Matching filters of degree 1.

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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 4-ports model of the antenna where the third and forth port represent the transmitted signal for each polarization (efficacy of the antenna). Then the system shown in Figure 1 is obtained where each filter $F1$ and $F2$ correspond to a dual-band filter composed of an input diplexer, two single-band filter and an output diplexer as shown in Figure 2.

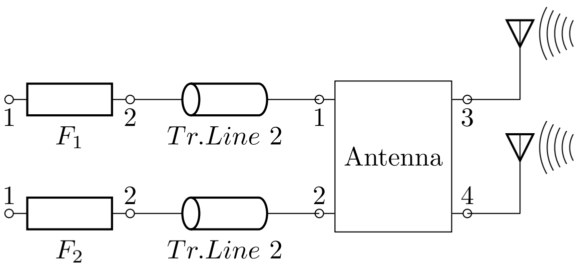

Figure 1: Complete transmission chain.

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 3). The parameters S_{11}^L and S_{31}^L of the load, obtained by chaining the second filter to the port 2 of the antenna take the following expression:

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

$$S_{31}^L = S_{31}^A \tag{2}$$

where the parameters S_{ij}^A refers to the antenna and the parameters S_{ij}^{Fk} to the k-th filter including the transmission line at the port 2. 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:

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

1.2 Practical implementation

The objective for the application that we are interested in is to maximize the transmission to the antenna (S_{31}) with a given requirement on the rejection in the stopband. With the condition over the rejection, the problem remains:

$$\underset{S^{F1}, S^{F2}}{Max} \left(\underset{f \in I}{Min} \, |S_{31}| - \gamma \sum_i |S_{31}(f_{si})| \right) \tag{5}$$

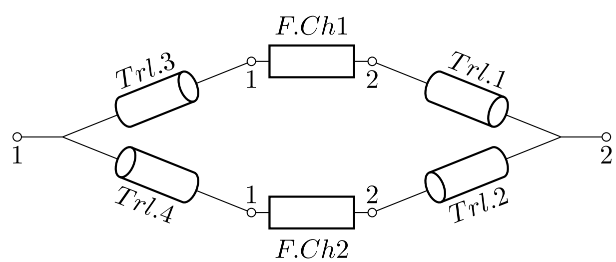

Figure 2: Dual-band filter structure.

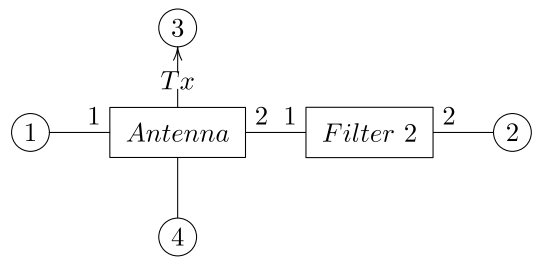

Figure 3: Load seen from the port 2 of the first filter.

where f_s are the edges of the stopband and γ is a positive weight (for the one-pole filters we consider $\gamma = 0$).

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

By solving this problem the matching filter in Figure 5 is obtained.

2.1 Transmission line.

The touchstone of the transmission line correspond to an ideal line of length $L = 7.8mm$ with $\beta(f) = 44.3582 \cdot \frac{f}{fc}$ and the following scattering matrix:

$$S = \begin{pmatrix} 0 & e^{-jL\beta(f)} \\ e^{-jL\beta(f)} & 0 \end{pmatrix} \tag{6}$$

2.2 Required data

2.2.1 Frequency Specifications.

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

2.2.2 Required files.

- Files in the folder "10-Jun-2016_Touchstones_losses.tar.gz"
  - 10-Jun-2016_Filter_b1.s2p
  - 10-Jun-2016_Matrix_band1.txt
  - 10-Jun-2016_Phase_port1_band1.s2p
  - 10-Jun-2016_Phase_port2_band1.s2p
  - 10-Jun-2016_Line_b1.s2p

3 Results for the upper band (L1).

Similarly to the previous results, Figure 6 shows the matching filter optimized for the second band.

3.1 Transmission line.

The touchstone of the transmission line correspond to an ideal line of length $L = 50.1mm$ with $\beta(f) = 54 \cdot \frac{f}{fc}$ and the scattering matrix from (6).

3.2 Required data

3.2.1 Frequency Specifications.

- f1= 1.5504 Ghz f2= 1.6004 Ghz fc= 1.5754 GHz

3.2.2 Required files.

- Files in the folder "10-Jun-2016_Touchstones_losses.tar.gz"
  - 10-Jun-2016_Filter_b2.s2p
  - 10-Jun-2016_Matrix_band2.txt
  - 10-Jun-2016_Phase_port1_band2.s2p
  - 10-Jun-2016_Phase_port2_band2.s2p
  - 10-Jun-2016_Line_b2.s2p

4 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.

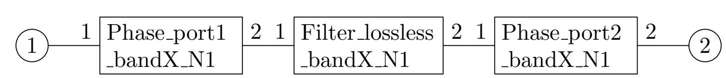

Figure 4: Equivalent model to the inter-digital filter.

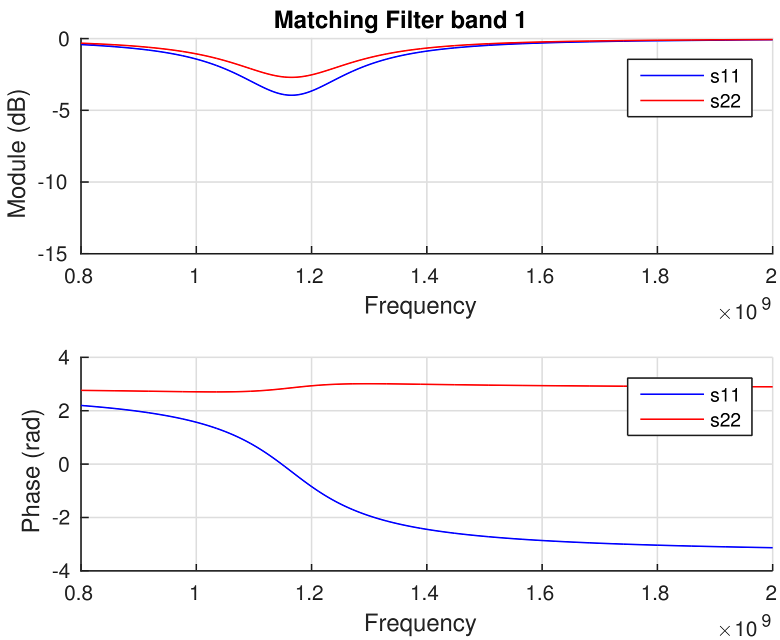

Figure 5: Matching filter for the band 1

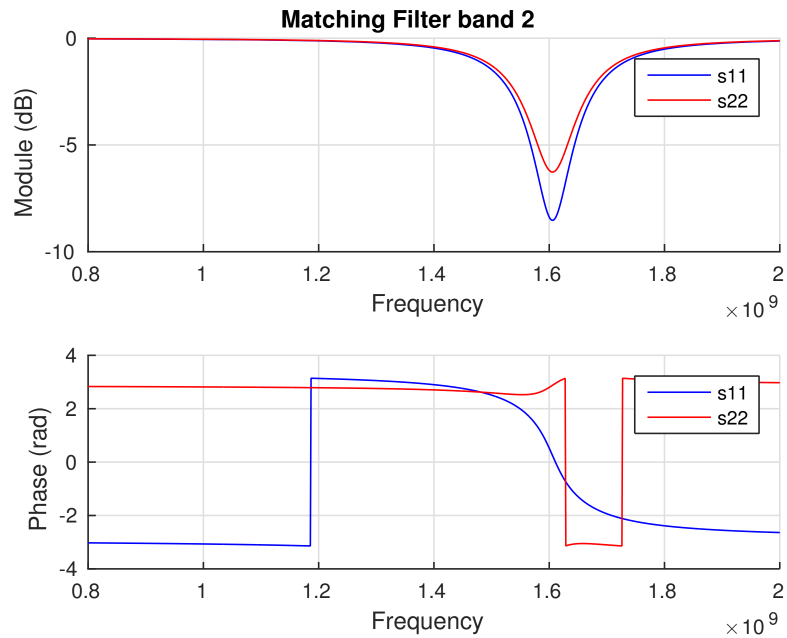

Figure 6: Matching filter for the band 2