FACULTY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF COMPUTER ENGINEERING
Wireless and Mobile Networks - ENCS5323

Project – Online Calculator for Wireless and Mobile Network

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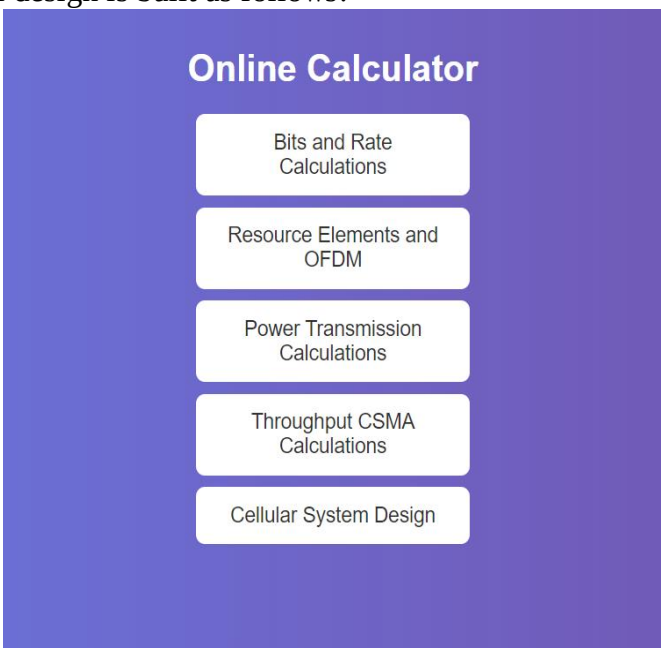
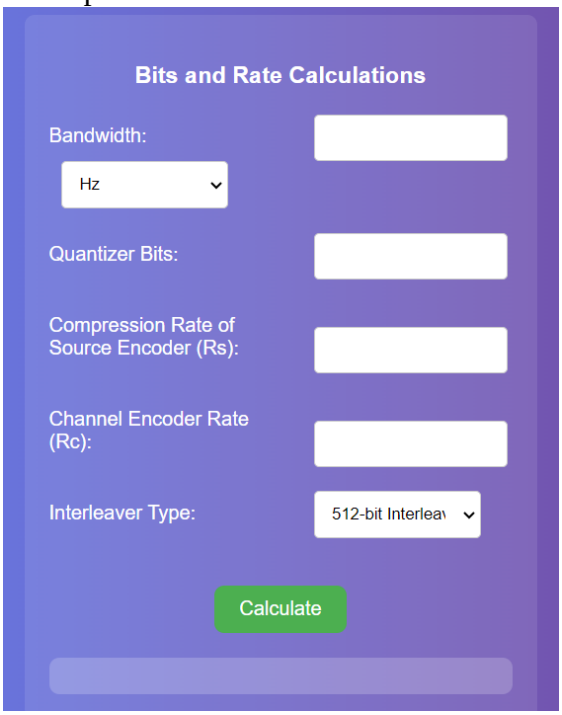
Date: June 18, 2024

The project aims to assist in various network calculations. It enables users to enter system characteristics to calculate bits and rates for various encoders, calculate resource components and OFDM parameters, analyze power transfer, evaluate throughput for multiple access modes, and design cellular networks. This website allows accurate calculations to know the infrastructure of wireless and mobile networks.

- The general design is built as follows:



- When click on **"Bits and Rate Calculations"** the screen appears as follow, which contains spaces to take input from the user and determine the bandwidth scale



The interface asks the user to enter the bandwidth, quantizer bits, compression rate of source encoder (Rs), a channel encoder a rate (Rc) and select the type of interleaver depends to number of bits and it print the results as it obvious in the figure above.
In this part, it uses the following steps and equation

1. Sampling frequency = (2 * BW)
2. The number of quantization levels = 2^quantizer bits
3. The bit rate at the output of the source encoder:
   - Should calculate the input bits of the source encoder
   = Fs (sampling frequency) * number of bits per sample
   - then find the output bits = the input bits * Rs

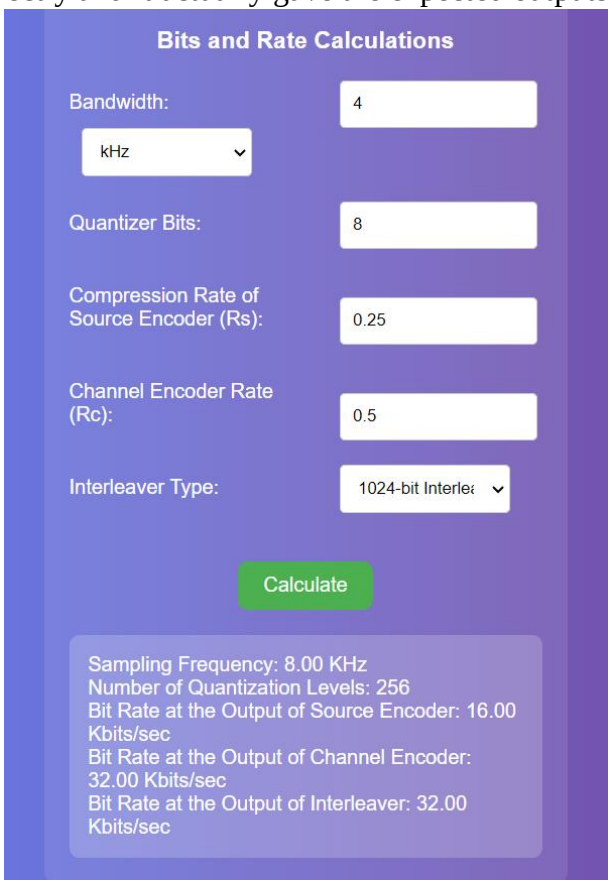
4. The bit rate at the output of the channel encoder

   = the output bits of the source encoder / Rc

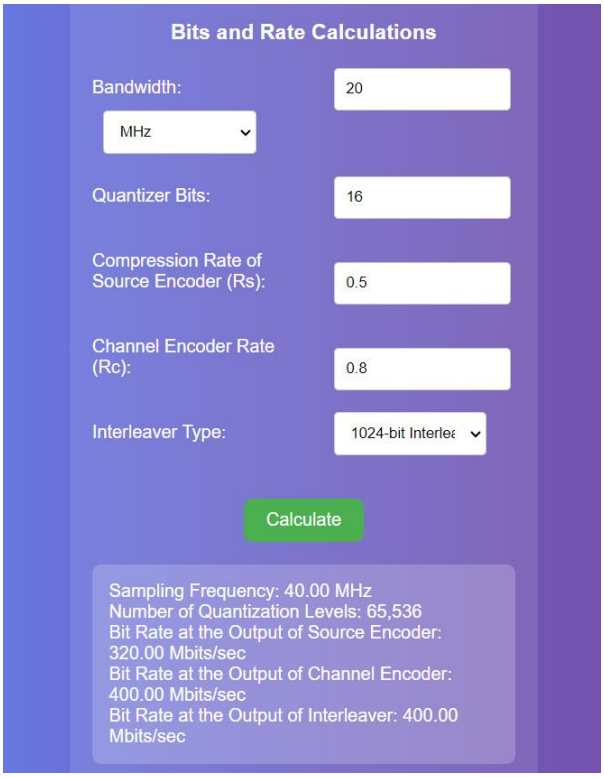
5. The bit rate at the output of the interleaver

   = the same bits of the output of the channel encoder

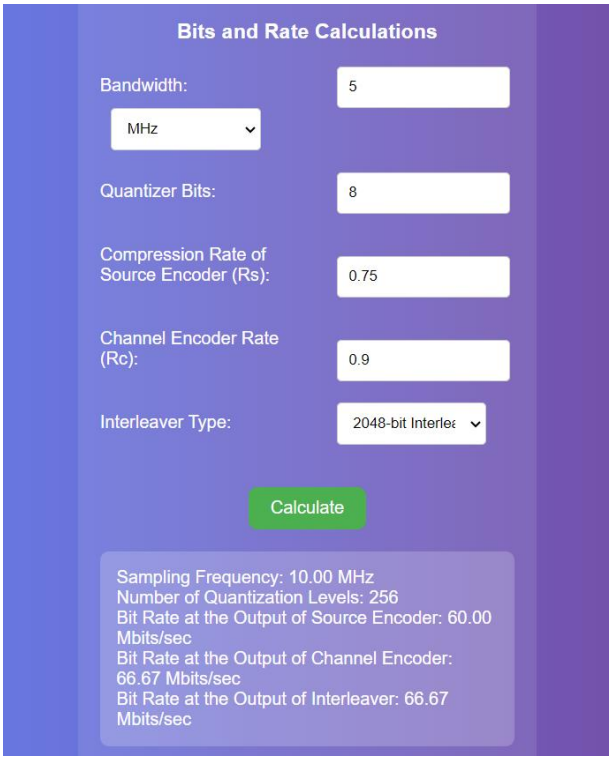
In the first scenario, the values of the exam question entered to test and examine the system and found that it worked correctly and it actually gave the expected outputs as follow:



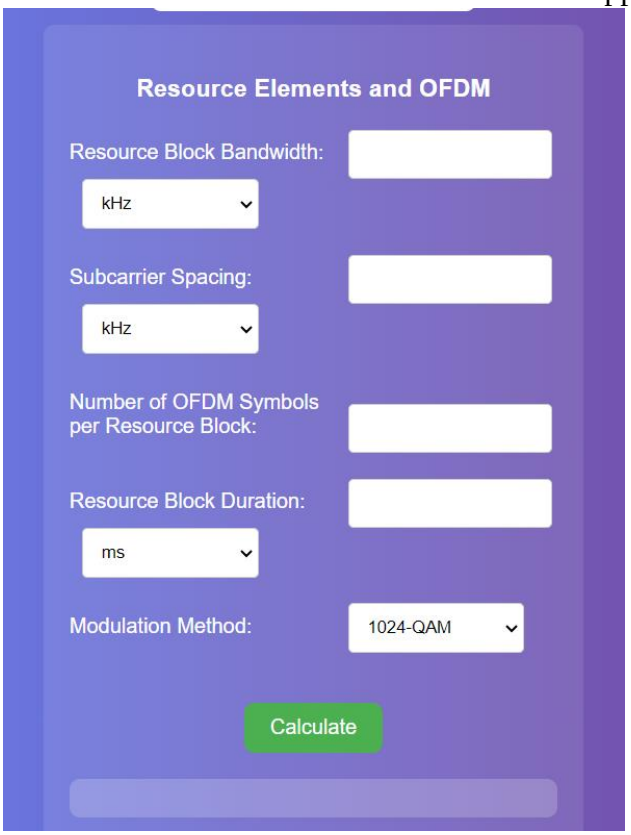
The next scenario, the inputs entered with these values, and it gets the correct results as the figure below:



The last scenario, the inputs entered with these values, and it gets the correct results as the figure below:



❖ When click on **"Resource Elements and OFDM"** the screen appears as follow:



The interface asks the user to enter the resource block bandwidth, the subcarrier spacing, number of OFDM symbols per resource block, each resource block duration and select modulation method (1024-QAM, 64-QAM, QPSK)

In this part, it uses the following steps and equation:

1. The number of bits per resource element = number of bits recording the modulation method
2. The number of bits per OFDM symbol = resource element * subcarrier

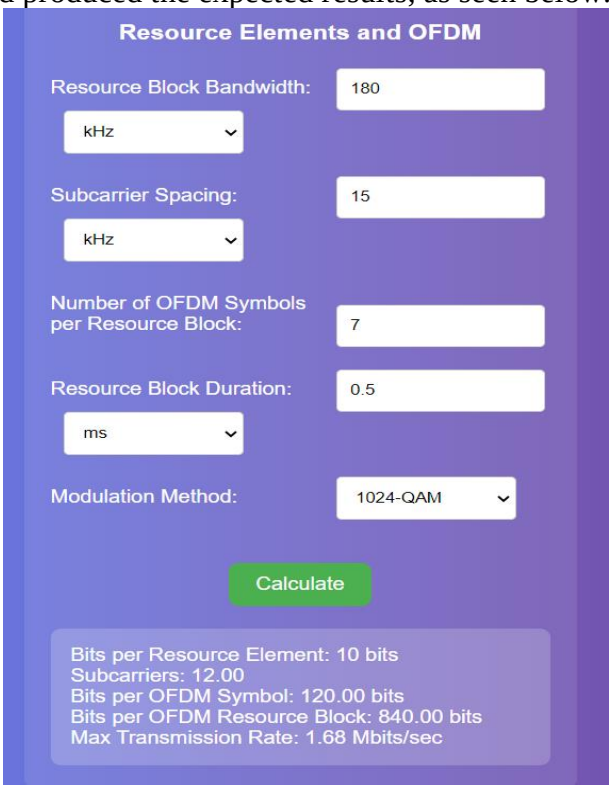
   the subcarrier = B.W / f (The subcarrier spacing)

3. The number of bits per OFDM resource block

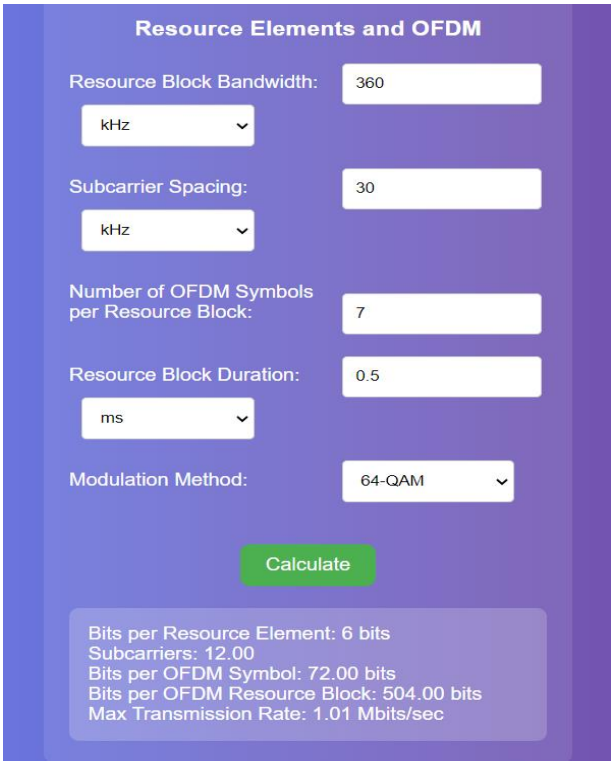
   = number of bits per OFDM symbol * symbols per resource block

4. The maximum transmission rate for the user when assigned a n parallel resource blocks continuously = (n * number of bits per OFDM resource block) / resource block duration

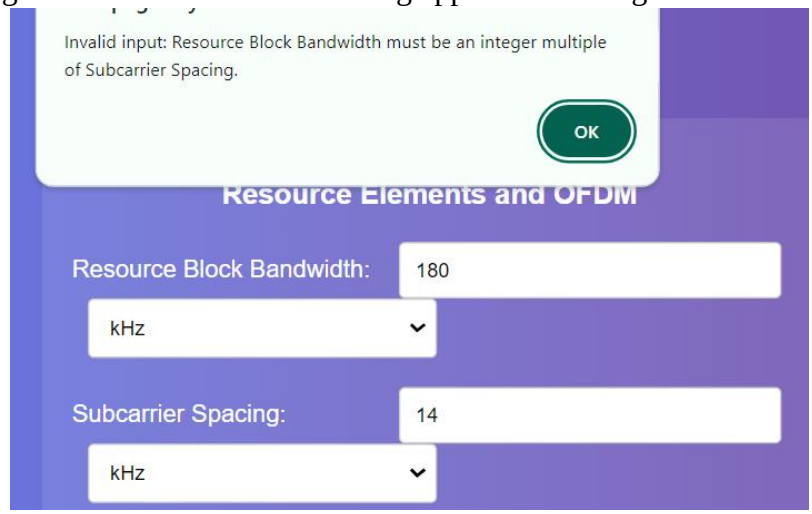
In the first scenario, the exam question values were entered to test, and it was discovered that it worked appropriately and produced the expected results, as seen below:



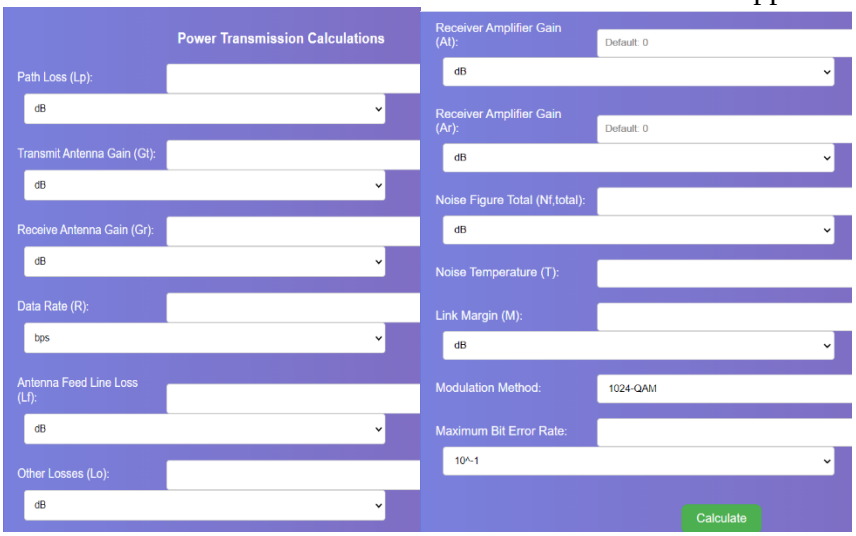
The second scenario, the inputs are filled in with these values, and the right results are obtained as shown in the picture below:



The third scenario, two numbers whose division result is not a integer was entered, and this is not within the logic of the solution so a warning appears as the figure below:



- When click on **"Power Transmission Calculations"** the screen appears as follow:



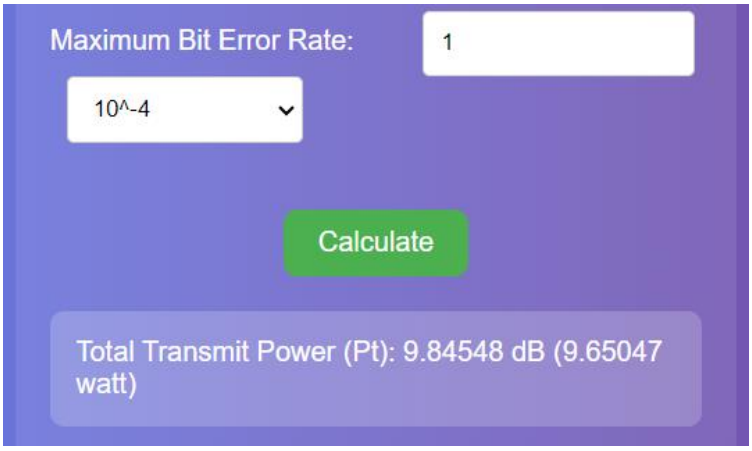
The interface asks the user to enter the path loss, frequency, transmit antenna gain, receive antenna gain, data rate, antenna feed line loss, other losses, a fade margin, receiver amplifier gain, receiver amplifier gain, noise figure total, a noise temperature, link margin, maximum bit error rate and the select modulation method (1024-QAM or 64-QAM or QPSK).

It is calculating the total transmit power required of modulated signal with the maximum bit error rate as follow:
Use equation: Pr = Pt + Gt + Gr + At + Ar - Lp - Lf -Lo -F margin

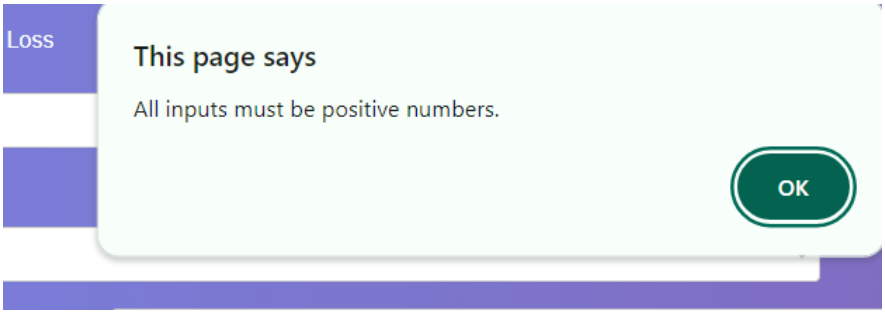
To find Pt it finds Pr first, from the equation which represent by M.

And the (Eb/No) value it determinate from table which that includes the data after entered them from the graph, regarding the modulation method and the numbers at the both axes.

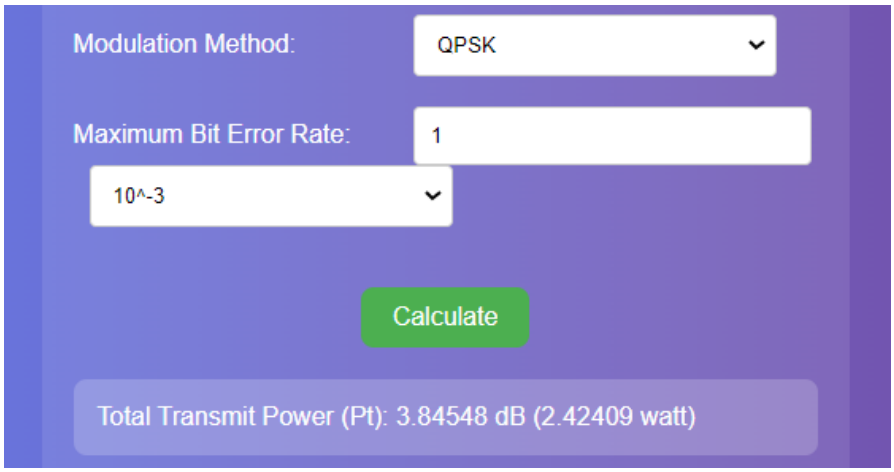
The exam scenario, Lp = 140 dB, Gt = 8dB and Gr = 0dB, R = 9.6kbps, Lf =12dB, Lo = 20dB, a F margin = 8dB, Ar = 24dB, Nf,total = 6dB, T = 290, and M = 8 dB and 8- PSK modulated signal with a maximum bit error rate of 10-4.
And got the correct result as below:



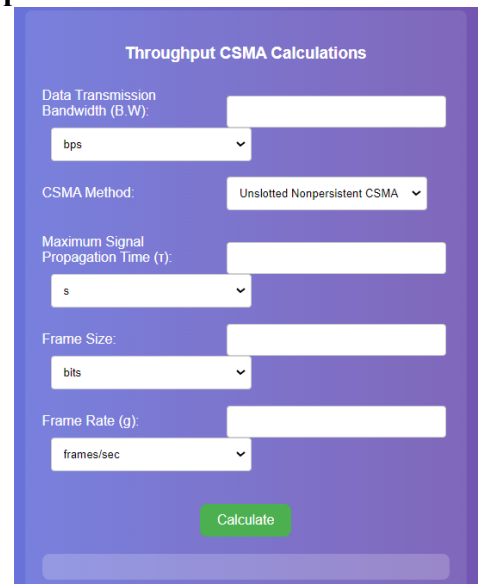
In other scenario, when enter the path loss a minus number, it gives an error as follow:



In the last scenario, the values changed to Lp = 140 dB, Gt = 10 dB, Gr = 0 dB, R = 9.6 kbps, Lf = 12 dB, Lo = 20 dB, F margin = 8 dB, At = 24 dB , Ar = 0 dB, Nf,total = 6 dB, T = 290 K, and M = 8 dB and QPSK modulated signal with a maximum bit error rate of 10^-3.

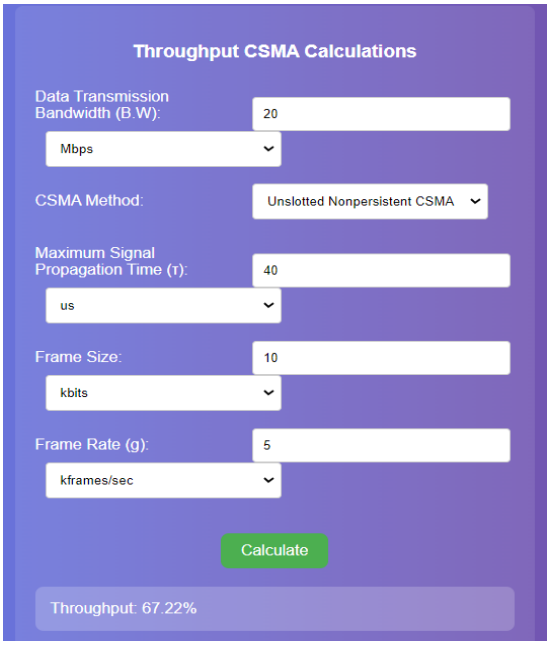


❖ When click on **"Throughput CSMA Calculations"** the screen appears as follow:

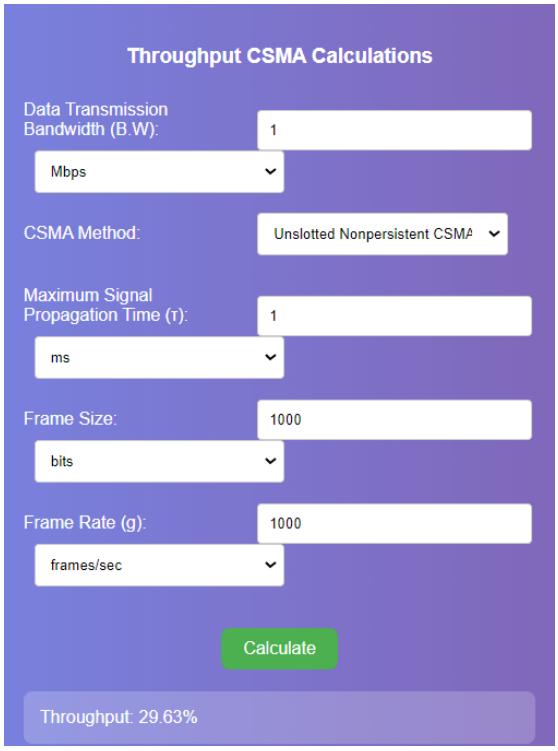


The interface asks the user to enter the data transmission bandwidth, the maximum signal propagation time from one node to another (τ), frames size, frame rate (g) and select which CSMA method that used in the MAC layer
Then it determines the throughput in percent by the following equations:
T = frame size * Tb
Tb = 1/ B.W
G = g * T
α = τ/T
then apply all of these in the appropriate rule for S depending on the method chosen.

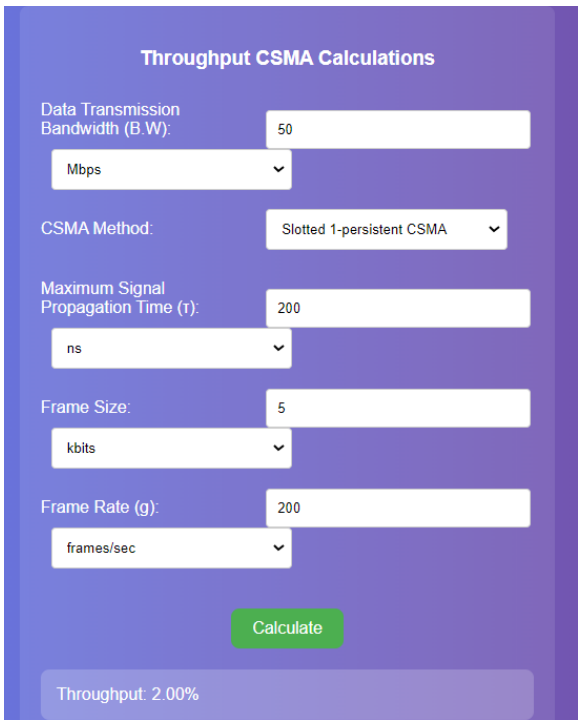
The exam scenario, was tested and the system give a correct exact output as follow:



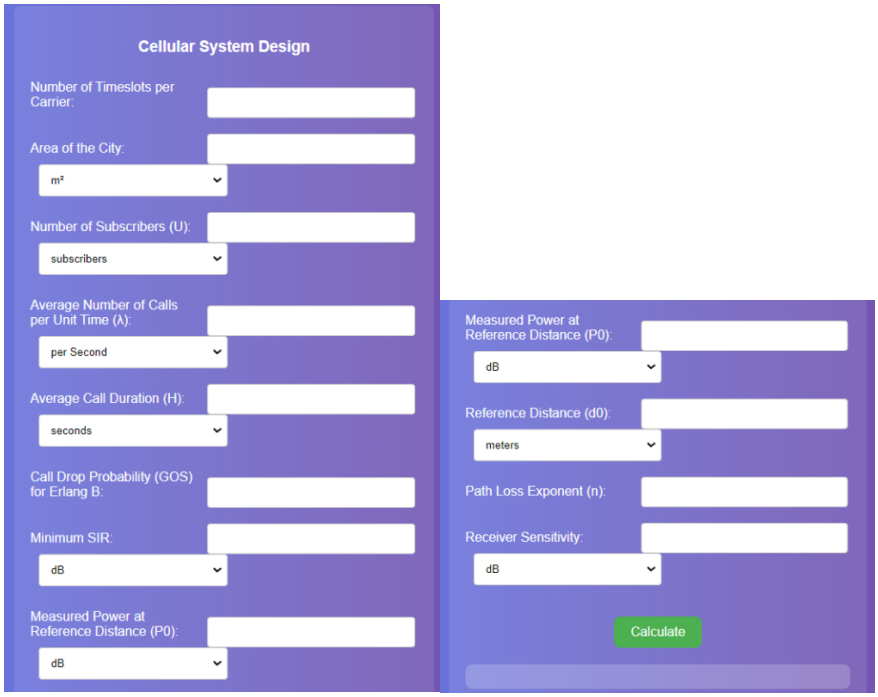
The second scenario, the inputs are filled in with these values, and the correct throughput value are obtained as shown in the picture below:



In the third case, the inputs are filled with these values using Slotted 1-persistent CSMA, and the right throughput value is produced, as seen in the figure below:



❖ When click on **"Cellular System Design"** the screen appears as follow:



It takes from the user the timeslots per carrier, the area of the city, the number of subscribers, the average of calls per unit time (λ), the average call duration (H), a call drop probability that the quality of service (GOS) for Erlang B and the minimum SIR needed to correctly provide the service (SIR), the measured power, the reference distance, base stations the path loss exponent and receiver sensitivity.

It uses this equation to find d $P_r = P_0\left(\frac{d}{d_0}\right)^{-n}$

Then use cell size $\frac{3\sqrt{3}}{2}(R^2)$

The number of cells = The area of the city / cell size
take it an integer

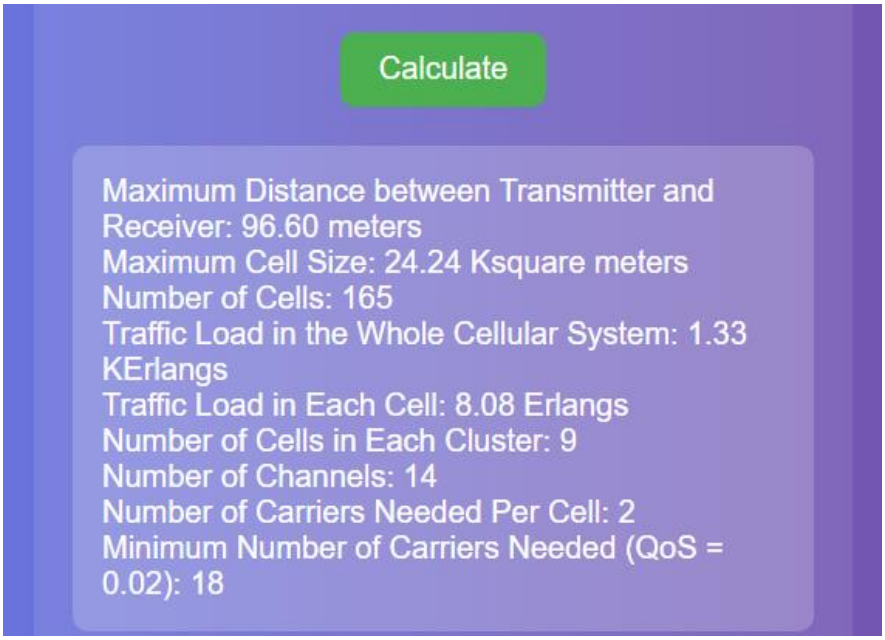
Then calculate traffic load in whole cellular = U * λ * H
Acell = the total traffic load / number of cells

Then apply SIR equation $\Rightarrow SIR = \frac{(\sqrt{3N})^n}{N_B} = \frac{Q^n}{N_B}$

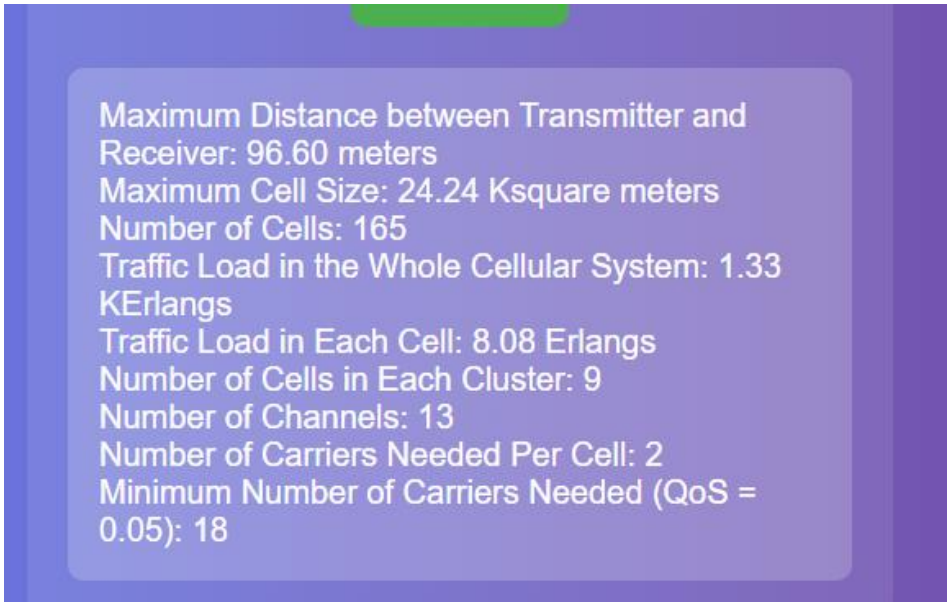
Then from its equation and Nb already known (6), it finds N and it should round the resulting number to the closest possible number that includes this number or is greater of the possible values of N (1, 3, 4, 7, 9, 12, 13, 16, 19, 21, 28).

The sheet scenario, was tested, and the system gave the identical output as follows:

- When the Call Drop Probability (GoS) for Erlang B = 0.02:



- When the Call Drop Probability (GoS) for Erlang B = 0.05:

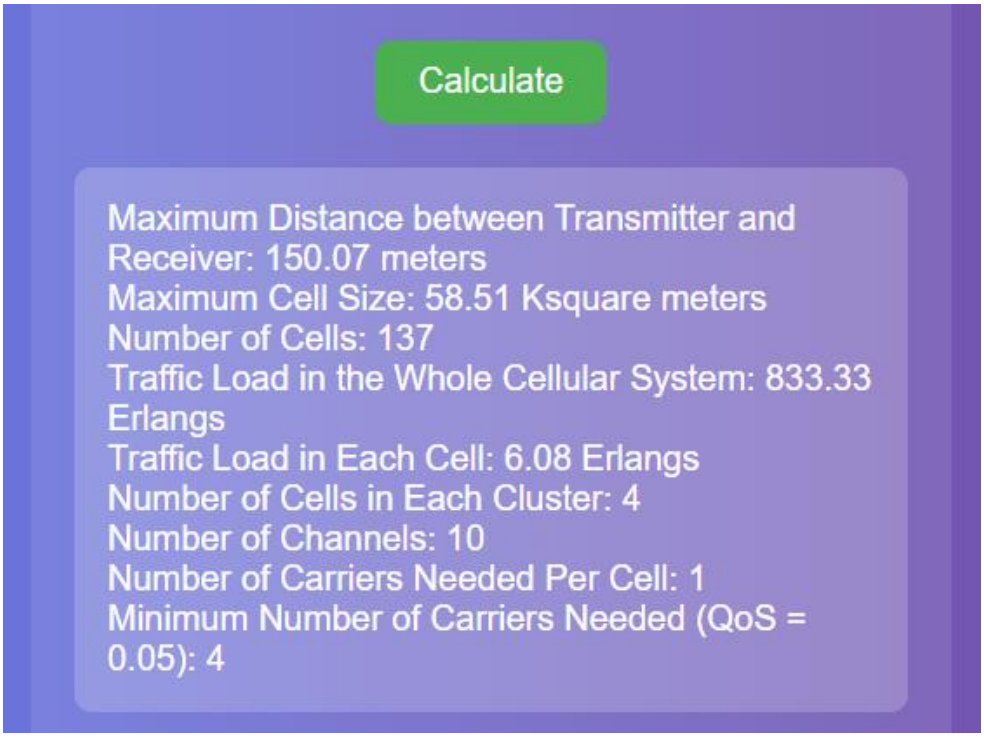


There is different in the number of channels but when calculate the number of carriers and round them; they are equal.

In another scenario, the inputs entered as follow:

- Number of Timeslots per Carrier: 10
- Area of the City: 8 km²
- Number of Subscribers (U): 120 thousand
- Average Number of Calls per Unit Time (λ): 5 per Day
- Average Call Duration (H): 2 mins
- Call Drop Probability (GoS) for Erlang B: 0.01
- Minimum SIR: 15 dB
- Measured Power at Reference Distance (P0): -18 dB
- Reference Distance (d0): 20 meters
- Path Loss Exponent (n): 4
- Receiver Sensitivity: 5 µwatt

And the system gives a correct and logical answers as shown below:



- Note:

  To find all details about the call drop probability (GOS), the table entered as array and the system search in the data specific to the selected probability from user. And when it finds the closest number that includes number (Ac), here it finds number of channels.

  Then it finds the number of carriers needed per cell = number of channels / timeslots per carrier
  Finally, the number of carriers the whole system is = the number of carriers needed per cell * N