# Parametric Macromodeling of the Coupling Between Two Nearby Parabolic Antennas Using the Cauchy Method


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***Abstract*— In an effort of determining the cross coupling between two nearby parabolic antennas, a parametric modeling of the front door coupling, using Poles and Residues, extracted through the Cauchy method is presented. Different parameters of the system were taken in consideration, among them: distance between antennas (15 m, 45 m, 100 m) antenna diameter (0.6 m, 0.9 m, 1.2 m), among others. A rational model is obtained for each parameter configuration. The resonances extracted of the complex S-parameters data was validated comparing the original signal and its reconstruction (a similarity of 98% in average). These validated resonances describe the behavior of the communication link between antennas, and its movement, when the configuration is changed, expose the interference parameters desired.**



***Keywords—Cauchy Method, front door coupling, parabolic antenna.***


## I. Introduction

Common approaches for estimating the front door coupling between two antennas are: Integral from of the coupling equation [1], the Friis power transmission formula [2] and numerical evaluation using a full-wave simulation in time domain or frequency domain. However, it is important to notice that these methods require long execution time or present limitations for the near-field region in terms of applicability and simplicity.

Hence, we proposed a method for predict the behavior of the communication link between two parabolic antennas as a function of some antennas' parameters [3], [4]. Different scenarios were considered and simulated by varying parameters such as distance and reflectors diameter.

In this paper, the Cauchy method has been applied to approximating the transfer function of a Linear Time Invariant System (LTI) in the frequency domain as a ratio of two rational polynomials [5], [6]. Therefore, we extract poles and residues of the complex S-parameters using this method.

## II. Overview of the Cauchy Method

The transfer function $H(s)$ for an LTI system, as a rational function of frequency, can be characterized by

$$H(s) = \frac{\sum_{n=0}^{P} a_n s^n}{\sum_{n=0}^{Q} b_n s^n} = \sum_{m=1}^{M} \frac{R_m}{s - s_m} \tag{1}$$

Where $a_n$ and $b_n$ are the unknown coefficients, $R_m$ is the residue and $s_m$ is the $m$th pole. We can extract the poles using the Singular Value Decomposition (SVD) and Total Least Square (TLS) method.

## III. Antenna Configurations

Different scenarios were considered by varying the parameters show in figure 1, such distance and reflector diameter.

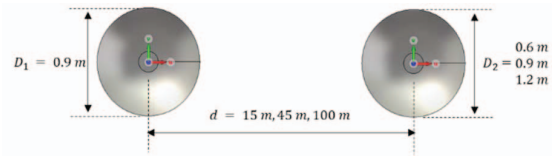


Fig. 1. Antenna Configuration

## IV. Method Implementation

Several simulations were performed, coupling was obtained for the frequency range from 5.8 to 7.2 GHz, by varying distance between 15 m and 100 m, and reflector diameter between 0.6 m and 1.2 m.

Equation 2 assumes that distances and diameter influence resonance frequencies.

$$H(s) = \sum_{m=1}^{M} \frac{R_m(d, D_{1,2})}{s - s_m(d, D_{1,2})} \tag{2}$$




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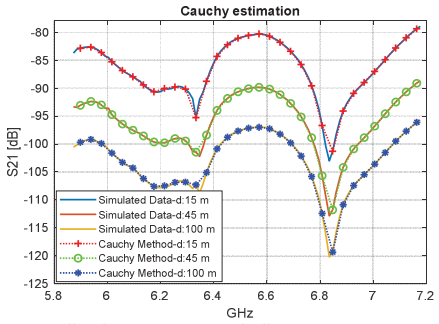


Fig. 2. Coupling between two parabolic antennas. $D_1$: 0.9 $m$, $D_2$: 0.9 $m$.

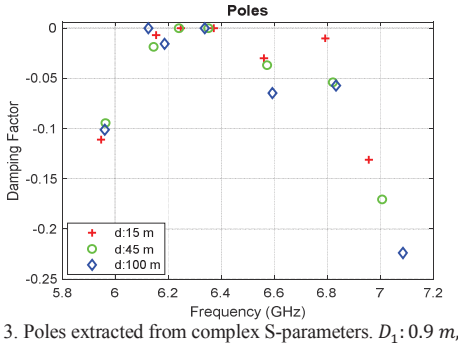


Fig. 3. Poles extracted from complex S-parameters. $D_1$: 0.9 $m$, $D_2$: 0.9 $m$.

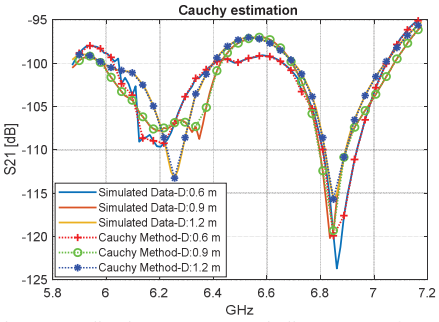


Fig. 4. Coupling between two parabolic antennas. $d$: 100 $m$.

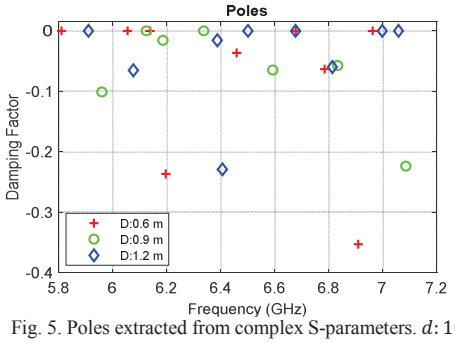


Fig. 5. Poles extracted from complex S-parameters. $d$: 100 $m$.

Figure 2 and 4 shows the magnitude of coupling for several configurations. While, figure 3 and 5 shows the behavior of poles extracted through the Cauchy method from S-parameters. These resonances are used to reconstruct the signal. Figure 6 shows a comparison between the simulation and parametric computation of the coupling between two parabolic antennas with the following parameters: Tx antenna diameter: 0.9 m, Rx antenna diameter: 1.2 m and distance: 25 m.

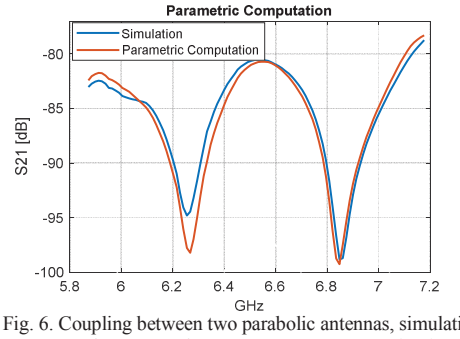


Fig. 6. Coupling between two parabolic antennas, simulation and parametric computation, $D_1$: 0.9 $m$, $D_2$: 1.2 $m$, $d$: 25 $m$.

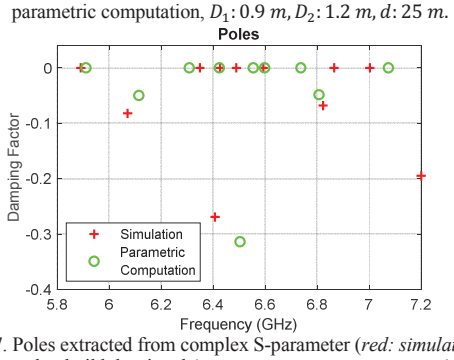


Fig. 7. Poles extracted from complex S-parameter (*red: simulation*), poles used to build the signal (*green: parametric computation*).

Figure 7 displays the behavior of poles used to build the signal trough equation 2.

## V. Conclusions

The model relates the coupling to frequency, antennas' diameter ($D_1, D_2$) and distance ($d$). However, the parameters have the following restrictions: $0.6\ m < D_2 < 1.2\ m, 5.8\ GHz < f < 7.2\ GHz, D_1 = 0.9\ m$.

The results show that Cauchy method provides a great performance in terms of accuracy when modelling the front door coupling of two nearby parabolic antennas for a diverse set of configurations.

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