ANR COCORAM
Matching Filter

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System structure

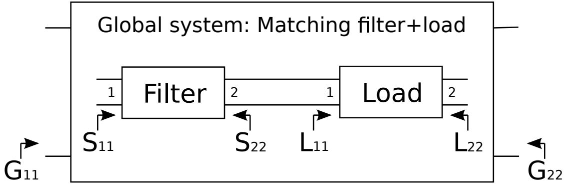

Figure 1: Filter chain.

$$G_{22} = \frac{n}{e} \qquad G_{21} = \frac{m}{e} \qquad ee^* = nn^* + mm^*$$

$$S_{22} = \frac{p}{q} \qquad S_{21} = \frac{r}{q} \qquad qq^* = pp^* + rr^*$$

$$L_{22} = \frac{\varphi}{\psi} \qquad L_{21} = \frac{\rho}{\psi} \qquad \psi\psi^* = \varphi\varphi^* + \rho\rho^*$$

Initial filter

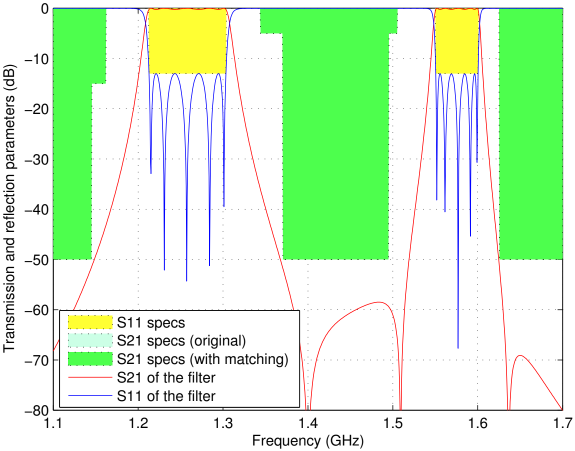

Figure 2: Tenth-order filter with three transmission zeros.

Initial filter

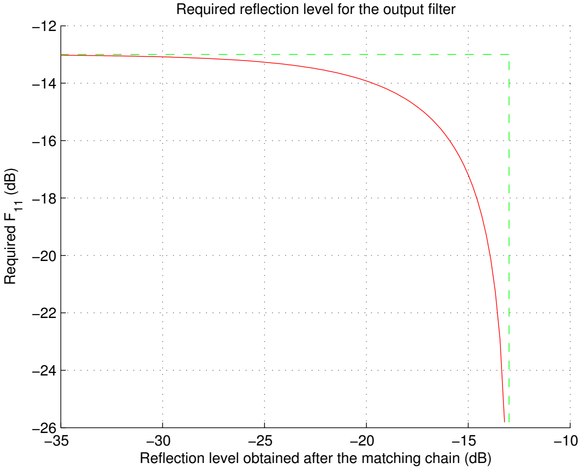

Figure 3: Required reflection level for the output filter.

Matching filter

Problem (Minimize the pseudohyperbolic distance)

$$\underset{p,q}{minmax} \left(\frac{p(\omega) - q(\omega) L_{11}^*(\omega)}{q(\omega) - p(\omega) L_{11}^*(\omega)} \right) \quad \forall \omega \in B$$

$$qq^* = pp^* + rr^*$$

Problem (Synthesis of the global filter G)

$$\underset{n,e}{minmax} \left(\frac{n}{e}(\omega) \right) \qquad \forall \omega \in B$$

$$ee^* = nn^* + mm^*$$

$$\frac{\partial}{\partial \omega} \left(\frac{n}{e} \right) \Big|_{\omega=\omega_i} = \frac{\partial}{\partial \omega} \left(L_{22} \right) \Big|_{\omega=\omega_i} \quad \forall \omega_i : m(\omega_i) = 0$$

Reflection level by solving problem 2

Solve problem 2 with real matching points.

Considerations

- $G = \frac{n}{e}$ is symmetric.
- All transmission zeros are at infinity.
- L_{11} is of order 1.
- $L'_{11} = h$ is fixed.

Best result.

$$RL(dB) = -10 \cdot log \left[1 + \frac{1}{4} \left(Z^N - Z^{-N} \right)^2 \right] \quad (1)$$

$$Z = h \cdot sin \left(\frac{\pi}{2N} \right) + \sqrt{h^2 \cdot sin^2 \left(\frac{\pi}{2N} \right) + 1} \quad (2)$$

Reflection level by solving problem 2

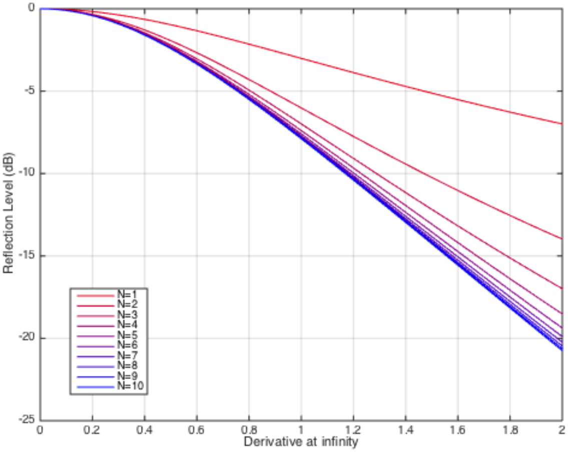

Figure 4: Evolution of the best reflection level with the derivative (h).

Reflection level by solving problem 2

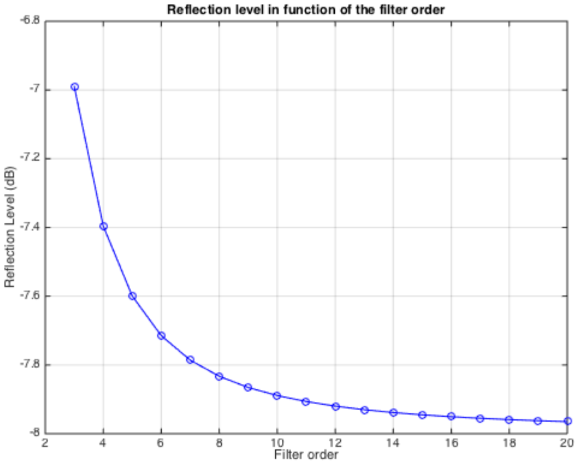

Figure 5: Evolution of the reflection level with the degree of n (h=1).

Reflection level by solving problem 2

Solve problem 2 with complex matching points.

Considerations

- $G = \frac{n}{e}$ is symmetric.
- n is a complex polynomial.
- All transmission zeros are at infinity.
- L_{11} is of order 1.
- $L'_{11} = h$ is fixed.

Desired result.

- Both n and e equioscilate in the passband.
- The roots of n and e must go away from the passband until the condition on the derivative is met.

Equioscilating polynomials:

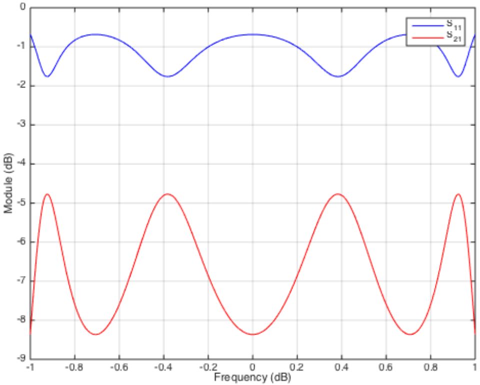

Figure 6: Equioscilating filter response.

Global filter

$G_{22} = \frac{n}{e} \quad G_{21} = \frac{m}{e}$

Constraints

$$nn^* = T_N T_N^* + \alpha^2$$
$$ee^* = T_N T_N^* + \beta^2$$

Oscilating levels

$\gamma_1, \quad \gamma_2$

Reflection level by solving problem 2

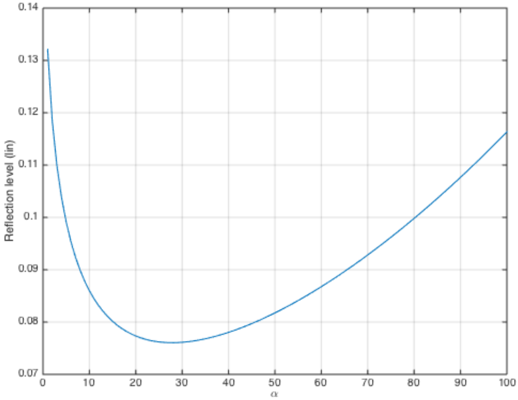

Figure 7: Minimum of the reflection level in terms of α.

Reflection level by solving problem 2

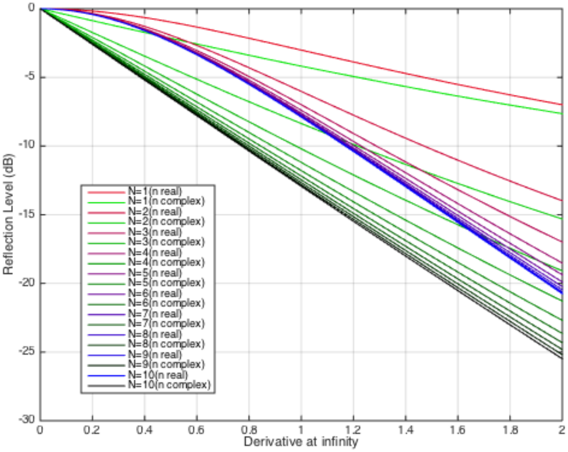

Figure 8: Evolution of the best reflection level with the derivative (h).

Antenna design

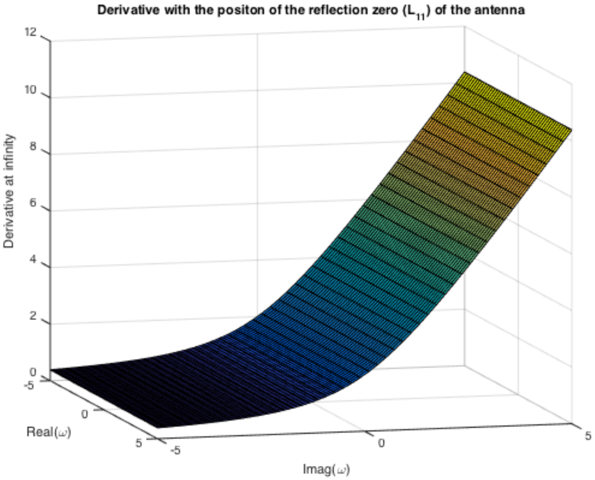

Figure 9: $\frac{\partial}{\partial \omega} L_{22}\Big|_{\omega=\infty}$ for each position of the reflection zero of L_{11} .

Antenna design

Results by moving the reflection zero of the antenna "$L_{11}(\omega_L) = 0$"

- The best antenna is not the one perfectly matched at real frequencies.
- The real part of ω_L is not relevant.
- ω_L must be in the semiplane where the poles lies.
- The bigger the imaginary part of ω_L, the better.

Consideration for the implementation.

- The antenna should not be tuned.
- The phase should show an increasing step in the passband.

- Red:
  $Im(\omega_L) < 0$
  $h = 0.9$
- Blue:
  $Im(\omega_L) > 0$
  $h = 1.1$

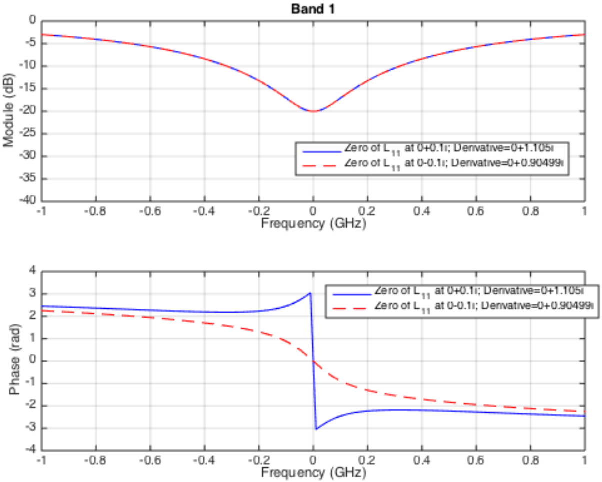

Figure 10: L_{11} by moving ω_L to the complex plane.

Real antenna (First band)

First order antenna in the first band: $h_1 = 0.86$.

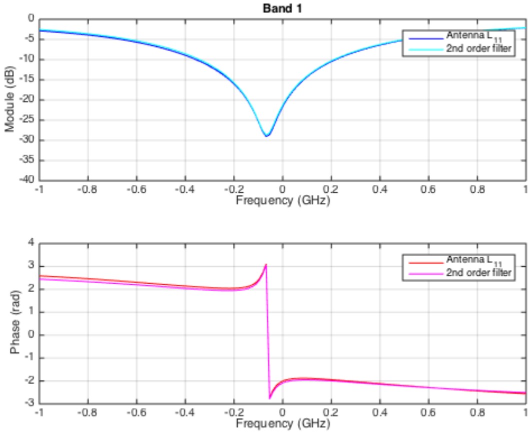

Figure 11: Fitting of the antenna in the first band.

Real antenna (First band)

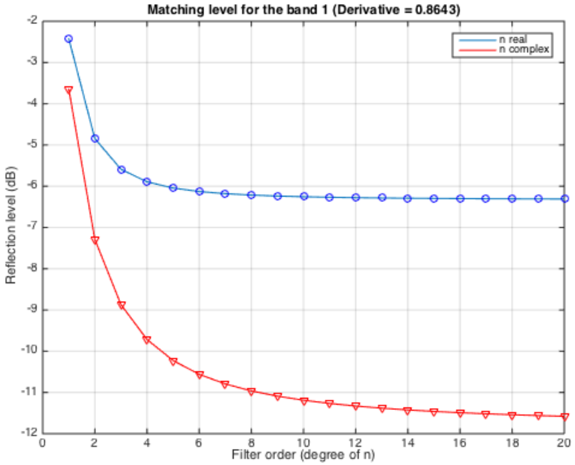

Figure 12: Reflection levels with n real and complex in the first band.

Real antenna (First band)

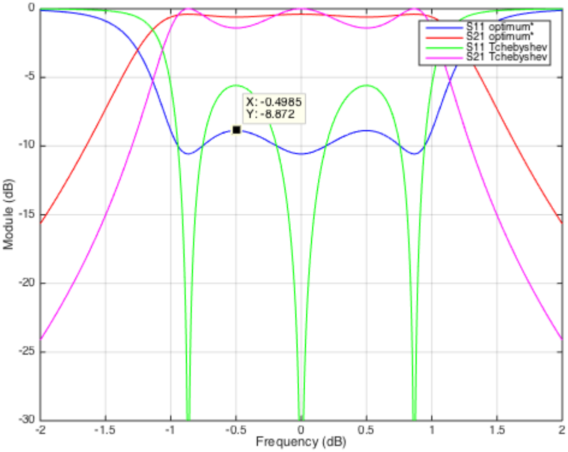

Figure 13: Theoretical filters with $n = 3$ for the first band.

Real antenna (Second band)

First order antenna in the second band: $h_2 = 1$.

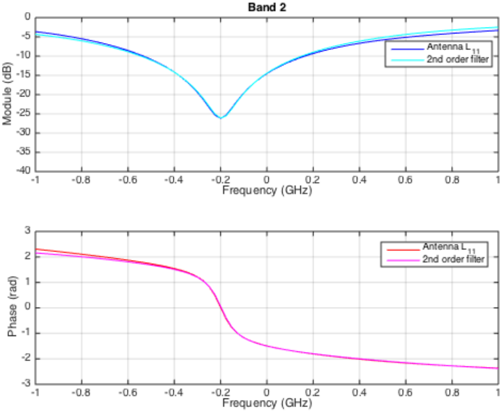

Figure 14: Fitting of the antenna in the second band.

Real antenna (Second band)

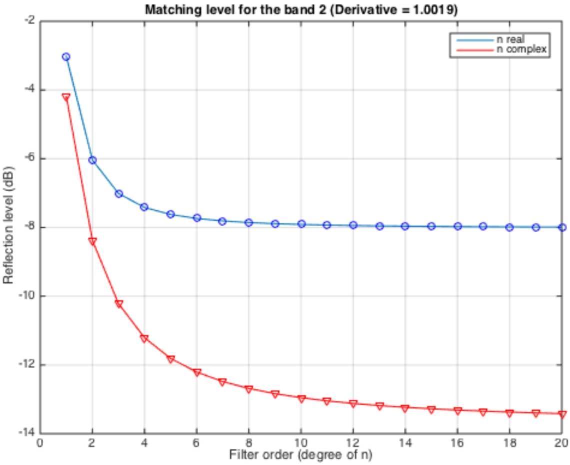

Figure 15: Reflection levels with n real and complex in the second band.

Real antenna (Second band)

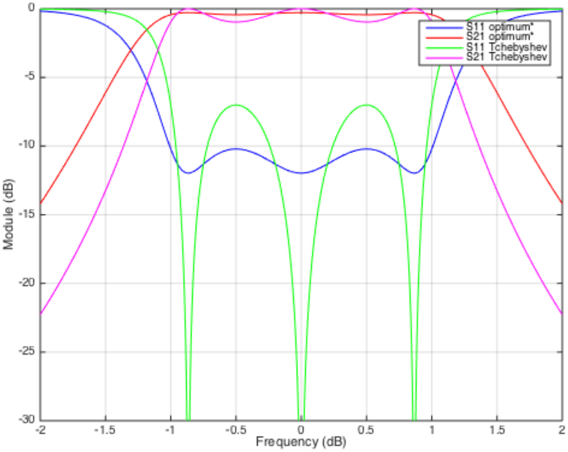

Figure 16: Theoretical filters with n=3 for the second band.

Extracted matching filter

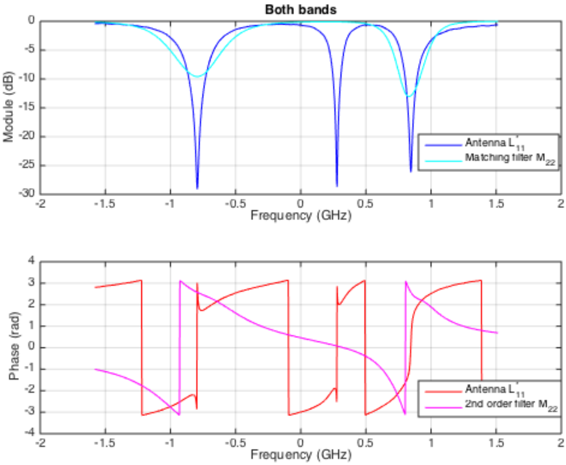

Figure 17: Initial matching filter extracted from the single band case..

Reflection level by solving the problem 1

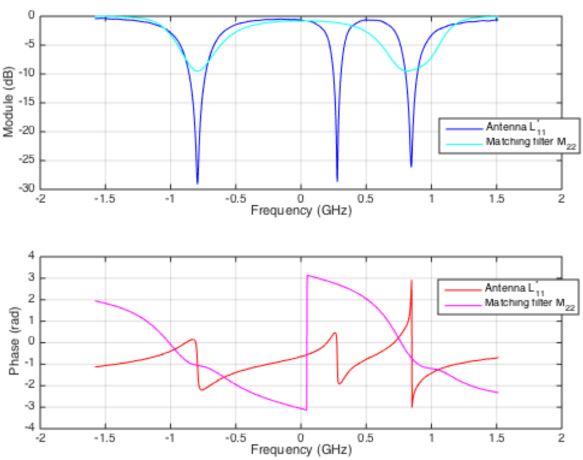

Figure 18: Result obtained by optimizing the pseudohyperbolic distance..

Reflection level by solving the problem 1

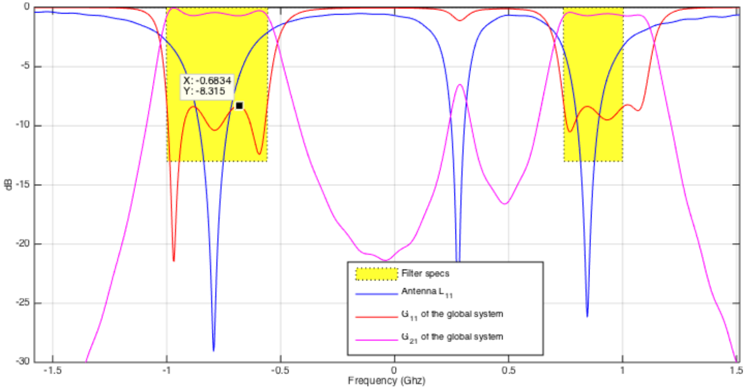

Figure 19: Global filter G of 4th order after optimizing in both bands.

Reflection level by solving the problem 1

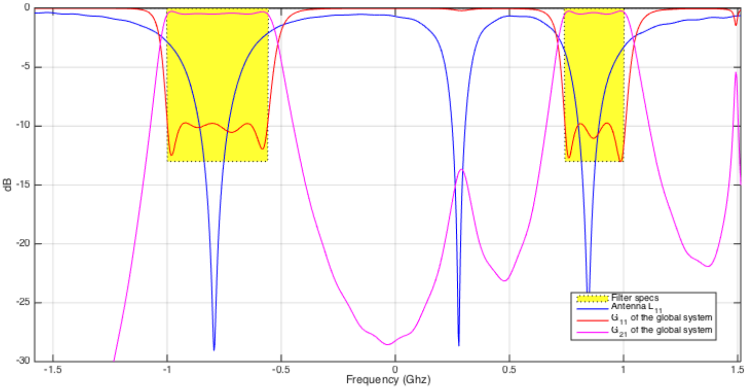

Figure 20: Global filter G of 6th order.

Reflection level by solving the problem 1

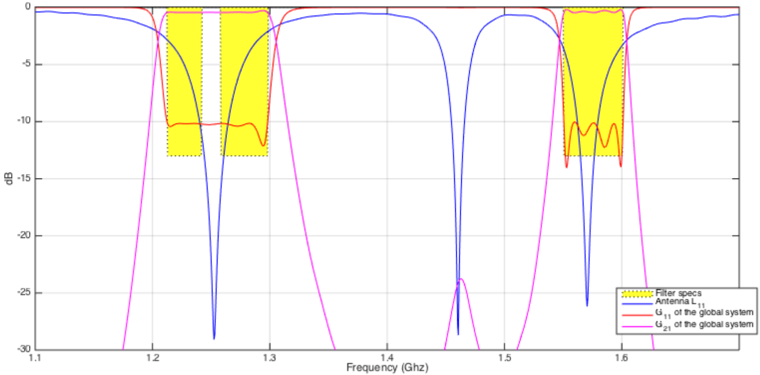

Figure 21: Global filter G of 7th order.

Output filter

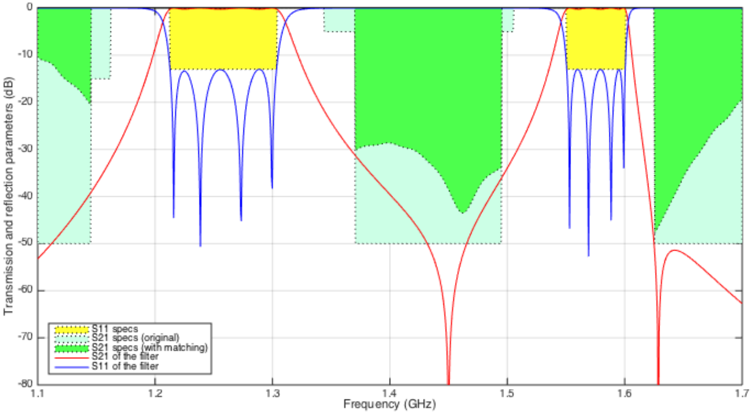

Figure 22: Output filter F (8-2) with a 4th order matching filter.

Output filter

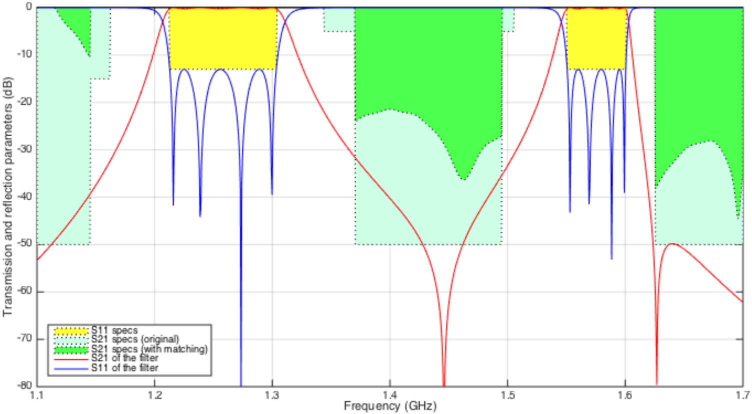

Figure 23: Output filter F (8-2) with a 6th order matching filter.

Output filter

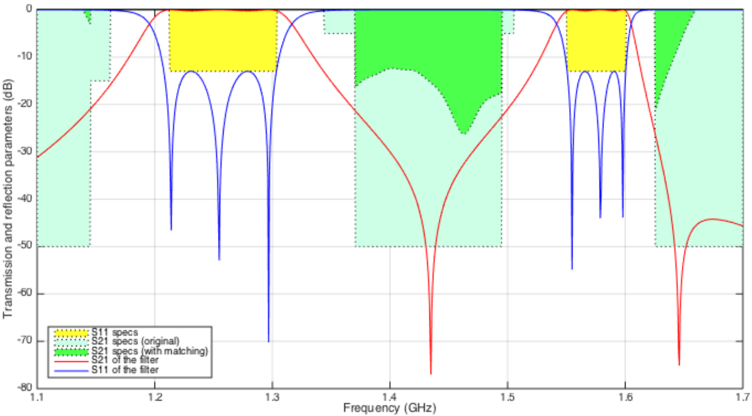

Figure 24: Output filter F (6-2) with a 7th order matching filter.