij} \end{bmatrix} + k_0 \begin{bmatrix} ic\epsilon_0 (\mathbf{B}_r d) \cdot (\mathbf{B}_r d)^T & 0 \\ ic\epsilon_0 (\mathbf{b}_r^i d)^T & 0 \end{bmatrix} + k_0^2 \begin{bmatrix} -\mathbf{C}_r & 0 \\ 0 & 0 \end{bmatrix} \right) \begin{bmatrix} \mathbf{x}_r \\ a \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

The above eigenproblem is solved using CISS in order to compute **transmission and reflection zeros** of the scattering parameters. **Poles** are computed by solving the eigenproblem:

$$(\mathbf{T}_r - k_0^2 \mathbf{C}_r + ik_0 c \epsilon_0 (\mathbf{B}_r d) \cdot (\mathbf{B}_r d)^T) \cdot \mathbf{x}_r = 0 \quad (2)$$

3 Comparison of results

The zeros and poles from the **eigenproblem** are compared with the zeros and poles from the **Vector Fitting** (extracted from the characteristics - Figure 2). All results in [GHz].

- Transmission zeros

l	Eigenproblems	Vector Fitting
1	4.128901989503020 - 0.000012320514430i	4.128922886537540 - 0.000000000120572i

Residuum: $|r| = 4.7885e - 13$

- Reflection zeros

l	Eigenproblems	Vector Fitting
1	4.490324883881211 - 0.001116341086772i	4.490320770510930 - 0.001120837918840i
2	4.507523085388273 + 0.001126393974389i	4.507516430249770 + 0.001130874995790i

Residuum: $|r_1| = 2.4586e - 14$, $|r_2| = 2.2355e - 14$

- Poles

l	Eigenproblems	Vector Fitting
1	4.487121453306050 + 0.007853779696851i	4.487124070456553 + 0.007833262182615i
2	4.510726133421905 + 0.008492784817531i	4.510723543255895 + 0.008513229872787i

Residuum: $|r_1| = 3.6811e - 14$, $|r_2| = 1.9279e - 14$

4 S-characteristics obtained using zeros-poles compared to the original ones

- S_{11}

	Values [GHz]
p_1	4.487121453308411 + 0.007853779703582i
p_2	4.510726133429106 + 0.008492784824356i
p_3	5.852172283473028 + 0.000000017004915i
p_4	6.121668851249979 - 0.000063949945339i
z_1	4.490324883898119 - 0.001116341137633i
z_2	5.852172283524895 - 0.000000001875862i
z_3	6.121668851255875 - 0.000063949937221i

- S_{21}

	Values [GHz]
p_1	4.487121453308411 + 0.007853779703582i
p_2	4.510726133429106 + 0.008492784824356i
p_3	5.852172283473028 + 0.000000017004915i
p_4	6.121668851249979 - 0.000063949945339i
z_1	4.128922936204057 + 0.000000009396115i
z_2	5.852165148519612 + 0.000000074671923i
z_3	6.121668845665229 - 0.000063960748293i

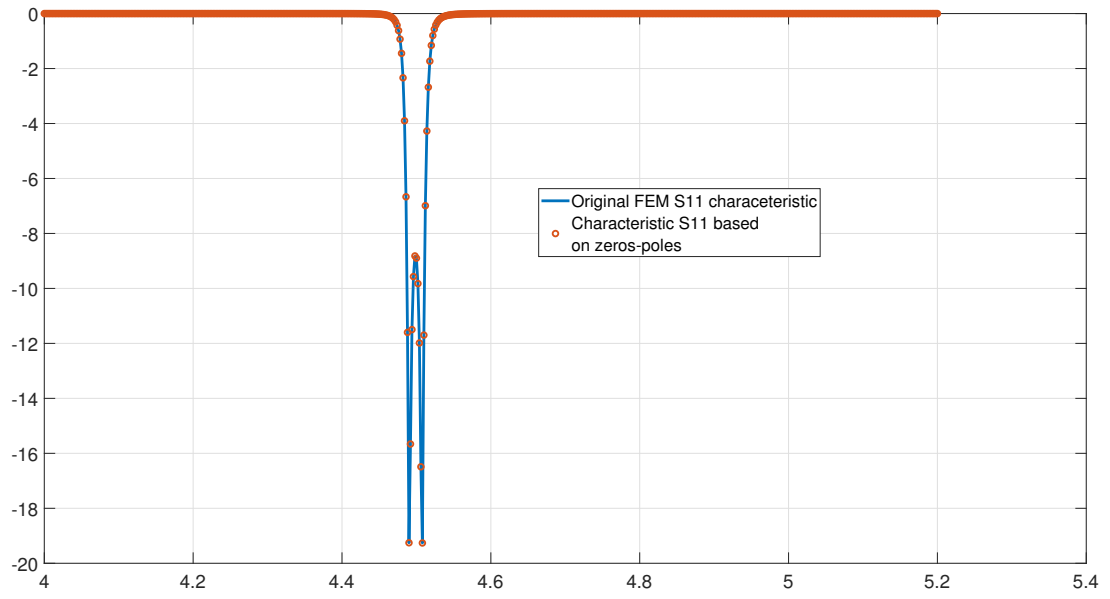


Figure 3: S - characteristics (ROM/zeros-poles).

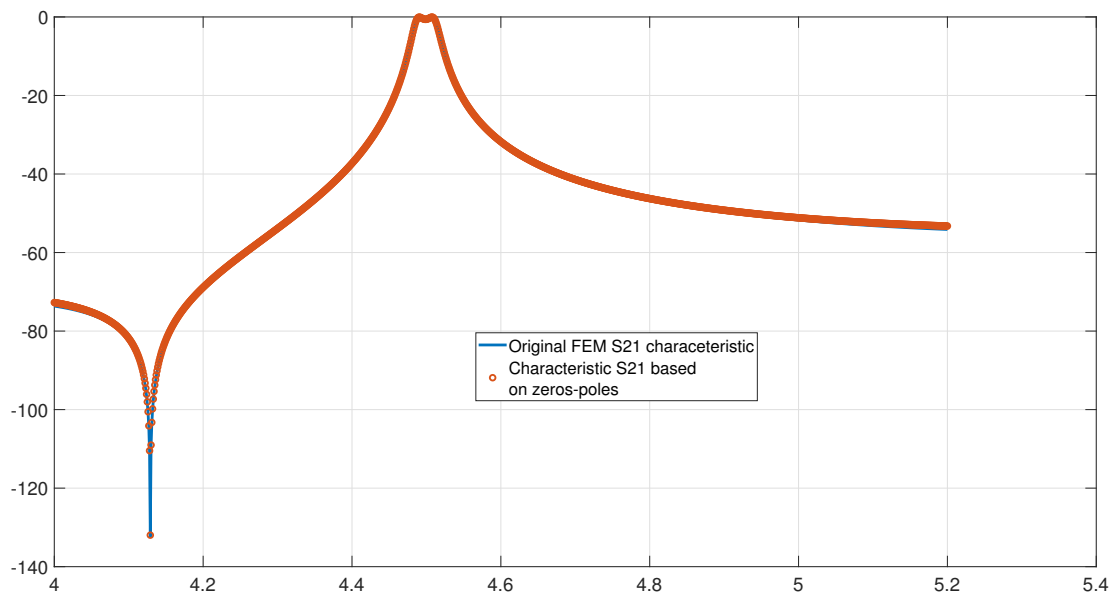


Figure 4: S - characteristics (ROM/zeros-poles).

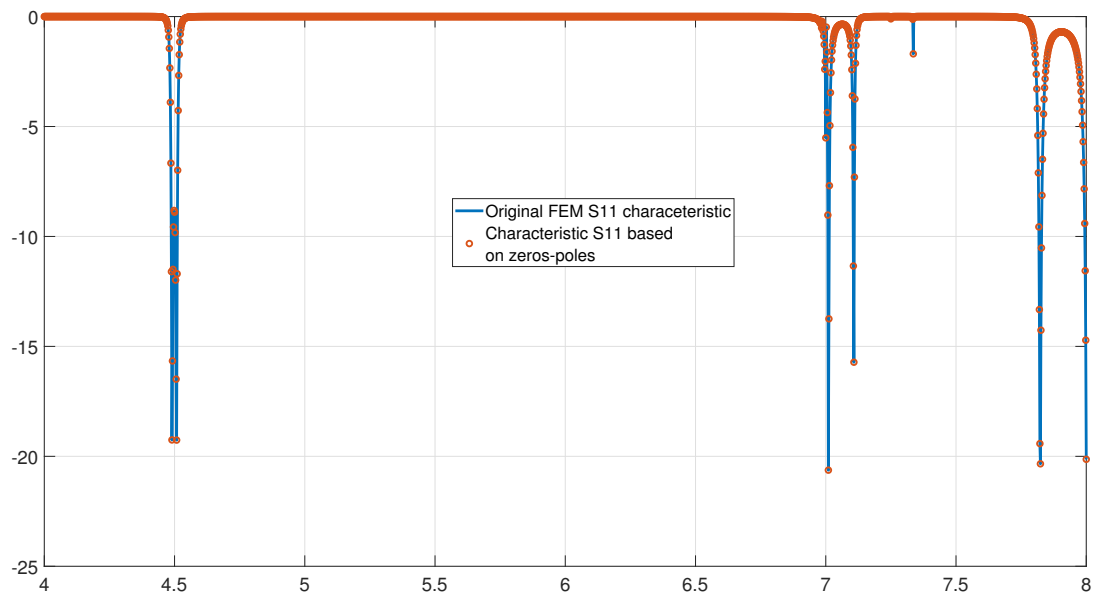


Figure 5: S - characteristics (ROM/zeros-poles).

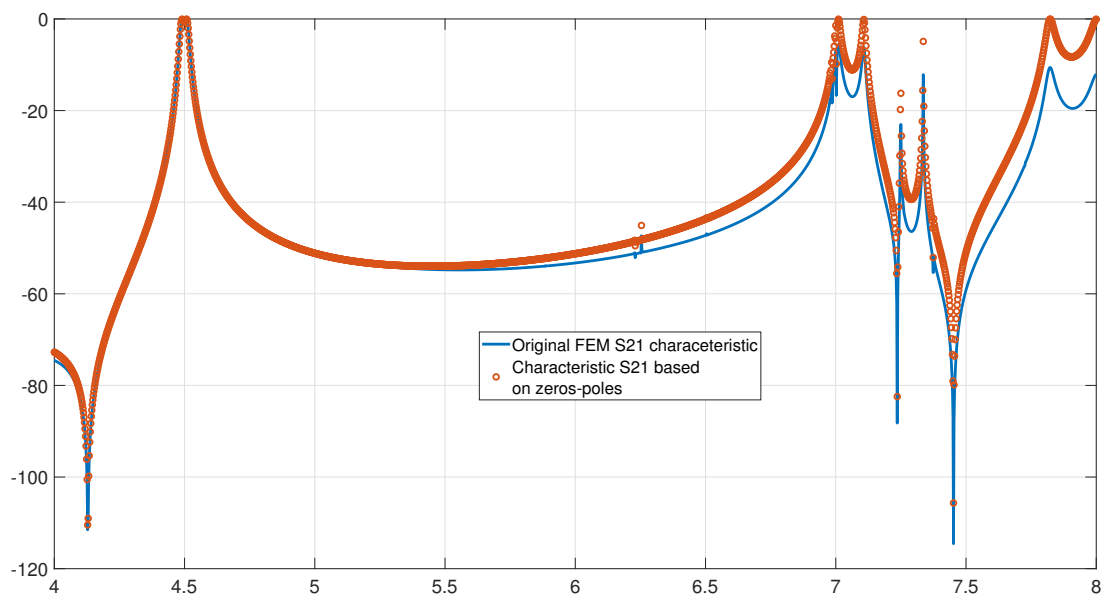


Figure 6: S - characteristics (ROM/zeros-poles).