Task 2

LAB 2: TWO RAY GROUND REFLECTION MODEL

NAME: ABDELRAHMAN MATARAWY SAYED
SECTION: 5

Objectives:

- Observing the effect of ground reflection on the wireless channel.
- Implementing the two ray ground reflection model in MATLAB.

Summary:

- Friis propagation model considers the line-of-sight (LOS) path between the transmitter and the receiver. The expression for the received power becomes complicated if the effect of reflections from the earth surface has to be incorporated in the modeling. In addition to the line-of-sight path, a single reflected path is added in the two-ray ground reflection model.

The distances traveled by the LOS ray and the reflected ray are given by:

$$d_{los} = \sqrt{d^2 + (h_t - h_r)^2}$$
$$d_{ref} = \sqrt{d^2 + (h_t + h_r)^2}$$

- **phase difference (f) between the LOS ray and reflected ray:**

$$\phi = \frac{2\pi\left(d_{ref} - d_{los}\right)}{\lambda}$$

- **the power of the received signal can be expressed as:**

$$P_r = P_t\left[\frac{\lambda}{4\pi}\right]^2 \left|\frac{\sqrt{G_{los}}}{d_{los}} + R\frac{\sqrt{G_{ref}}e^{-j\phi}}{d_{ref}}\right|^2$$

- **Task (2):**
  - a WiFi (IEEE 802.11n standard) transmission-reception system operating at f = 2.4 GHz band with 1 mW output power from the transmitter. The gain of the transmitter antenna is 3 dBi and the receiving antenna is isotropic.

a) Implement a MATLAB function that calculates the received power according to according to the 2-ray ground reflection Model.

```
% ===================Abdelrahman Matarawy===================%
% ========================Section 5========================%
function [Pr_dBm] = GroundReflected(Pt, Glos, Gref, Ht, Hr, f, d)
% Distance From Tx and Rx As line of sight
Dlos = sqrt(d.^2 + (Ht - Hr)^2);
% Distance From Tx and Rx That found due to Ground Reflection
Dref = sqrt(d.^2 + (Ht + Hr)^2);
Lamda = (3*10^8) / f;
% phase difference between the LOS ray and reflected ray
Phay = (2 * pi * (Dref - Dlos)) ./ Lamda;
% Power Received
Pr = (Pt) * ((Lamda / (4 * pi)) ^2) * ((abs((sqrt(Glos) ./ Dlos) - ((sqrt(Gref) * exp(-i *Phay))./Dref))).^2);
% Power Received In dBm
Pr_dBm = 10 * log10(Pr);
end
```

b) MATLAB function Using the approximation:

```
% ===================Abdelrahman Matarawy===================%
% ========================Section 5========================%
function [Aproximate_Power] = Approximate(Pt, Glos, Gref, Ht, Hr, f)
Lamda = (3*10^8) / f;
% critical distance
dc = (4*Ht*Hr)/Lamda;
% At d <= Ht
d1 = [0.1 : 1 : Ht];
% At Ht < d <= dc
d2 = [Ht + 0.0001 : 1 : dc];
% At d > dc
d3 = [dc + 0.0001 : 1 : 10^5];
% Constant Factor
K = (Glos * Gref * (Lamda^2)) / ((4 * pi)^2);
K1 = (Glos * Gref * (Ht^2) * (Hr^2));
% Approximate Power Received
Pr1 = (Pt * K) ./ ((d1 .^ 2) + (Ht ^2));
Pr2 = (Pt * K) ./ ((d2 .^ 2));
Pr3 = (Pt * K1) ./ (d3 .^ 4);
Aproximate_Power = [Pr1  Pr2  Pr3];
end
```

1. Main Code:

```
% ===================Abdelrahman Matarawy===================%
% ========================Section 5========================%
clc
clear
d = [0.1 : 1 : 10^5];
f = 2.4e9;
Pt = 1;
Glos = 10^0.3;
Gref = 10^0;
Ht = 50;
Hr = 2;
[Reflected_Power] = GroundReflected(Pt, Glos, Gref, Ht, Hr, f, d);
[Approximate_Power] = Approximate(Pt, Glos, Gref, Ht, Hr, f);
semilogx (d, Reflected_Power)
hold on;
grid on;
semilogx(d, 10*log10(Approximate_Power));
title('Two Ray Ground Approximate Propagation Model');
xlabel('Distance (m)');
ylabel('Received Power(dBm)');
```

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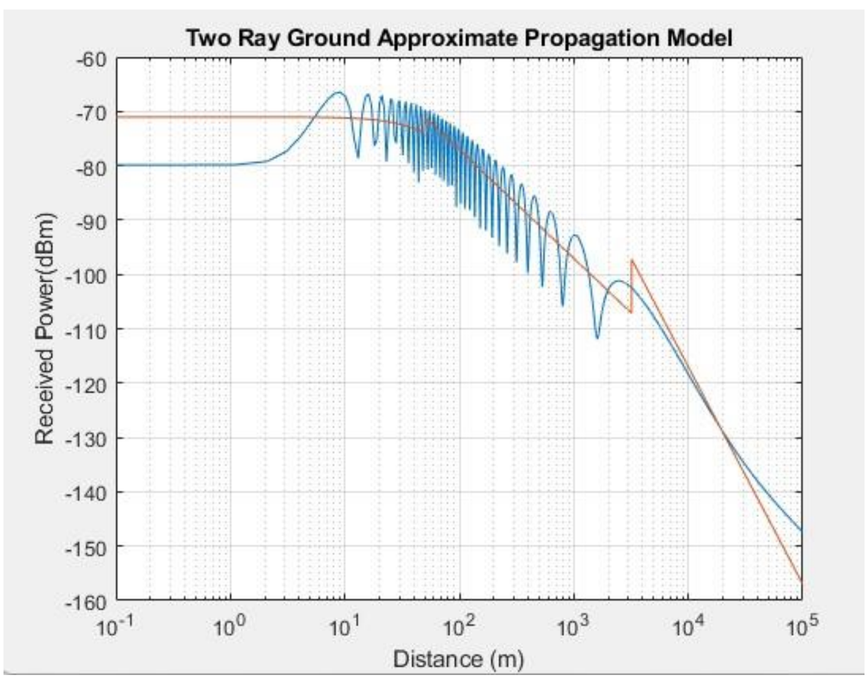
c) Plot the received power versus distance using the two functions:



"Exact Blue One and Approximate is Red One"