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Cairo University
Faculty of Engineering
Electronics and Communications Engineering Department – 4th Year

Assignment-1

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Contents

Radio Propagation Model

<u>Output (1):</u>

<u>-Simulation setup:</u>

- First, we set up the required simulation settings and choose whether the data are read from excel sheet or generated randomly. If generated randomly, then we will have to configure the settings for example:
  - operating frequency=4 GHz
  -Standard deviation=6
  -Number of measured distances=5
  -Number of samples:50

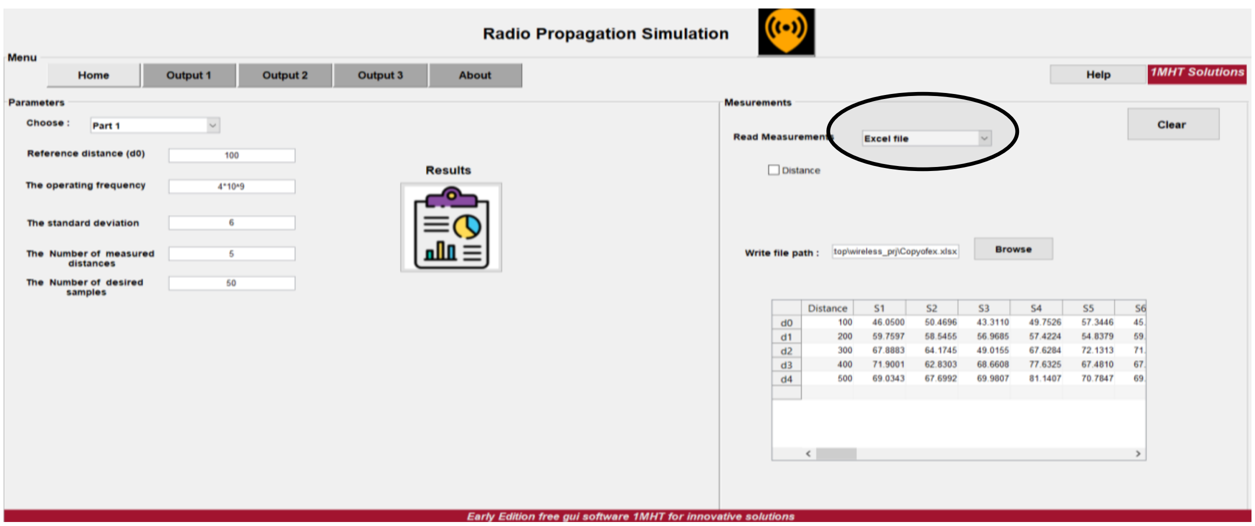

Figure 1 Home menu to select mode of operation.

-Gui interface shows the input read in excel mode.

- Results & conclusion:

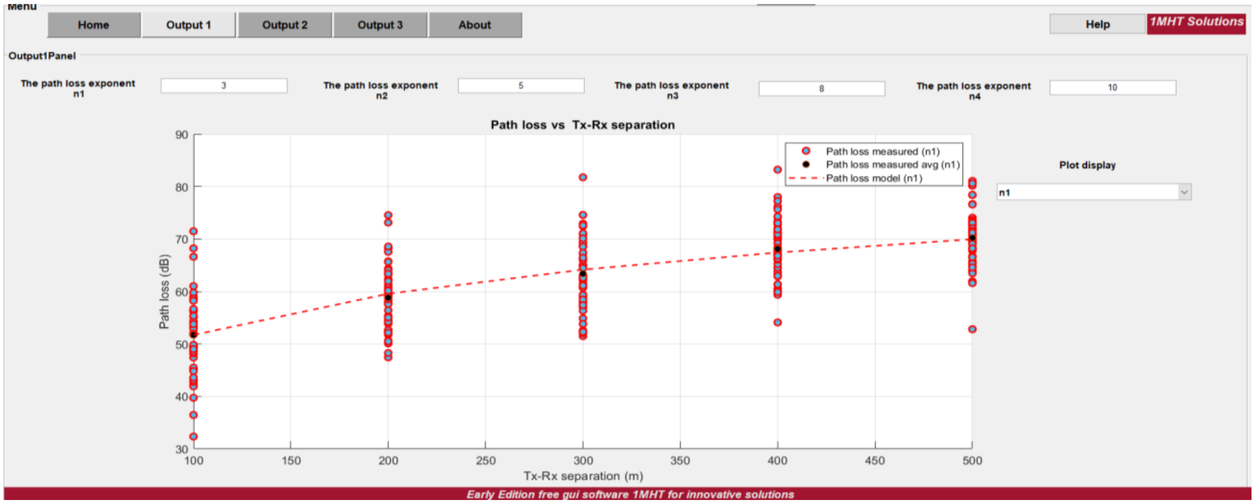

Figure 3 Pathloss(dB) vs tx-rx separation for n=3

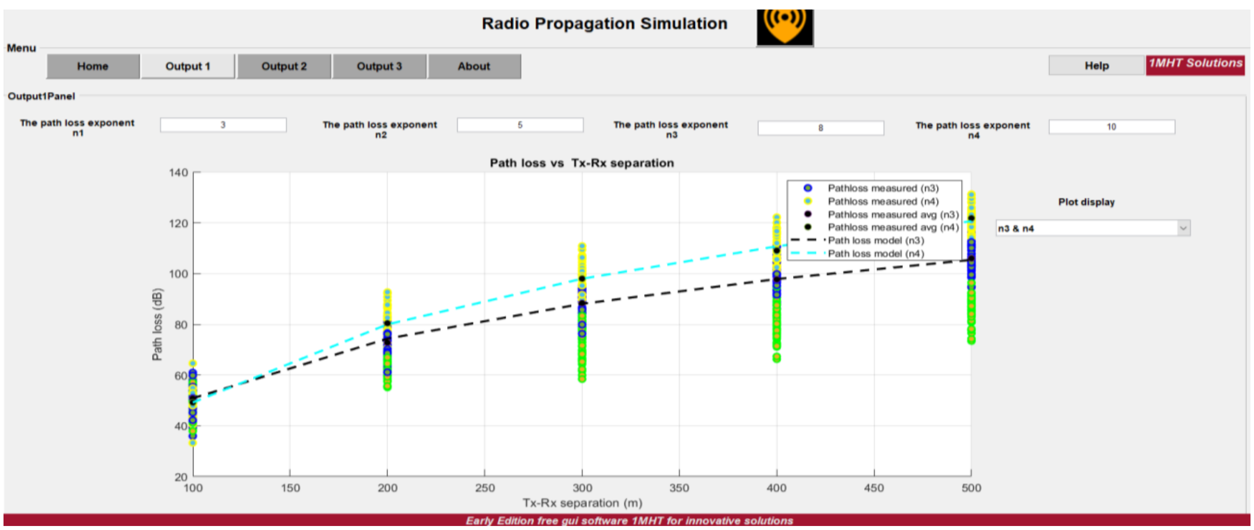

Figure 2 Pathloss(dB) vs tx-rx separation for 3 n values

$$PL_{dB}(d) = PL_{dB}(d_0) + 10nlog\left(\frac{d}{d_0}\right) + X_\sigma$$

- The first two terms represent mean power level and its effect in the value of pathloss, and we can see that it is affected by the ratio between distances and pathloss exponent(n).
  -As separation distance increases w.r.t to reference distance the pathloss increase and we can see that from the equation.
  -As pathloss exponent (n) increases the pathloss increase and it represents medium effect.

-Gui Interface:

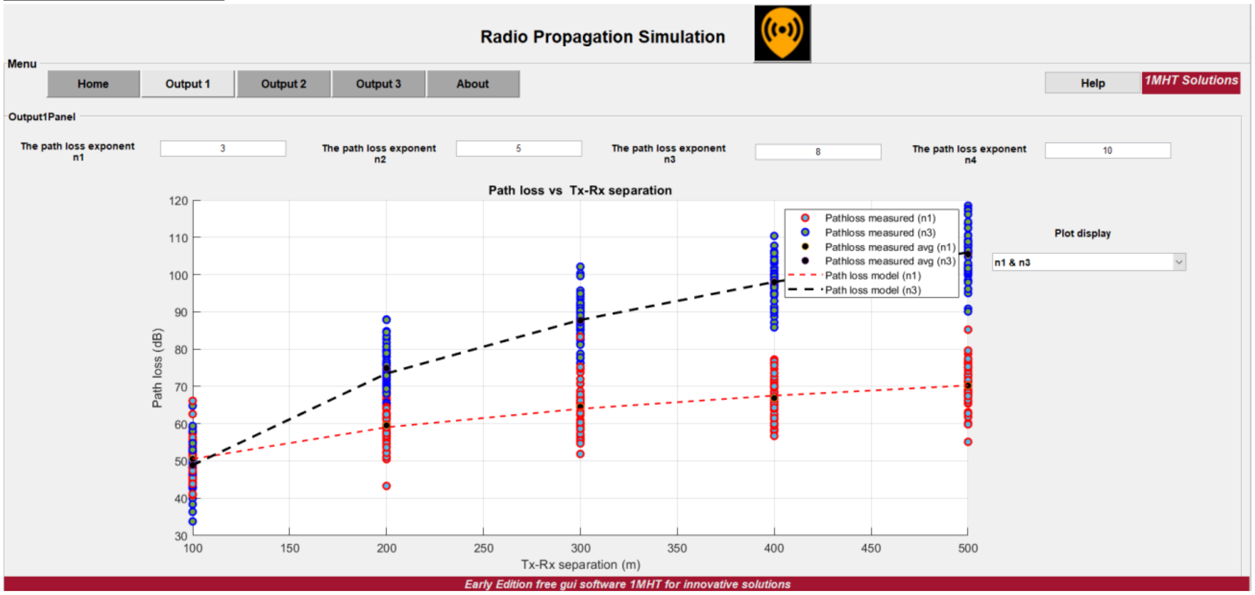

Figure 4 Pathloss(dB) vs tx-rx separation

-We have the option to select which n to display its readings and we can also show them all together or combinations of different pathloss exponents together.

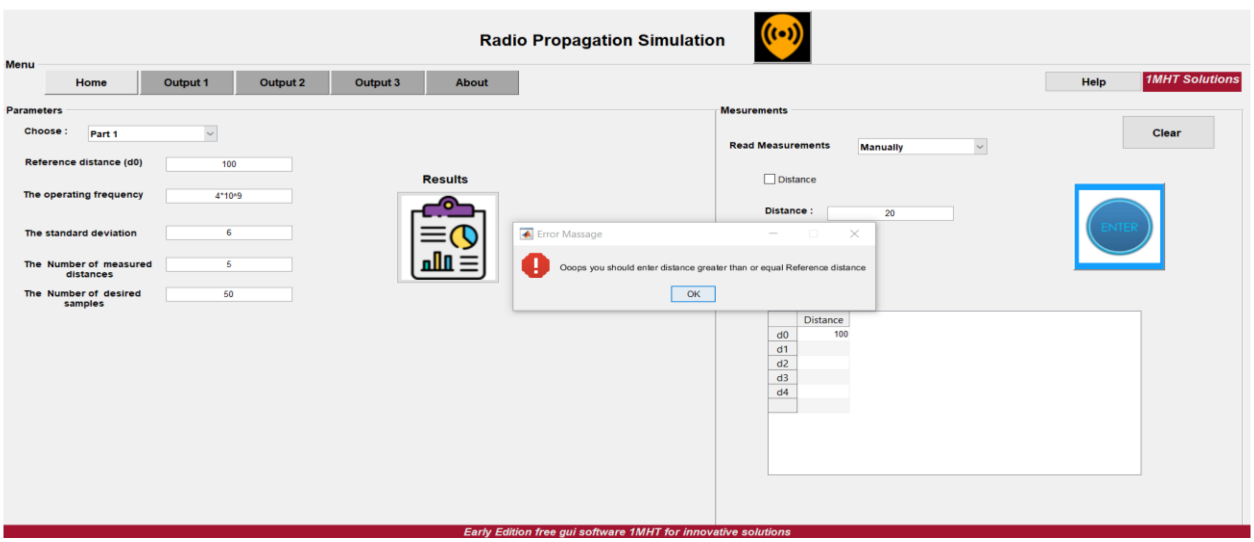

Figure 5 Home menu

-Home menu handles the problem if the user enters a separation less than the reference distance.

Output (2):

-Simulation setup:

- simulation settings: we will continue with the same readings from previous output.
- At this part we will calculate n* (pathloss exponent) and standard deviation mathematically and also the accuracy between modeled pathloss and reatings.
- We can see 4 different graphs each for different n* at each graph we draw the pathloss.

-Results & Conclusion:

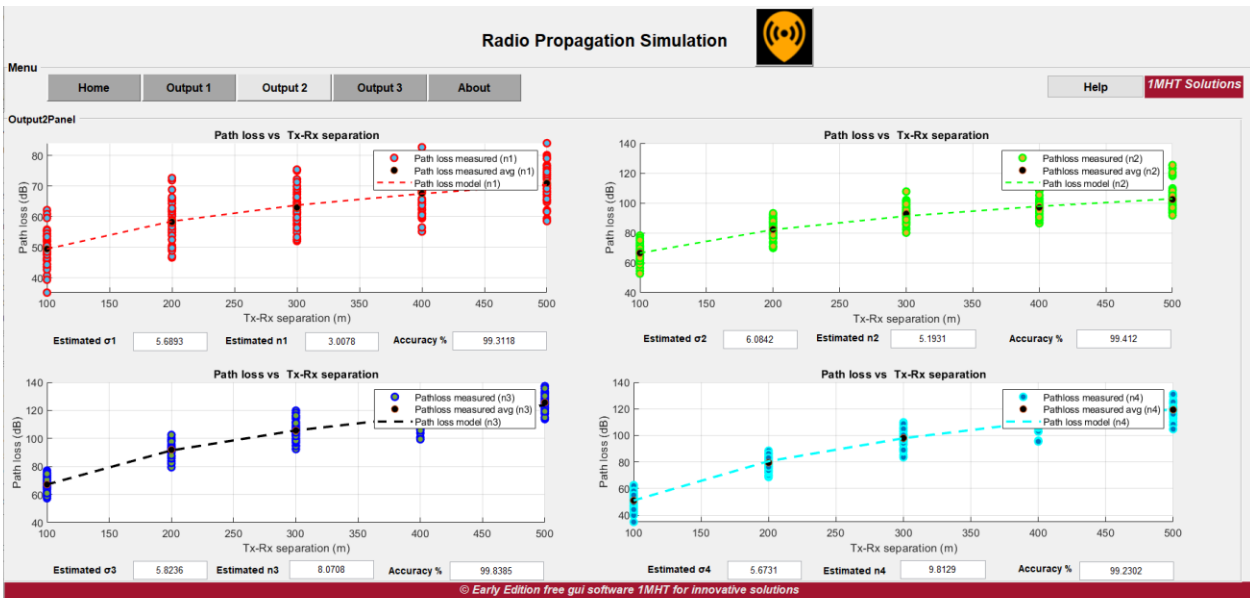

Figure 6 Output 2 Pathloss(dB) vs tx-rx separation and estimate parameters.

$$j(n) = \frac{1}{N}\left[\sum_{1}^{N} \left(P_r(d_i) - \overline{P_r(d_i)}\right)^2\right]$$

- By calculating the mean square difference between the readings and the power calculated from the mathematical model we differentiate the equation then we can get the n*.
- We substitute we the mean of all samples in a certain distance for $P_r(d_i)$.
- At case of 50 samples per distance and n= [3,5,8,10].

Real (n)	3	5	8	10
Estimated (n*)	3.0078	5.1931	8.0708	9.8129
Accuracy of pathloss	99.318%	99.412%	99.8385%	99.2302%

Output (3):

-Simulation setup:

- simulation settings: we will continue with the numbers from previous output.
- At certain pathloss exponent, we calculate the accuracy between the pathloss of estimated mathematical model and the generated samples at each distance, then we take the average of accuracies at all distances and get the final accuracy, we sweep by changing the number of samples.

-Results & conclusion:

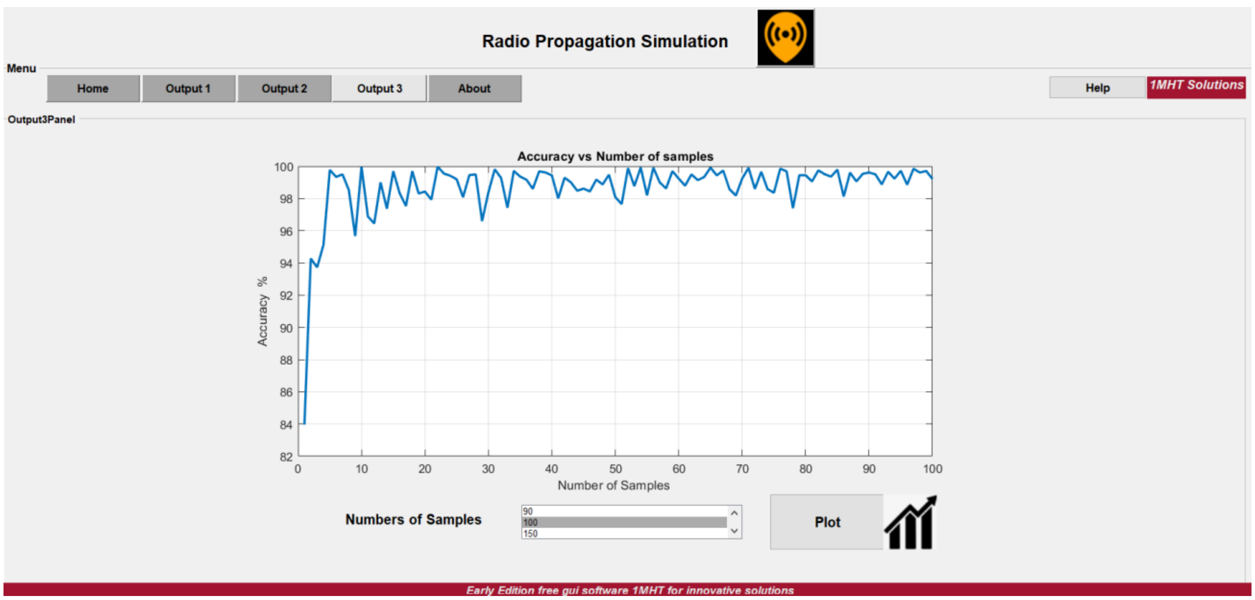

Figure 7 Accuracy vs number of samples

- We can see that as the number of samples increases the accuracy increases. At the beginning the accuracy increases significantly and then it becomes nearly constant within the range of high values.

Output (4):

-Simulation setup:

- simulation settings: At this part First, we set up the required simulation settings and choose whether the data are read from excel sheet or generated randomly. We decide the:
  -Transmitter antenna gain =15
  -Receiver antenna gain =25
  -Transmitter power =60
  - operating frequency=4 GHz
  -Separation between Tx & Rx, pathloss exponent, standard deviation.

-Calculations:

- We want to enter the desired received power and a Tx Rx separation and calculate how much power received exceeds the desired one.

We use the free space model to get the pathloss at d_{0}:

$$PL_{dB}(d_0) = -20\log\left(\frac{\lambda}{4\pi d_0}\right), \lambda = \frac{c}{f_{op}}$$

Then we use the log-normal shadowing to get the pathloss at other distances.

$$PL_{dB}(d) = PL_{dB}(d_0) + 10n log\left(\frac{d}{d_0}\right) + X_\sigma$$

Then we calculate the received power:

$$P_r = P_t + G_t + G_r - PL \quad , in\ dB$$

- We will calculate at every distance (d) at different pathloss exponent(n) the percentage of time the samples exceeded the desired received power.
- Using Q function:

$$P(P_r(d) > desired\ power) = 1 - Q\left(\frac{\overline{P_r(d)} - desired\ power}{\sigma}\right)$$

- We will calculate the max distance by reversing the process.

Results & Conclusion:

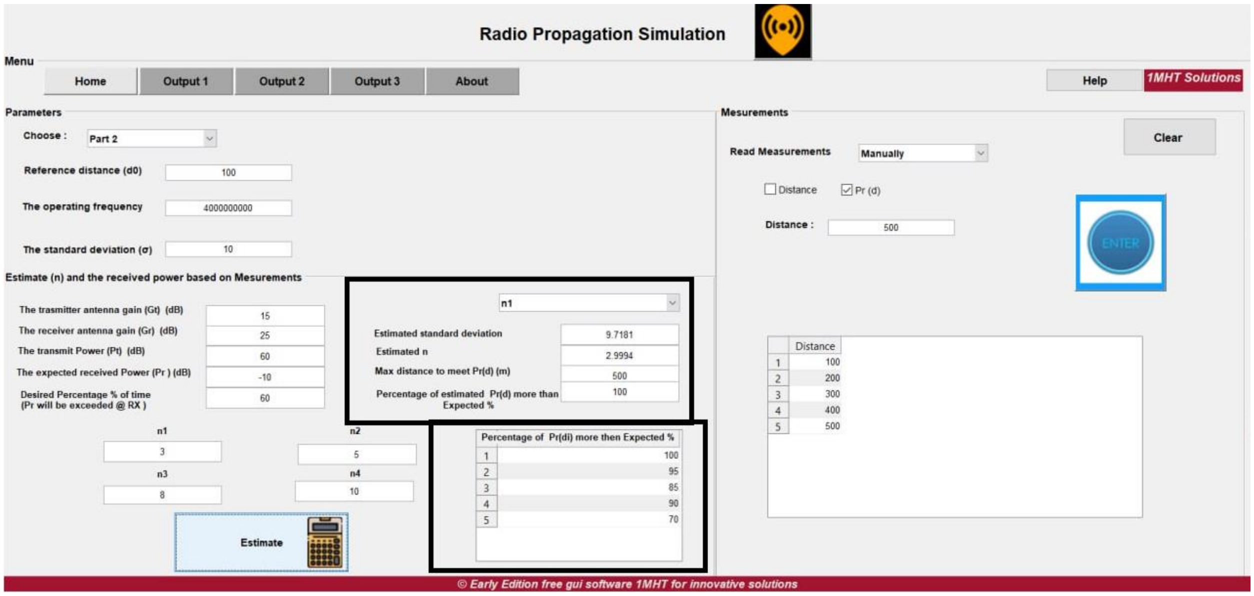

Figure 8 Home menu for Output (4)

- The desired received power at least=-10 dB.
- Percentage of time exceeded=60%

*The first box displays for the selected pathloss exponent (n1):

-the estimated n* and standard deviation.

-The maximum distance that meets the desired requirements for the received power is 500 m.

- As we can see from the second box, at every (d) from the 5 Tx-Rx separations the calculated power received exceeded the desired one in all the distance with percentage all more 60%.

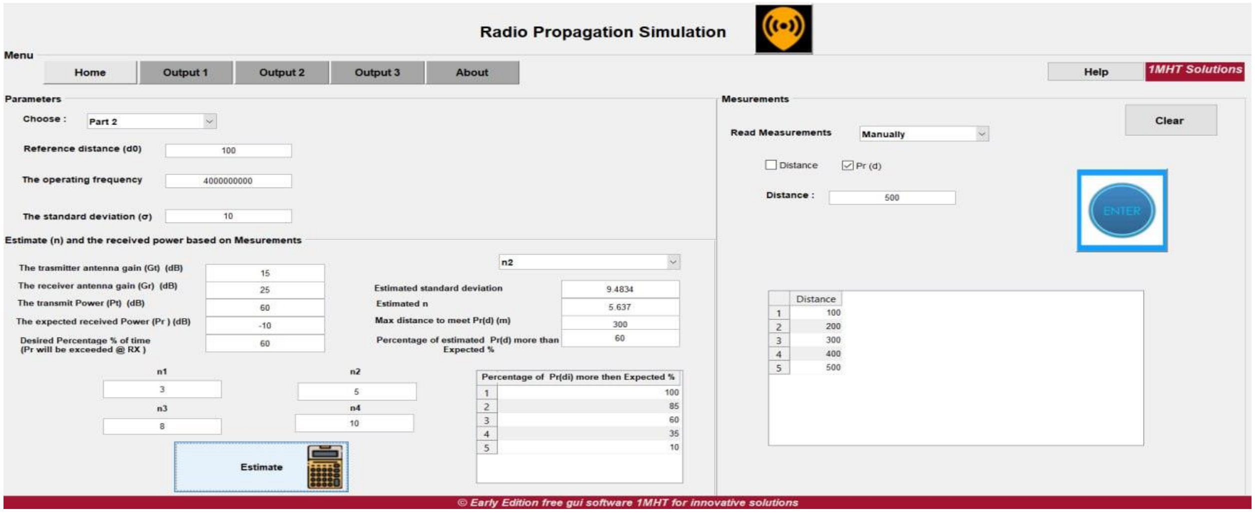

Figure 9 Home menu for Output (4)

- The desired received power at least=-10 dB.
- Percentage of time exceeded=60%.

-We calculated the percentage of time the power received met the desired requirements for each (n) and distance and you can select it from the second box.

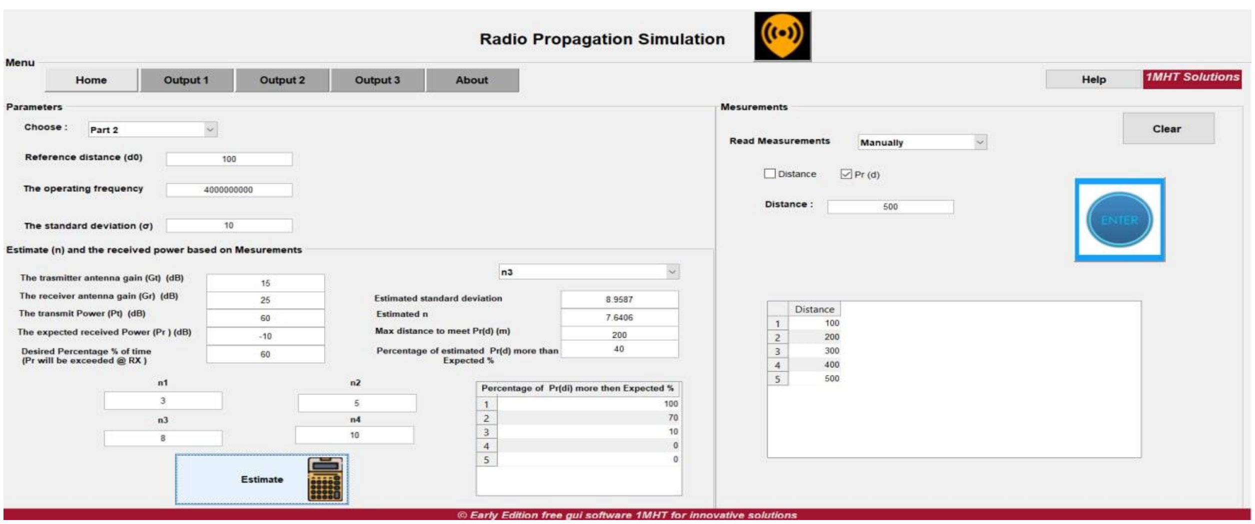

Figure 10 Home menu for Output (4)

- The desired received power at least=-10 dB.
- Percentage of time exceeded=60%.

-The second box shows the percentage of time exceeded the requirements.

-About the GUI: