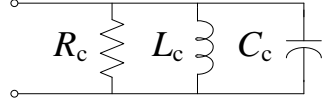


# Space Mapping Problem: RLC Parallel Lumped Resonator

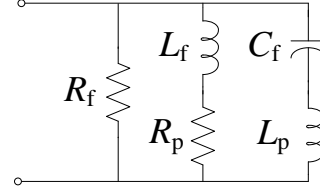
J. E. Rayas-Sánchez  
March 19, 2014

## Coarse Model



$$\mathbf{x}_c = [R_c (\Omega) \quad L_c (\text{nH}) \quad C_c (\text{pF})]^T$$

## Fine Model



$$\mathbf{x}_f = [R_f (\Omega) \quad L_f (\text{nH}) \quad C_f (\text{pF})]^T$$

Models are defined as in [1].

Specifications ( $Z_0 = 50 \Omega$ )

$$\begin{aligned} |S_{11}| &> 0.8 \text{ from } 1 \text{ GHz to } 2.5 \text{ GHz and from } 3.5 \text{ GHz to } 5 \text{ GHz} \\ |S_{11}| &< 0.2 \text{ from } 2.95 \text{ GHz to } 3.05 \text{ GHz} \end{aligned}$$

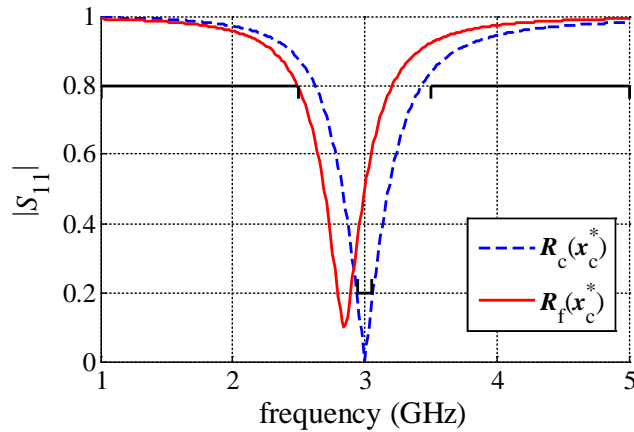
Design variables:  $\mathbf{x} = [R (\Omega) \quad L (\text{nH}) \quad C (\text{pF})]^T$

$$\mathbf{x}_c^* = [50 \quad 0.2683 \quad 10.4938]^T$$

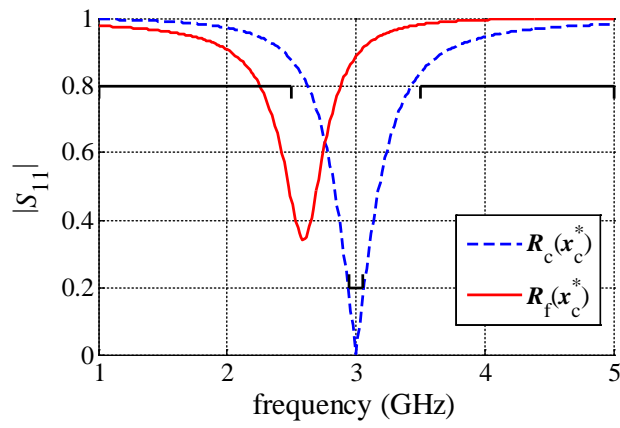
$\mathbf{x}_f^* = [114.3991 \quad 0.3533 \quad 5.7966]^T$  (for Case 3: high difficulty,  $R_p = 0.5 \Omega$ ,  $L_p = 0.13 \text{ nH}$ ), with  $U(\mathbf{x}_f^*) = -0.032751$  using  $p_1 = 40$ ,  $p_2 = 20$ , and  $p_3 = 40$  frequency points uniformly distributed for each specified frequency range (1-2.5 GHz, 2.95-3.05 GHz and 3.5-5 GHz).

Using  $p = 301$  frequency points uniformly distributed from 1 GHz to 5 GHz for plotting.

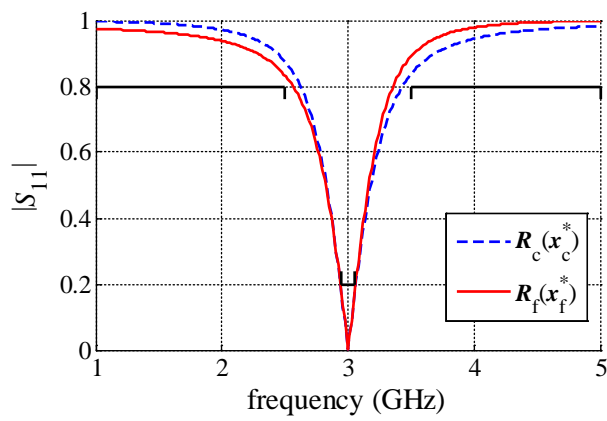
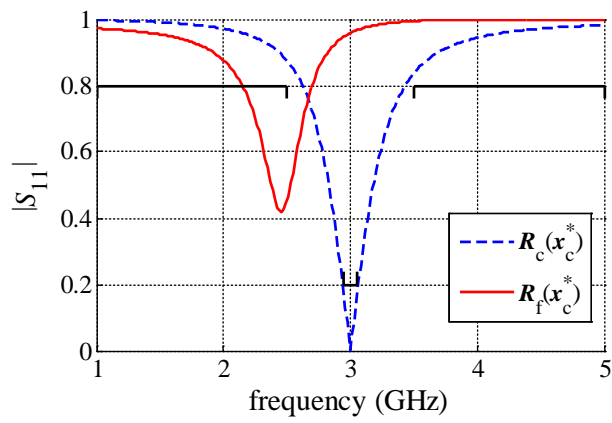
Case 1: Low difficulty,  $R_p = 0.1 \Omega$ ,  $L_p = 0.03 \text{ nH}$



Case 2: Medium difficulty,  $R_p = 0.4 \, \Omega$ ,  $L_p = 0.09 \, \text{nH}$



Case 3: High difficulty,  $R_p = 0.5 \, \Omega$ ,  $L_p = 0.13 \, \text{nH}$



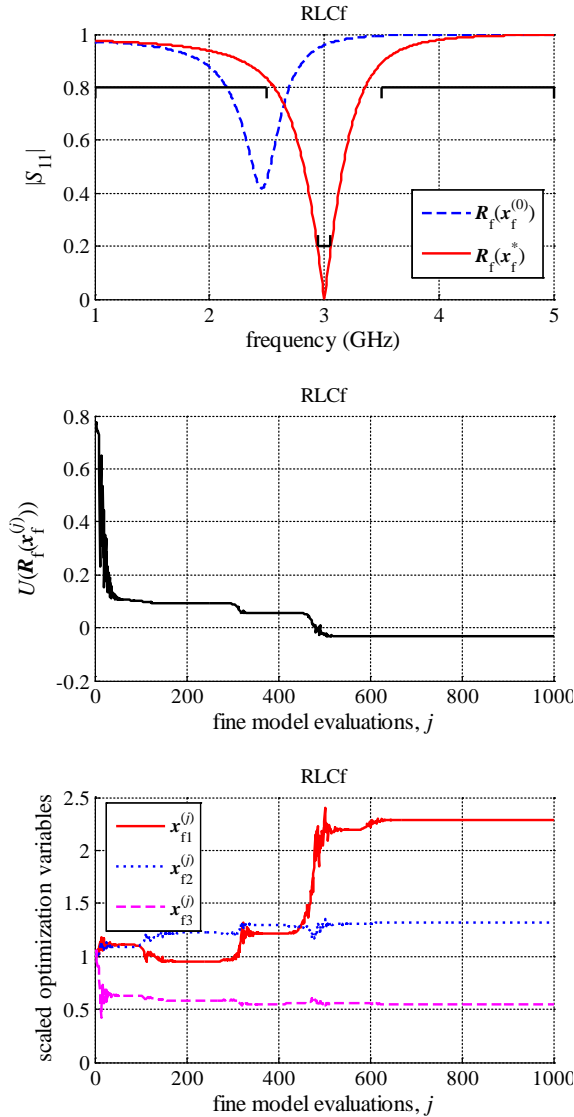
## Direct Optimization of the Fine Model (for comparison with SM methods)

Case 3: High difficulty,  $R_p = 0.5 \Omega$ ,  $L_p = 0.13 \text{ nH}$

Using  $\mathbf{x}_f^{(0)} = \mathbf{x}_c^* = [50 \ 0.2683 \ 10.4938]^T$ , with  $p = 501$  for plotting and calculating objective function with  $p_1 = 40$ ,  $p_2 = 20$  and  $p_3 = 40$  per specified frequency range.

### Nelder-Mead method

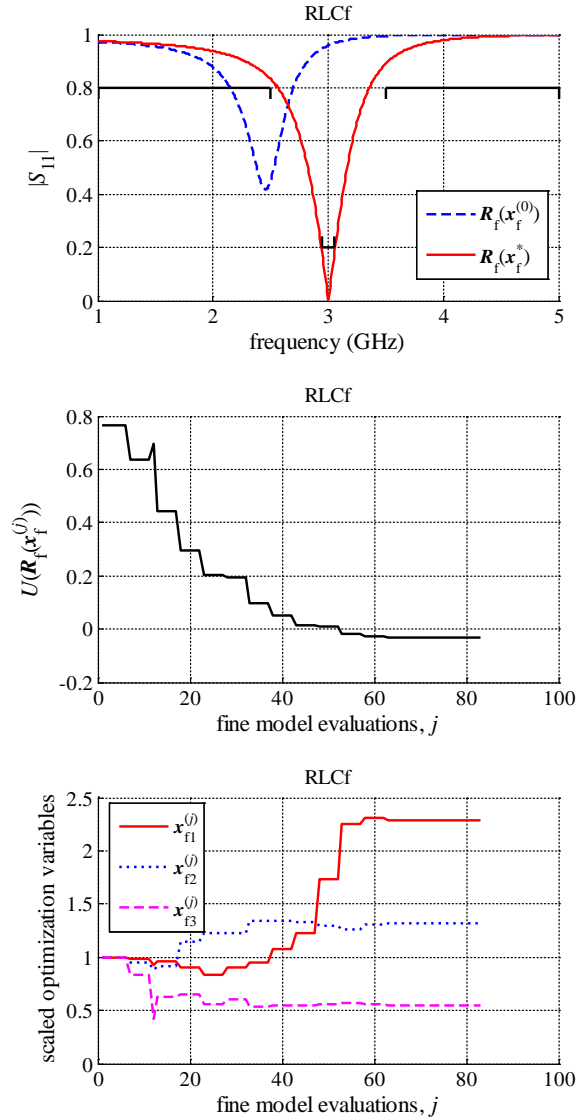
TolFun = 1e-8, TolX = 1e-8



Total number of model evaluations: 1000  
 $\mathbf{Xopt} = [114.4016 \ 0.3533 \ 5.7966]$   
 Objective function value at  $\mathbf{Xopt} = -0.032751$

### SQP method

TolFun = 1e-8, TolX = 1e-8, DiffMinChange = 10TolX, TolCon = 1e-05; and  $\mathbf{x}^{lb} = 0.3\mathbf{x}^{(0)}$ ,  $\mathbf{x}^{ub} = 3\mathbf{x}^{(0)}$



Total number of model evaluations: 83  
 $\mathbf{Xopt} = [114.3991 \ 0.3533 \ 5.7966]$   
 Objective function value at  $\mathbf{Xopt} = -0.032751$

- [1] J. E. Rayas-Sánchez, F. Lara-Rojo and E. Martínez-Guerrero, "A linear inverse space mapping (LISM) algorithm to design linear and nonlinear RF and microwave circuits," *IEEE Trans. Microwave Theory Tech.*, vol. 53, pp. 960-968, Mar. 2005..