ANTENNA DESIGN COURSE

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CHAPTER 1

ANTENNAS AND PROPAGATION THEORY

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Antenna Introduction

The antennas are the devices that make the transition from the wave in free space to the waveguiding device (waveguide or transmission line) and vice versa.

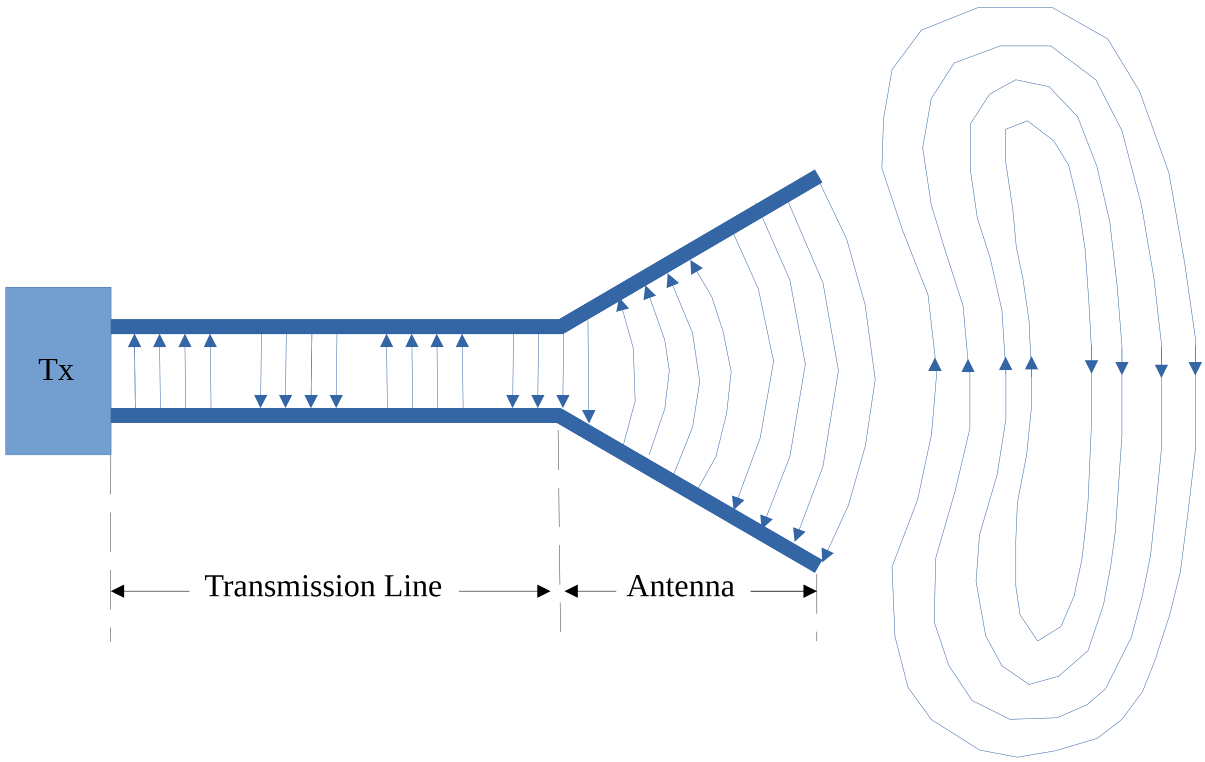

Fig. 1: Representation of Generator + Transmission Line + Antenna (Source [CABAL]).

Antenna Definitions

From Webster's Dictionary: "a usually metallic device (as a rod or wire) for radiating or receiving radio waves".

From the IEEE: "a means for radiating or receiving radio waves".

Introduction and Types of Antennas

As a tool to understand how the energy is distributed in a transmitter you can use a Thevenin Equivalent, as the one in Fig. 2.

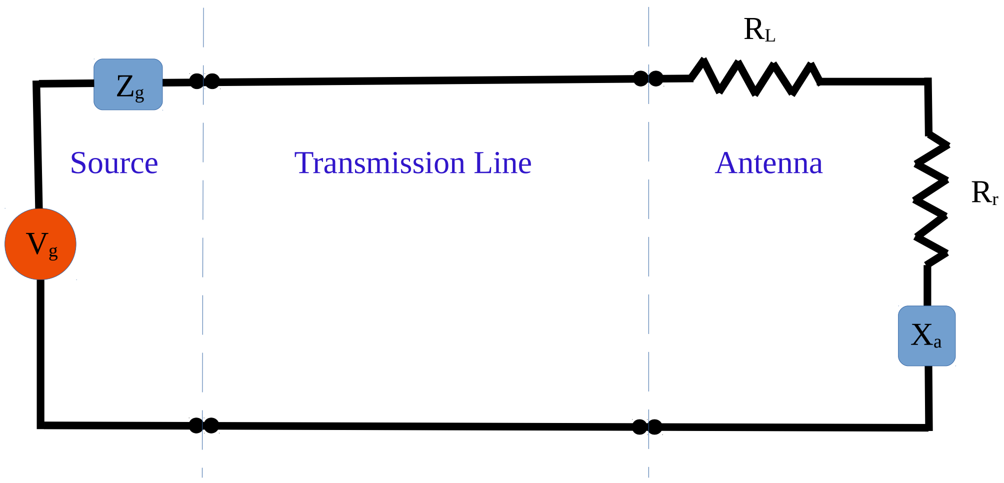

Fig. 2: Thevenin Equivalent for a system composed by Generator + Transmission Line + Antenna (Source [CABAL]).

Where:

Vg - peak voltage from the generator
Zg - Internal impedance of the generator
R_L - Loss resistance
R_r - Radiation resistance
X_A - Radiation reactance

Zg models the internal impedance of the generator. R_L models losses in the conductors and in the dielectric associated with the antenna structure, R_r represents the radiation from the antenna. X_A is used to represent the imaginary part of the impedance associated with the antenna radiation.

Antenna Types

Making a raw classification, at least can be distinguished six types of antennas.

*** Wire Antennas**

* **Aperture Antenna**

*** Patch Antenna**

*** Array Antenna**

*** Reflector Atennna**

*** Lens Antenna**

Antenna Parameters

In the Chapter 2 of [CABAL], a detailed description of the main antenna parameters can be found. For following this course, the student should be familiar at least with following parameters:

Gain (G), Directivity (D), Antenna Efficiency in Conductors and Dielectric (e_{cd}), Input Impedance (Z), etc.

Also the student should be familiar with: Reflection Coefficient (Γ), impedance matching, Voltage Stationary Wave Ratio (VSWR), etc.

General Concepts of Propagation

Here a very quick summary of general propagation concepts for microwaves are presented with the intention of refreshing the mechanisms involved in the transmission of signals through the air. This concepts will be very important at the moment of antenna characterization and link evaluation.

Friis Transmission Equation

$$\frac{P_r}{P_t} = e_{cdt} \cdot e_{cdr} \cdot (1-|\Gamma_t|^2) \cdot (1-|\Gamma_r|^2) \cdot \left(\frac{\lambda}{4\pi R}\right)^2 \cdot D_t(\theta_t, \varphi_t) \cdot D_r(\theta_r, \varphi_r) \cdot |\hat{\rho}_t \cdot \hat{\rho}_r|^2 \quad \textbf{(1)}$$

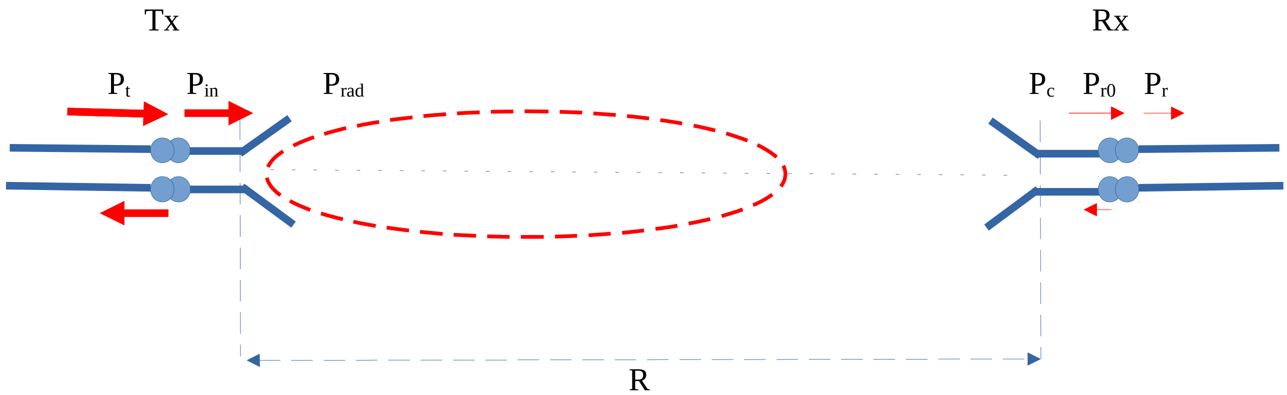

Fig. 3: Friis diagram.

For more information about Friis transmission equation the following link can be used:
C:\Users\Benigno\DOCENCIA\Diseno de Antenas\Documentos\0101_6.3_Ecuacion de Friis.pdf

Fresnel

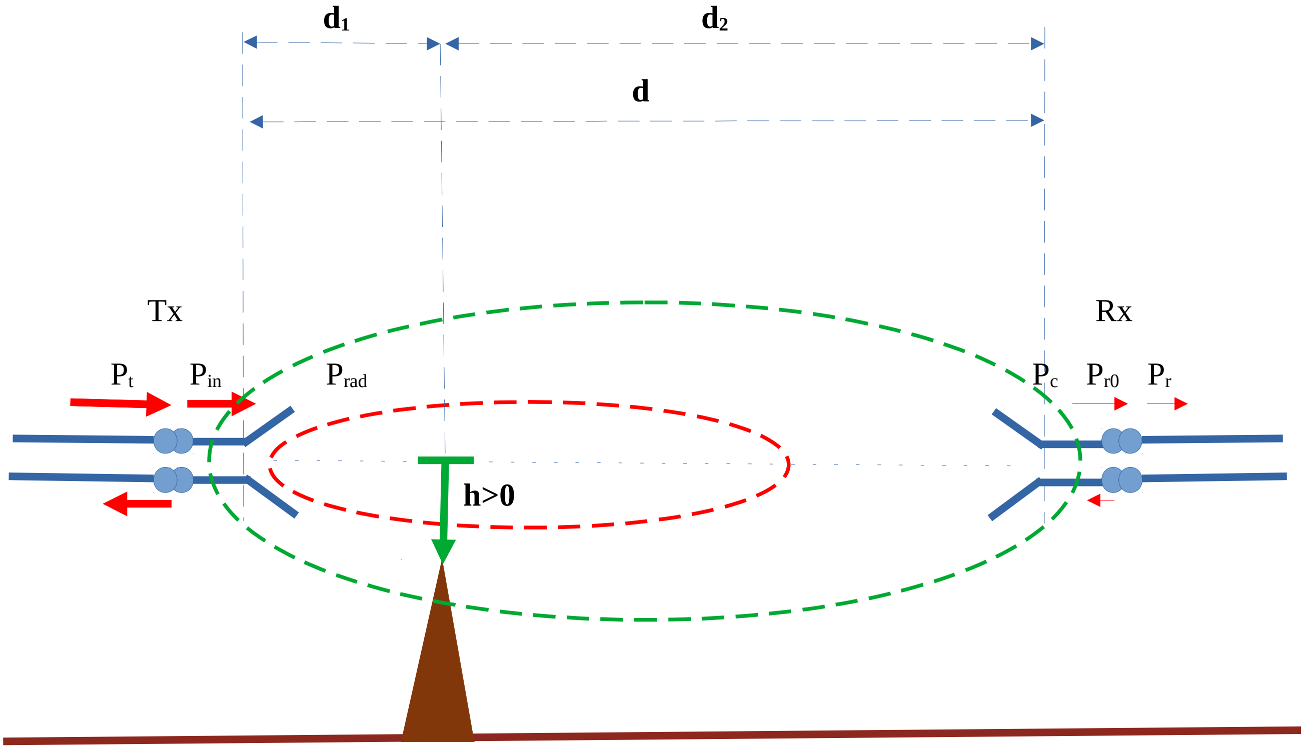

Fig. 4: Fresnel Diagram.

$$r_n = \sqrt{\frac{n.\lambda.d_1.d_2}{d_1+d_2}} \qquad (2)$$

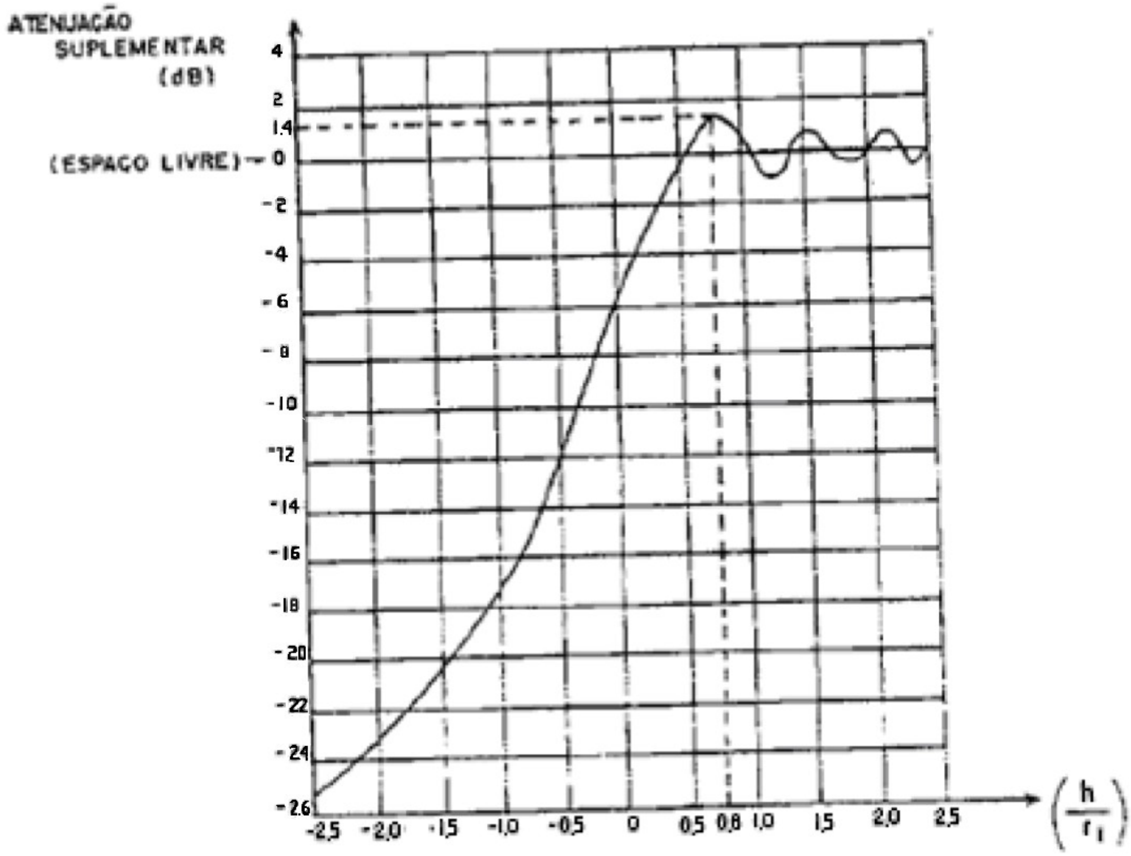

Fig. 5: Gain produced by Fresnel effect (Source [SBRAD]).

In Fig. 5: the Gain produced by Fresnel effect is shown. It is usually called attenuation, but what really shows this graphic is defined as a Gain (Attenuation [dB] = - Gain [dB]).

By using Friss and Fresnel is possible to calculate a link budget with a quite good level of precision.

Thinking a little bit more about propagation, we can indentify the propagation mechanisms presented in Fig. 3.

Propagation Mechanisms

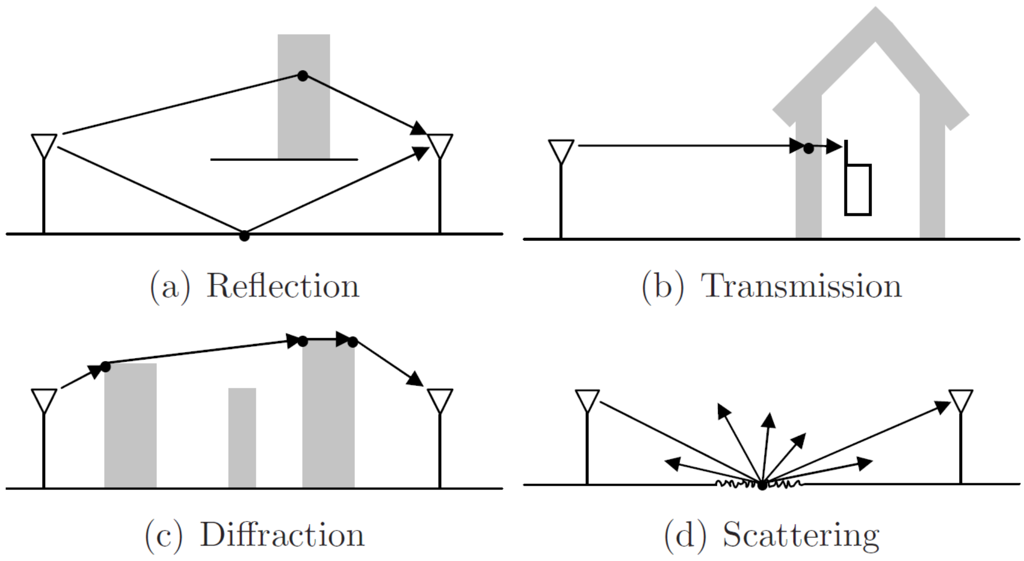

Fig. 3: Propagation Mechanisms (Source [BRD01]).

As described in Fig. 3, the main propagation mechanisms are: **Reflection**, **Transmission**, **Diffraction** and **Scattering**. The signal arriving to the receptor generally is achieved by the collaboration of these mechanisms.

Basically the signal received by a receiver is affected by three effects: Path Loss, Shadowing and Multipath Fading.

Path Loss was discussed when the Friis transmission equation (1) was presented.

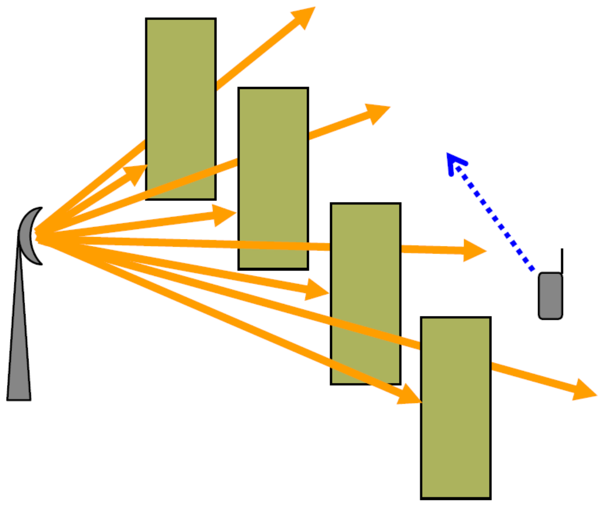

Fig. 4: Representation of the Shadowing effect.

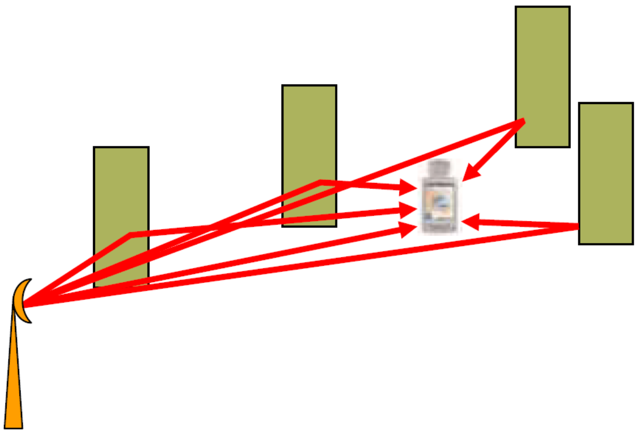

Fig. 5: Representation of the Multipath Fading effect (Source [BRD01]).

Combining all these effects, the received signal can looks as the dotted line in Fig. 6.

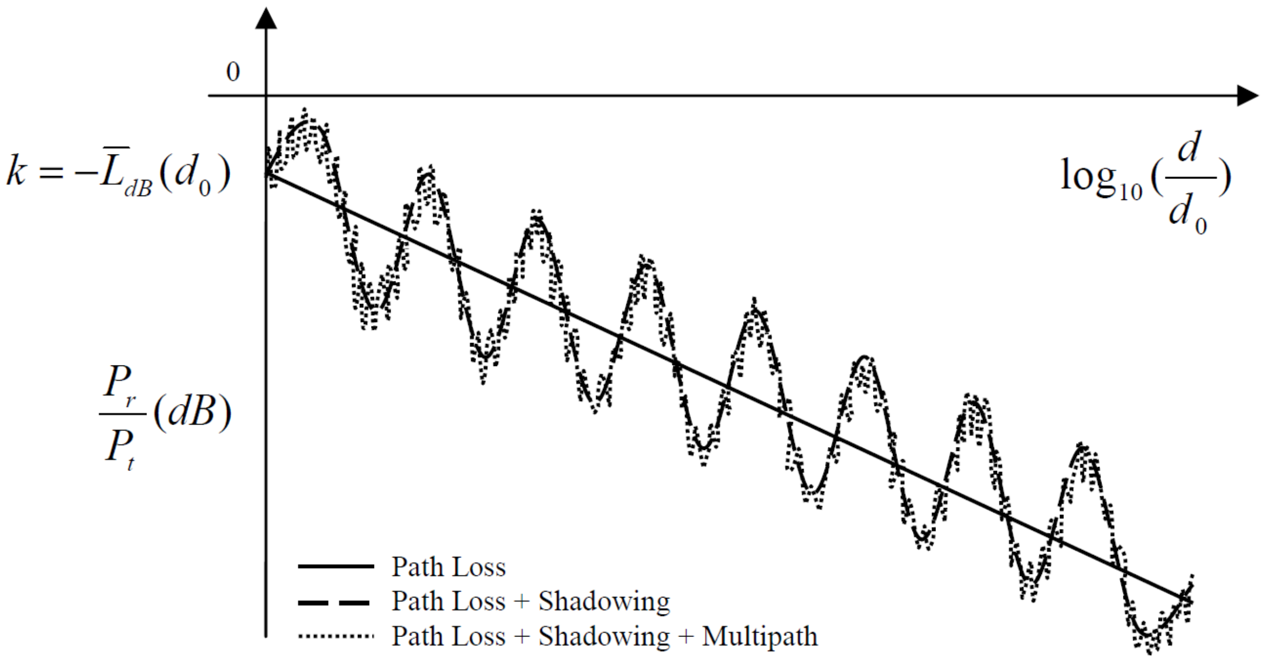

Fig. 6: Representation of a signal affected by Path Loss + Shadowing + Multipath fading (Source [BRD01]).

REFERENCES

CHAPTER 1 REFERENCES

CABAL: C. A. Balanis, ANTENNA THEORY Analysis and Desig, 1997
SBRAD: Gilberto Silva and O. Barradas, Telecomunicacoes: Sistemas Radiovisibilidade, 1978
BRD01: Benigno Rodríguez Díaz, Differential STBC for OFDM based Wireless Systems, 2007

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