Transmission optimization of a lossy system.

David Martínez Martínez

March 21, 2016

Projet ANR-13-ASTR-14 COCORAM

1 Computation of the transmission.

With the aim to compute the effective transmission of the antenna when both filter are connected to the access 1 and 2 respectively, we consider a 3-ports model of the antenna where the third port represent the transmitted signal (efficacy of the antenna). Then the system shown in Figure 1 is obtained.

1.1 Transmision of the 3-port chain.

Now we consider the matching problem for the first filter. This filter is connected to a load "L" composed by the antenna and the second filter (Figure 2). The parameters S_{11}^L and S_{31}^L of the load, obtained by chaining the second filter

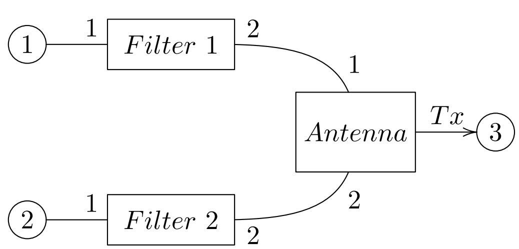

Figure 1: Complete transmission chain.

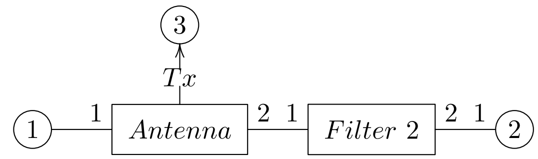

Figure 2: Load seen from the port 2 of the first filter.

to the port 2 of the antenna take the following expression:

$$S_{11}^L = S_{11}^A + \frac{S_{12}^A S_{21}^A S_{22}^{F2}}{1 - S_{22}^{F2} S_{22}^A} \tag{1}$$

$$S_{31}^L = S_{31}^A + \frac{S_{22}^{F2} S_{21}^A S_{32}^A}{1 - S_{22}^{F2} S_{22}^A} \tag{2}$$

where the parameters S_{ij}^A refers to the antenna and the parameters S_{ij}^{Fk} to the k-th filter. The transmission parameter (efficacy) of the whole chain (connecting the filter 1 to the port 1 of the antenna) takes the expression:

$$S_{31} = \frac{S_{21}^{F1} S_{31}^L}{1 - S_{22}^{F1} S_{11}^L} \tag{3}$$

Introducing now the expression of S_{11}^L and S_{31}^L we obtain:

$$S_{31} = \frac{S_{21}^{F1} S_{31}^A (1 - S_{22}^{F2} S_{22}^A) + S_{21}^{F1} S_{21}^A S_{22}^{F2} S_{32}^A}{(1 - F_{22}^{F2} S_{22}^A)(1 - S_{22}^{F1} S_{11}^A) - S_{12}^A S_{21}^A S_{22}^{F1} S_{22}^{F2}} \tag{4}$$

To maximize the transmission to the antenna in the passband I, we are interested in the problem:

$$\underset{S^{F1}}{Max} \underset{\omega \in I}{Min} \; |S_{31}| \tag{5}$$

2 Example for the lower band (L2 & E6).

We apply the previous problem to the first band of the cocoram project with the assumption that both access of the antenna are isolated: $S_{21}^A \to 0$, $S_{12}^A \to 0$, then we obtain the classical formula for the transmission:

$$S_{31} = \frac{S_{21}^{F1} S_{31}^A}{1 - S_{22}^{F1} S_{11}^A} \tag{6}$$

By solving this problem the matching filter in Figure 3 is obtained.

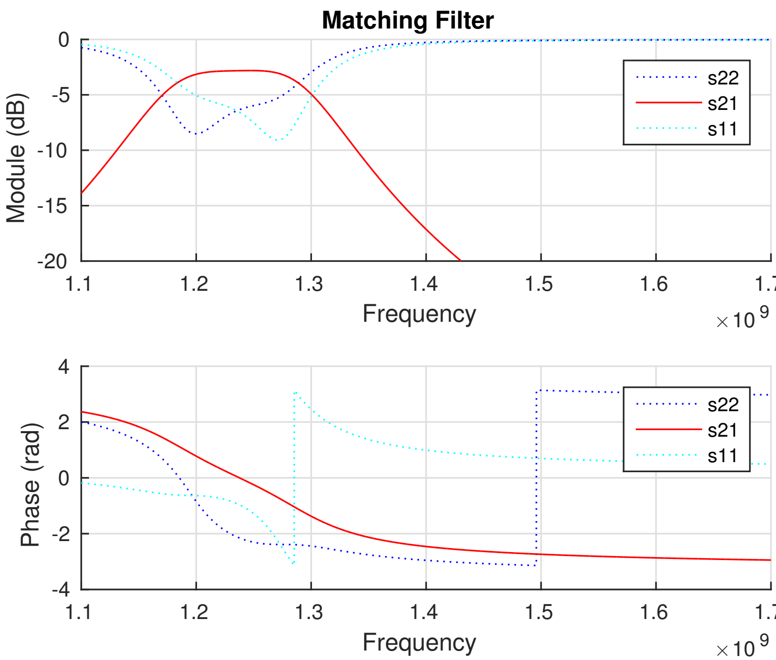

Figure 3: Matching filter for the band 1

This filter provides the best result (Figure 5) when the second port of the antenna is connected to a matched load (50Ω).

Finally, we compute the system response (using equation 4) when both filters are connected to both access of the antenna (Figure 6). It can be seen that this response agrees with the previous result and consequently, the assumption over the coupling coefficient of the antenna is legitimate.

Figure 7 shows a detailed comparison of the transmission to the antenna and the reflection in the cases when the second port of the antenna is matched and when another filter is connected to the second port. There is only a small difference around the frequency of 1.3 GHz (where the parameters S_{21}^{A} is maximum).

3 Required data to simulate the results

3.1 Frequency Specifications.

- f1= 1.2126 Ghz   f2= 1.30375 Ghz   fc= 1.2582 GHz

3.2 Required files.

- Antenna touchstonne
  - Antenne Cocoram Ref Plane 2mm.s2p
- Content of the file "20-Mar-2016_Touchstones_losses.tar.gz"
  - 20-Mar-2016_Filter_lossless_band1_N2.s2p
  - 20-Mar-2016_Matrix_lossless_band1_N2.txt
  - 20-Mar-2016_Phase_port1_band1_N2.s2p
  - 20-Mar-2016_Phase_port2_band1_N2.s2p
  - 20-Mar-2016_Transmission_line_lossless_band1_N2.s2p
  - 20-Mar-2016_Chaine_complete_lossless_band1_N2.s2p

3.3 Interdigital filter

To simulate the response of the real interdigital filter it is necessary to consider the phase due to the input and output coupling. The full-wave response of the filter in microstrip correspond to the structure shown in Figure 4.

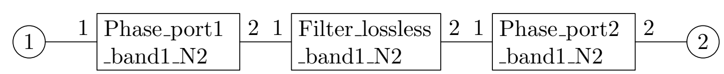

Figure 4: Equivalent model to the interdigital filter.

3.4 Transmission line.

The touchstone of the transmission line correspond to an ideal line of lenght $L = 64.7473mm$ with the following scattering matrix:

$$S = \begin{pmatrix} 0 & e^{-jL\beta(f)} \\ e^{-jL\beta(f)} & 0 \end{pmatrix} \quad (7)$$

where $\beta(f) = 44.3582 \cdot \frac{f}{fc}$.

3.5 System structure.

See Figure 8.

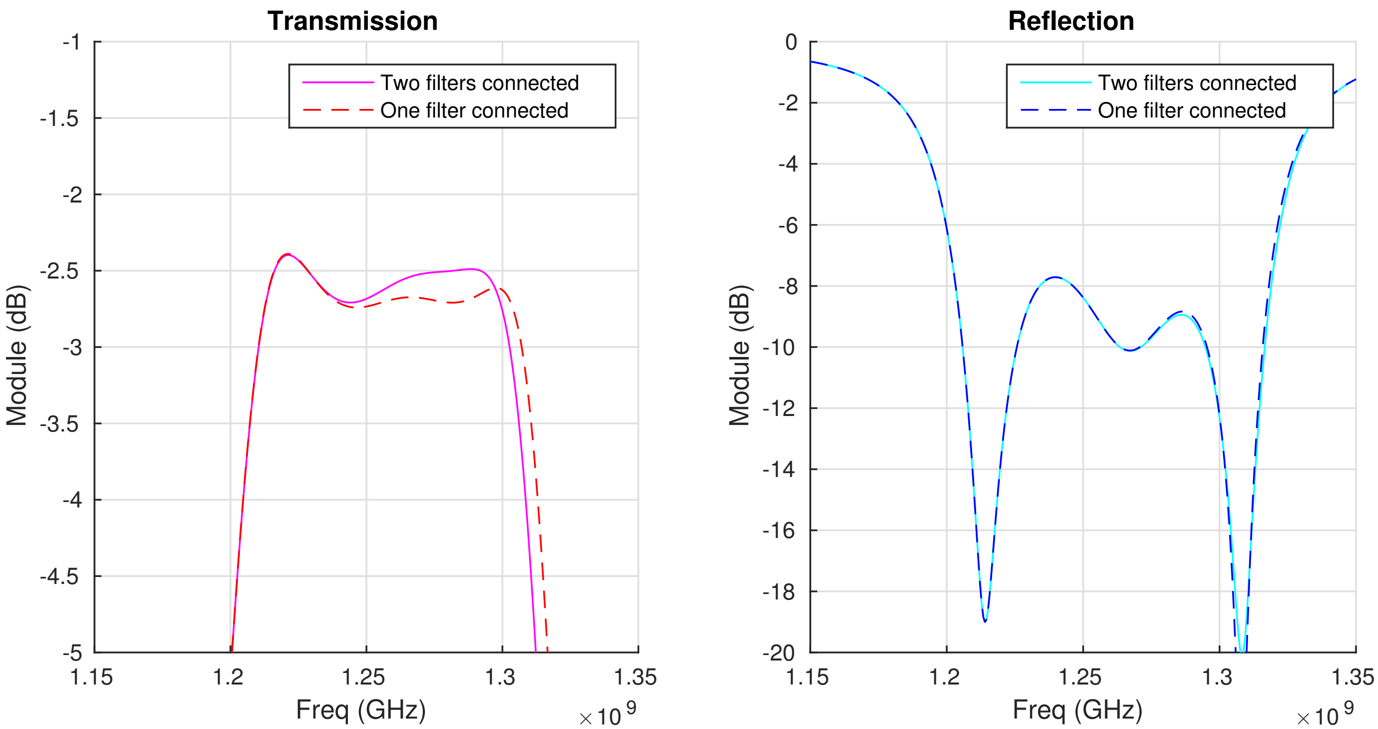

Figure 7: Detailed comparison.

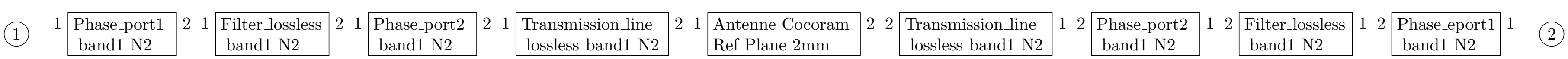

Figure 8: System structure

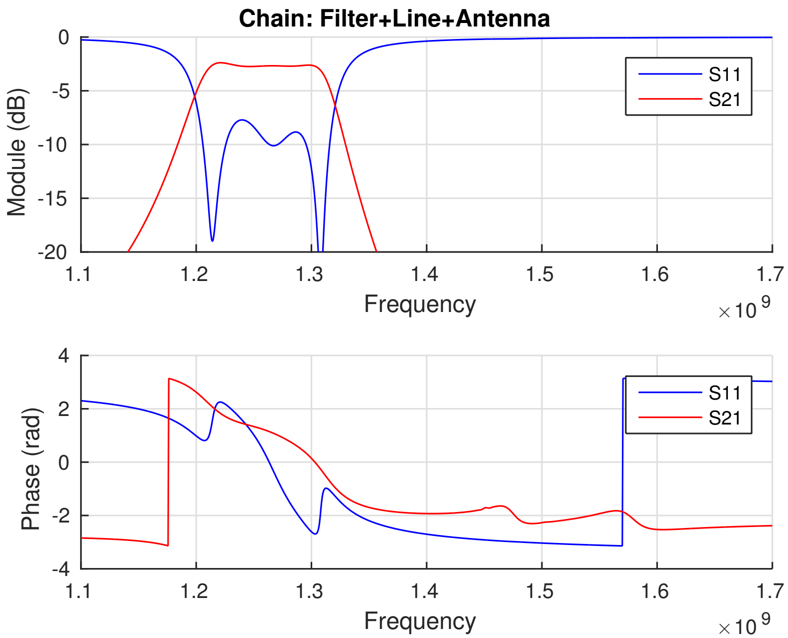

Figure 5: Response of the full chain if the coupling coefficient is neglected $S_{21}^A = S_{12}^A = 0$.

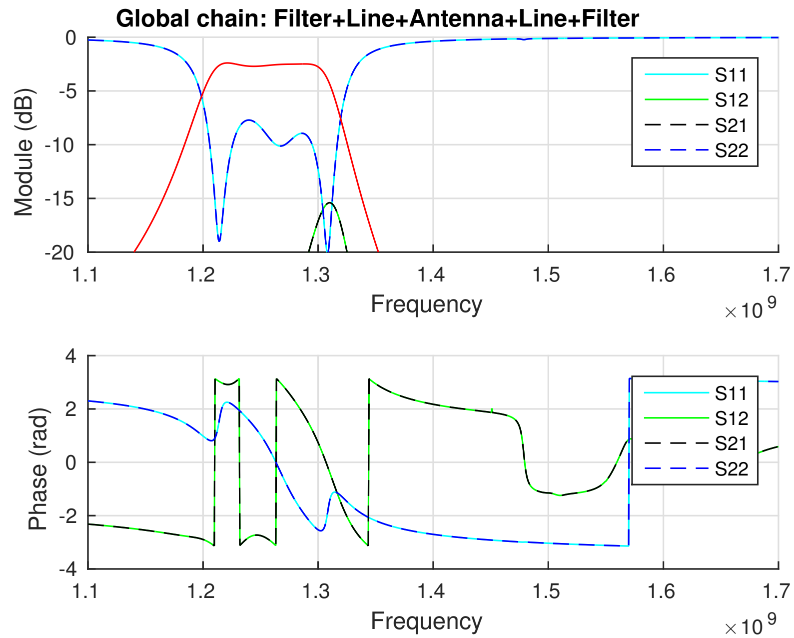

Figure 6: Response of the filter when both filters are connected.