Frii Transmission Equation

MLLDYL002 | EEE3089F | ASSIGNMENT 1

Introduction

An analysis of the propagation characteristics for any given radio-frequency communications link follows from an understanding of the specific operating environment and appropriate RF system parameters.

Factors such as humidity, temperature and ionospheric activity may determine the specific propagation mode of an electromagnetic source, while geometrical considerations determine the extent of wave diffraction, reflection and refraction that together constitute the phenomenon of multipath propagation.

Of particular importance is the source frequency and its associated bandwidth. It has been observed that the propagation mode of a source follows closely with the chosen link frequency.

For frequencies near the end of the VHF (300MHz) spectrum and above, the principle mode of propagation is known as LOS (Line of Sight). This mode of propagation is characterized by straight path travel from transmitter to receiver.

Important to the design of any communications link is the theoretical relation of transmit power to receive power.

In the case of a radio link, a relation known as the frii transmission equation (Eq.1) may be used to model a lossless, unobstructed transmitter-receiver pathway.

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi R)^2}$$

$P_t = transmit\ power(W),\quad P_r = receive\ power(W)$
$G_t = transmiter\ gain,\quad G_r = receiver\ gain$
$\lambda = source\ wavelength(m),\quad R = antenna\ separation(m)$

Eq. 1. Frii's transmission relation

Assuming the antenna gain (G_t, G_r) , transmit power P_t , separation distance (R) and source wavelength (λ) parameters are known, receive power may be calculated directly using Eq.1. Logarithmic representation of both transmit and receive powers relative to 1mW is common (units of dBm).

The Frii's transmission relation does not in its current form (Eq.1) account for path loss experienced by an electromagnetic source and is assumed negligible, as is evident by the absence of any loss terms. Path loss factors are, however, found in more detailed propagation models.

Briefly, the aim of this report shall be to compare the accuracy of the frii's transmission relation with experimental measurements of the receive power at various distances.

Method

An RF signal generator, with its power output and generation frequency set to 20dBm (100mW) and 5.86 GHz respectively, was used to model a monochromatic electromagnetic source. A mobile spectrum analyzer was used to model the receiver subsystem.

The antenna element for both instruments consisted of an omnidirectional WiFi antenna with a gain of approximately 2.1dB.

Paper grids, spaced at 5m intervals from the RF generator (0-35m) were used as range markers indicating the relevant measurement points.

Once the RF source was enabled, the experimental procedure consisted of moving to each marker, starting at 5m, and subsequently noting the incoming RF power (dBm) using a spectrum analyzer.

A theoretical calculation using Eq.1 was then performed for each range step and the results plotted as shown in Fig.1 and Fig.2.

Results

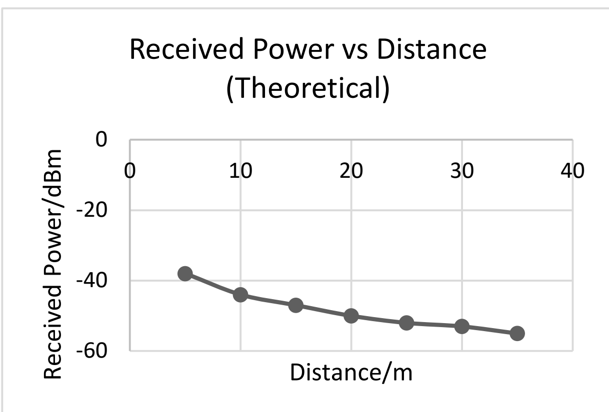

Fig.1 Theoretical receive power P_r given by frii transmission equation

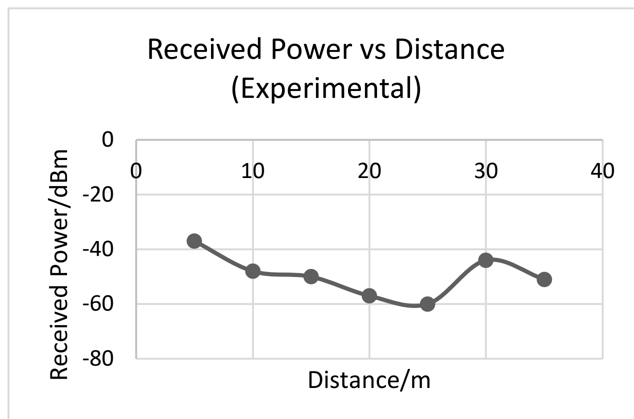

Fig.2 Measured data for power P_r at receive antenna.

From Fig.1 the theoretical receive power P_r is seen to follow a generalized trend downwards, while the experimental measurements (Fig.2) indicate fluctuations in the received power for certain range values. At a distance of ~30m, Fig.2 indicates a received power of ~ -30dBm, while Fig.1 indicates a value of ~ -50dBm.

The disparity in results may be explained in terms of the environmental geometry and the phenomenon of multi-path interference.

The resulting diffraction and reflection of an electromagnetic wave within a source environment results in the creation of multiple propagation pathways, for a given location in space, whose travel time or phase angle may differ.

Upon applying the principle of superposition of waves, the effect of constructive and destructive interference explains the fluctuations in receive power observed in Fig.2.