جامعة بيرزيت

BIRZEIT UNIVERSITY

Faculty of Engineering and Technology

Electrical and Computer Engineering Department

WIRELESS AND MOBILE NETWORKS

ENCS5323

Online Calculator for Wireless and Mobile Networks

Students' Names: Yousef Shamasneh, Nour Rabee'

ID Numbers: 1190300, 1191035

Instructor's Name: Dr. Mohammad Jubran

Section: 3

June 23, 2024

In this project, we implement a calculator using React to solve 5 types of questions:

1. The number of bits and rate of the sampler, quantizer, source encoder, channel encoder, and interleaver.
2. The number of bits and rate for resource elements, OFDM symbol, Resource Blocks, and maximum transmission using parallel resource blocks.
3. Power transmitted in a flat environment based on the transmitter and receiver specifications.
4. Throughput in percent of Multiple Access techniques.
5. Design of cellular system.

Main page :

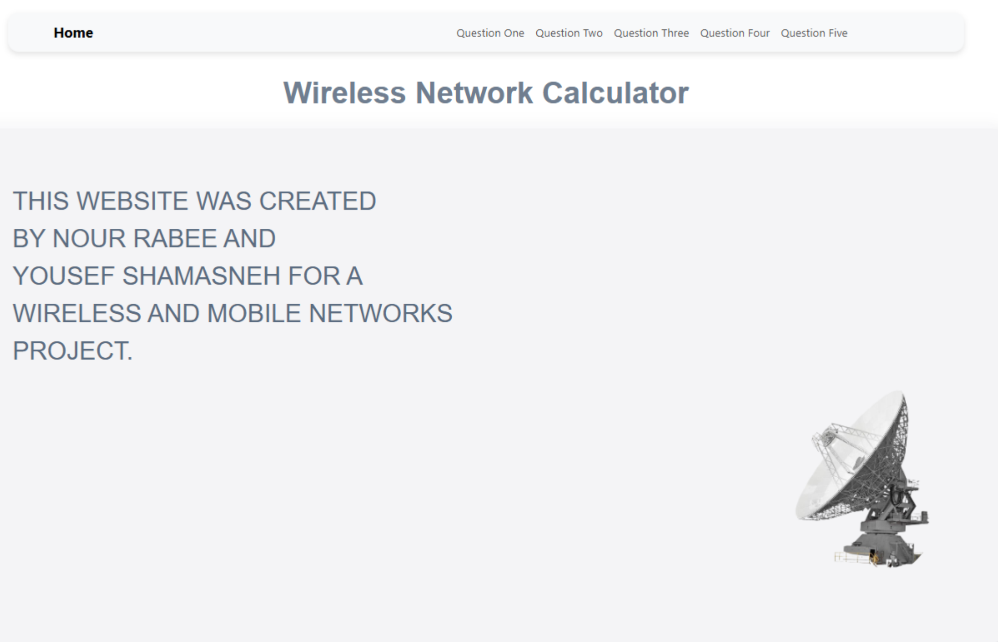


Figure 1: Menu Page

Note that our website is not responsive; components sizes may change when screen's size change. To run the code, you need to install the following libraries: react-router-dom and react-bootstrap.

Question One

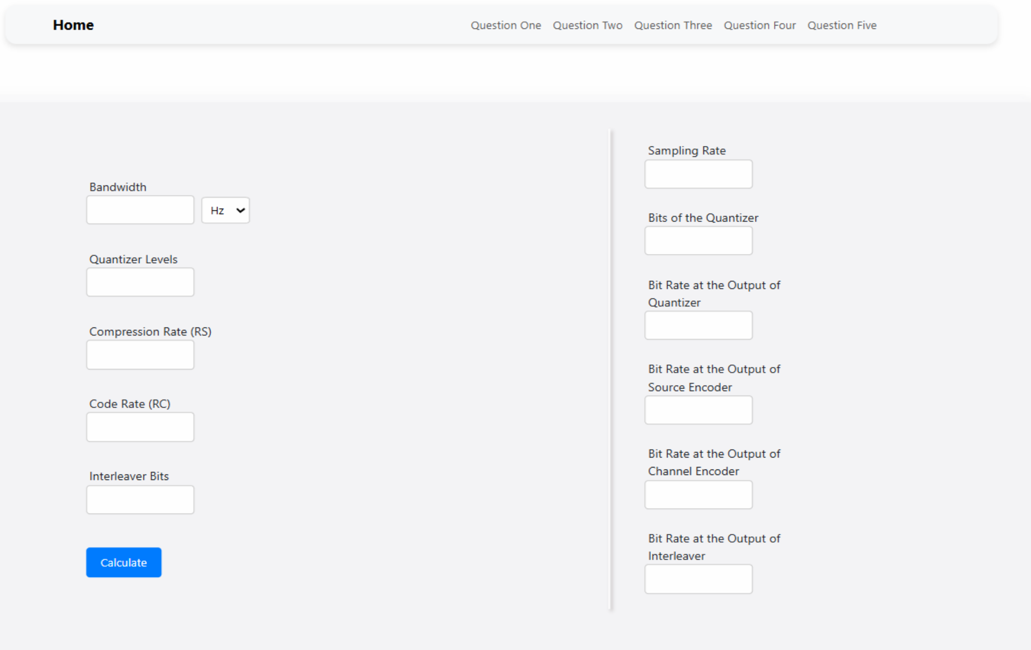
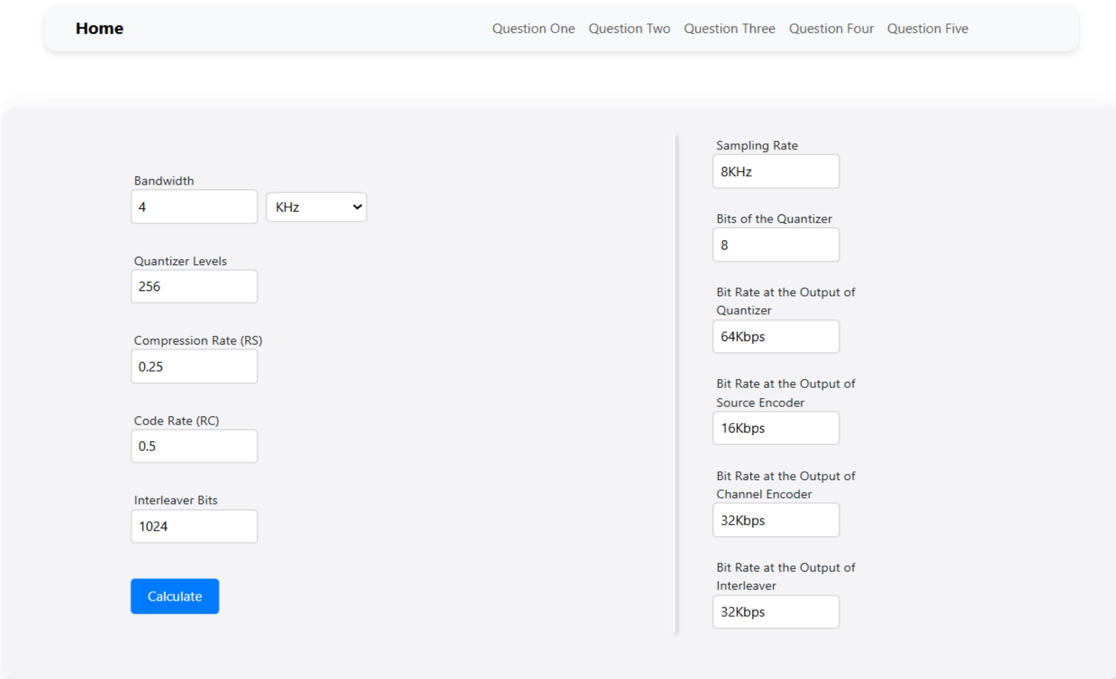


Figure 2: First Calculator "question one"

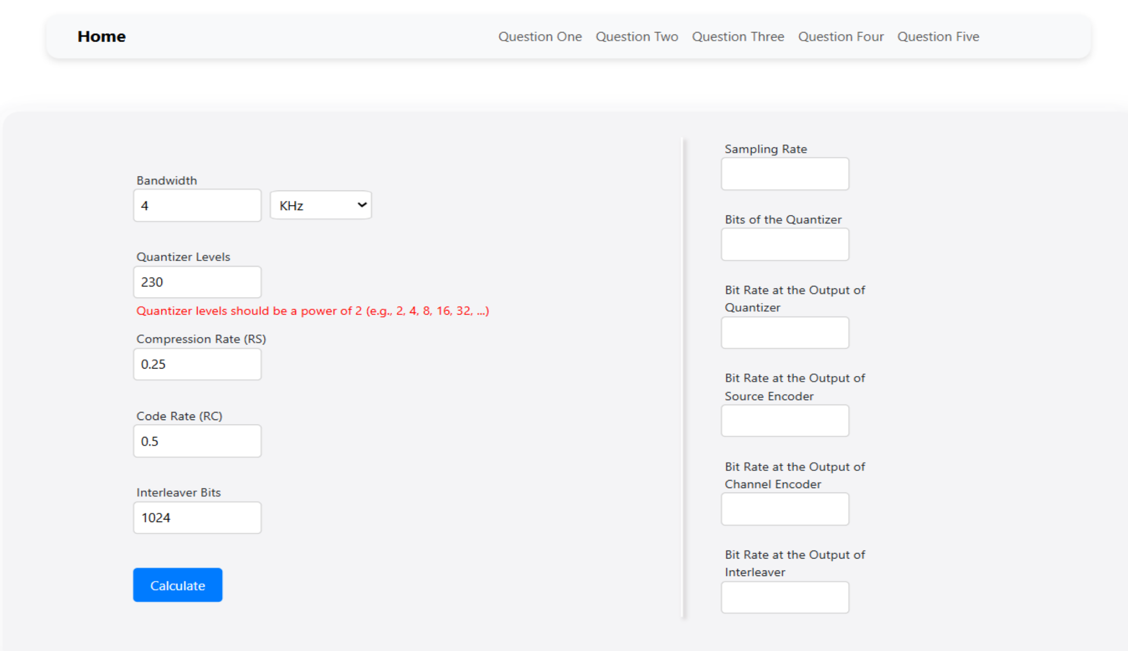
The user will enter the bandwidth (BW), number of quantizer levels (L), compression rate (Rc), code rate (Rs), and interleaver bits. Upon clicking the “Calculate” button, six outputs will be computed. First, the sampling rate which is 2(BW). Second, Bits of the Quantizer which is $\log_2 L \ bits/sample$. Third, the bit rate at the output of the quantizer (input to the source encoder), which is the sampling rate multiplied by the number of bits of the quantizer. Fourth, the bit rate at the output of the source encoder (input to the channel encoder), which is the input to the source encoder multiplied by the compression rate. Fifth, the bit rate at the output of the channel encoder (input to the interleaver), which is the input to the channel encoder divided by the code rate. Finally, the bit rate at the output of the interleaver remains the same as its input, since the number of bits of the interleaver does not affect the bit rate.

Scenario 1



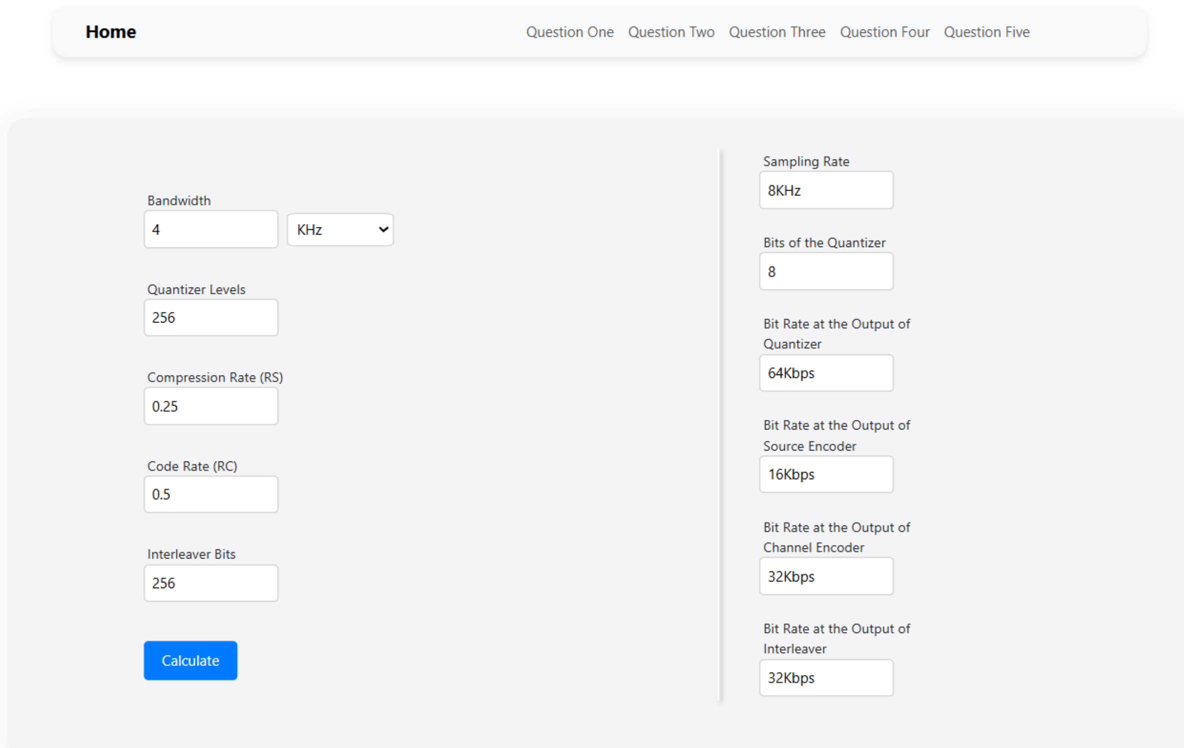
Users can select the unit for the bandwidth (BW) between Hz and kHz. All the results are correctly calculated and presented as mentioned earlier.

Scenario 2



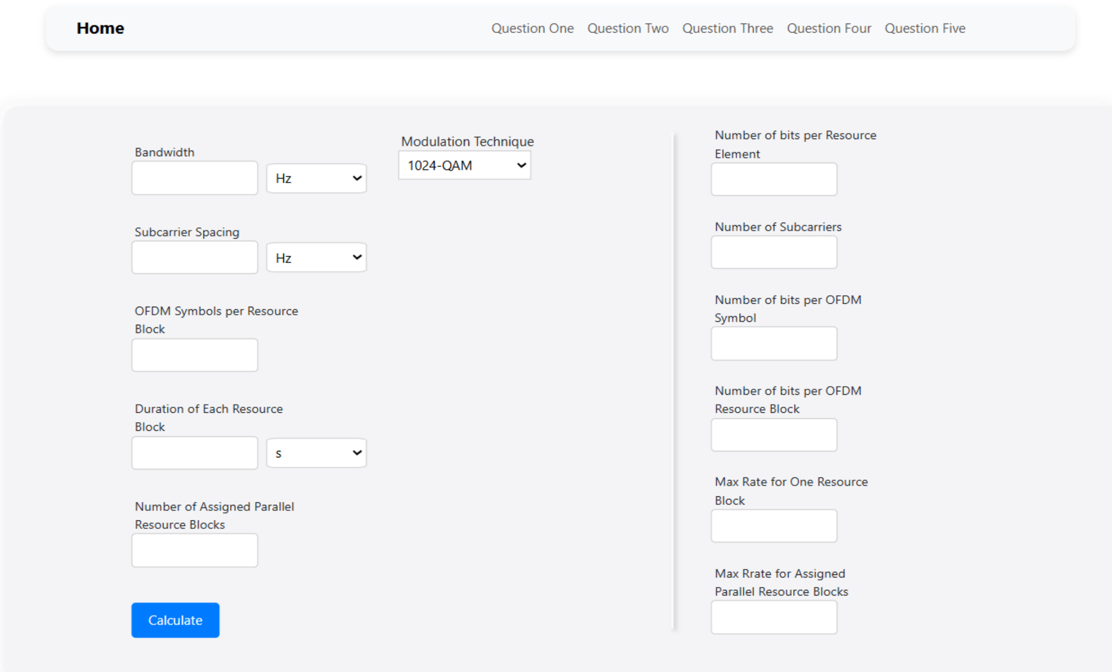
If the user enters a value in the quantizer levels field that is not a power of 2, an error will occur. This is because the logarithm base 2 of a nonpower of 2 value results in a float, but the number of bits for the quantizer must be an integer.

Scenario 3



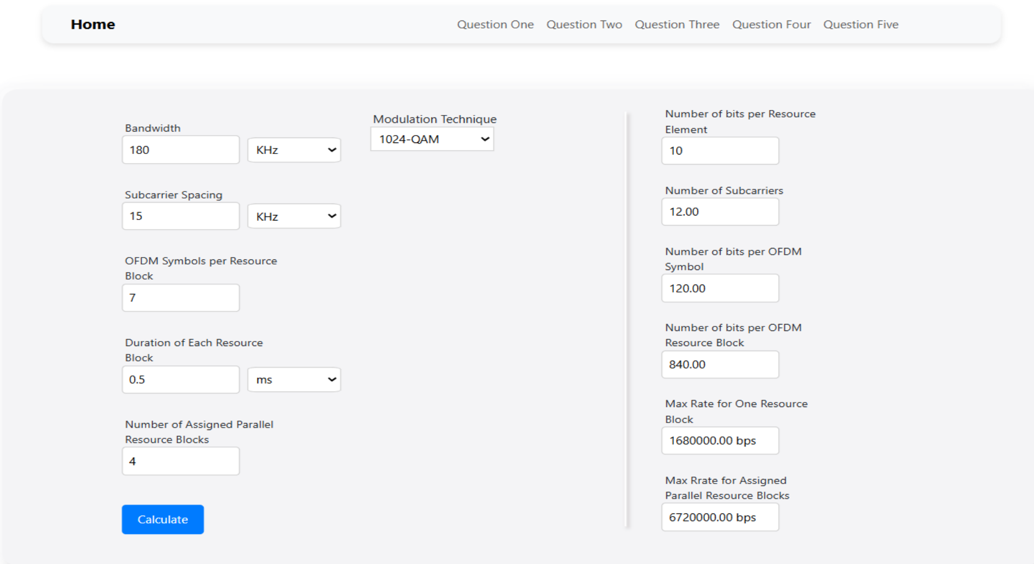
Changing the number of interleaver bits does not affect the bit rate of the interleaver output, as shown in the Figure above.

Question Two



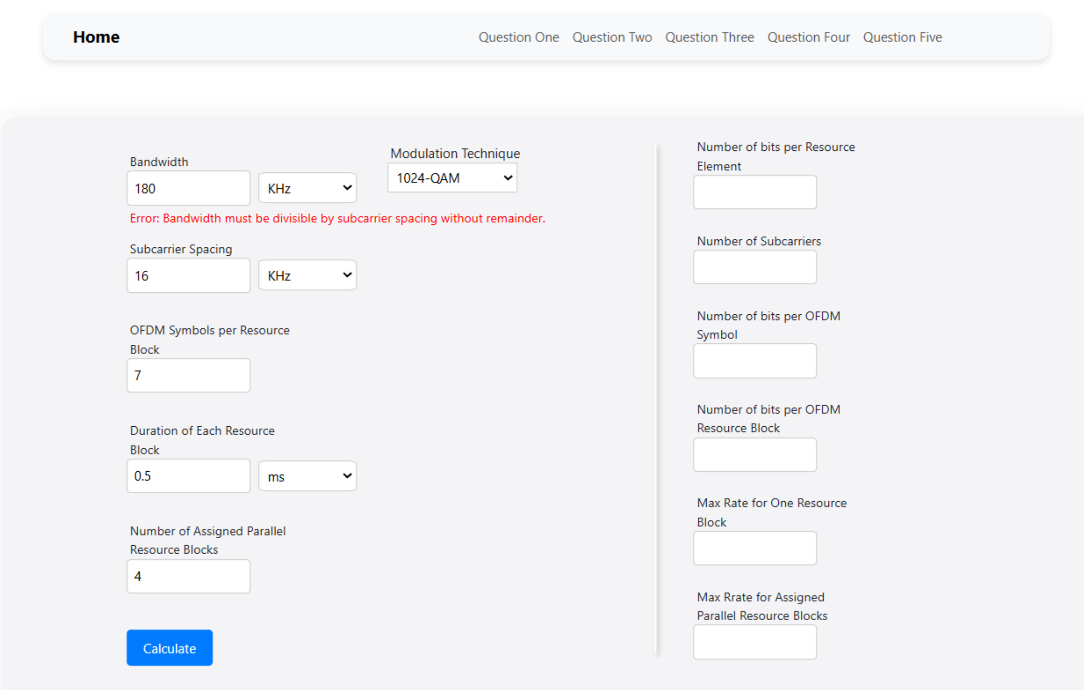
In this calculator, users input several parameters including bandwidth (BW), subcarrier spacing, number of OFDM symbols per resource block, duration of each resource block, and select one of five modulation techniques: BPSK, 16-QAM, 64-QAM, 256-QAM, or 1024-PQAM. Upon clicking the "Calculate" button, the system computes six key outputs. Firstly, it determines the number of bits per resource element based on the chosen modulation technique, calculated as the logarithm base 2 of the number of bits specific to that modulation scheme. Secondly, it calculates the number of subcarriers by dividing the bandwidth by the subcarrier spacing. Thirdly, it computes the number of bits per OFDM symbol by multiplying the bits per resource element by the number of subcarriers. Fourthly, the system determines the number of bits per OFDM resource block by multiplying the bits per OFDM symbol by the number of OFDM symbols per resource block. Fifthly, it calculates the maximum rate for one resource block by dividing the number of bits per OFDM resource block by the duration of each resource block. Finally, it computes the maximum rate for n resource blocks by multiplying the maximum rate for one resource block by n.

Scenario 1



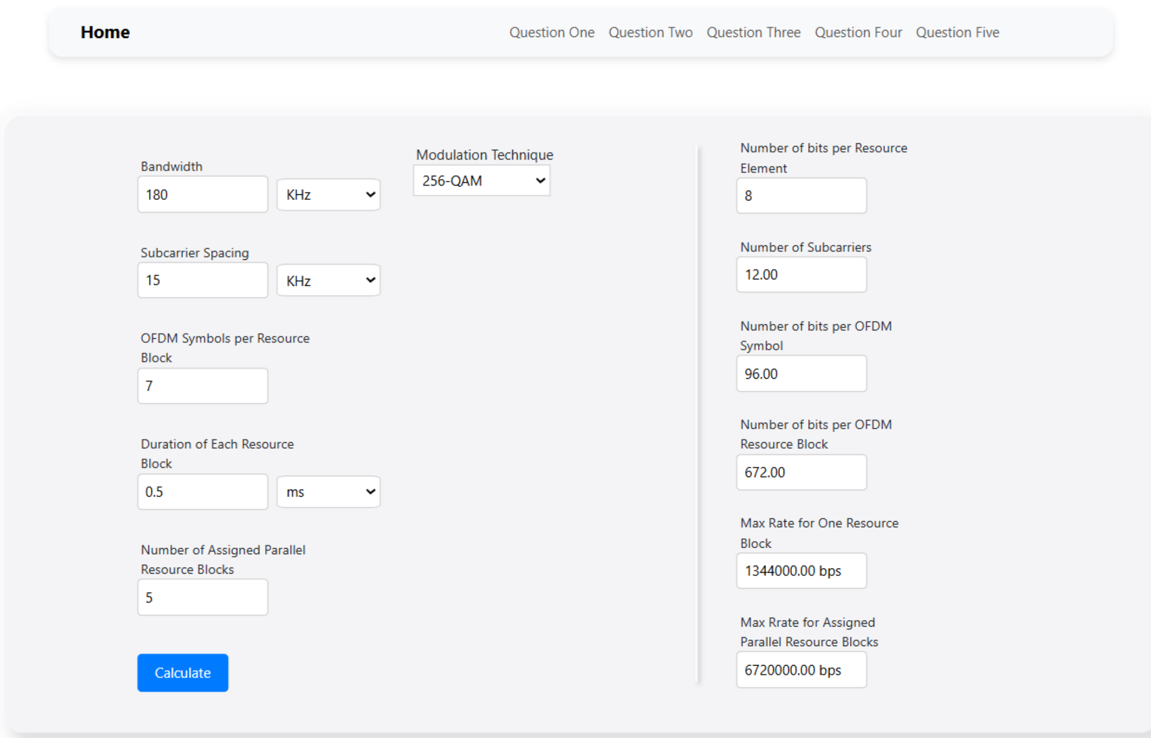
Users can select the unit for bandwidth (BW) and subcarrier spacing, choosing between Hz and kHz. Also, they can select the unit for the duration of each resource block from options including ms, sec, and microseconds (μs). All calculations are accurate and presented as previously described.

Scenario 2



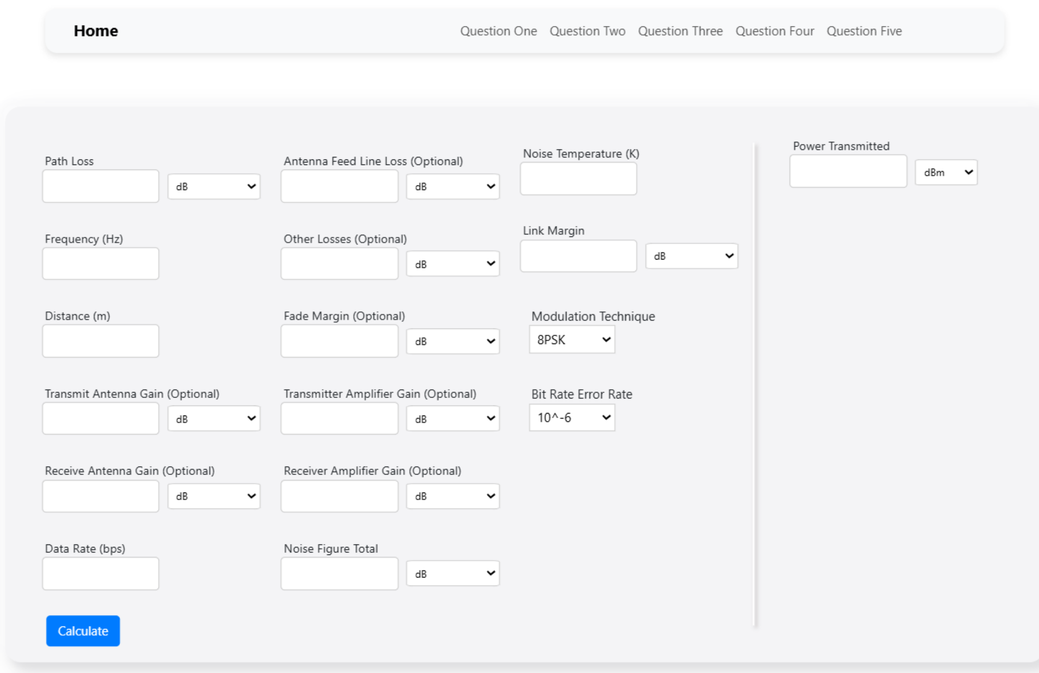
As mentioned earlier, the number of subcarriers is determined by dividing the bandwidth (BW) by the subcarrier spacing. Therefore, users must enter values that divide evenly without any remainder, as the subcarrier spacing must be an integer and cannot accept floating-point numbers.

Scenario 3



In this scenario, the user selected the modulation technique 256-QAM and chose to use 5 parallel resource blocks instead of 4. The calculations are as follows: the number of bits per resource element is 8 bits (since $\log_2 256 = 8$ bits); the number of subcarriers remains unchanged; the number of bits per OFDM symbol is 96 bits (8 bits per resource element multiplied by 12 subcarriers); the number of bits per OFDM resource block is 672 bits (96 bits per OFDM symbol multiplied by 7 OFDM symbols per resource block); the maximum rate for one resource block is 1,344,000 bps (672 bits per OFDM resource block divided by 0.5 ms duration); finally, the maximum rate for 5 resource blocks is 6,720,000 bps (1,344,000 bps multiplied by 5).

Question Three

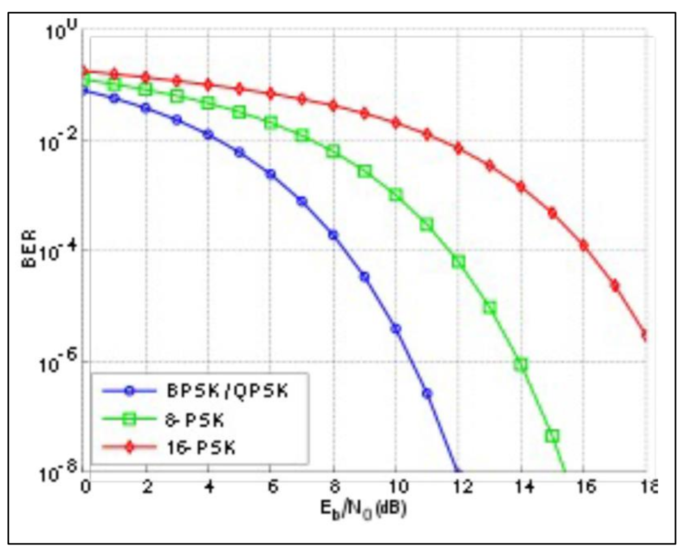


This calculator computes the transmitted power and displays it in three units: dB, dBm, and watt. The formula used is:

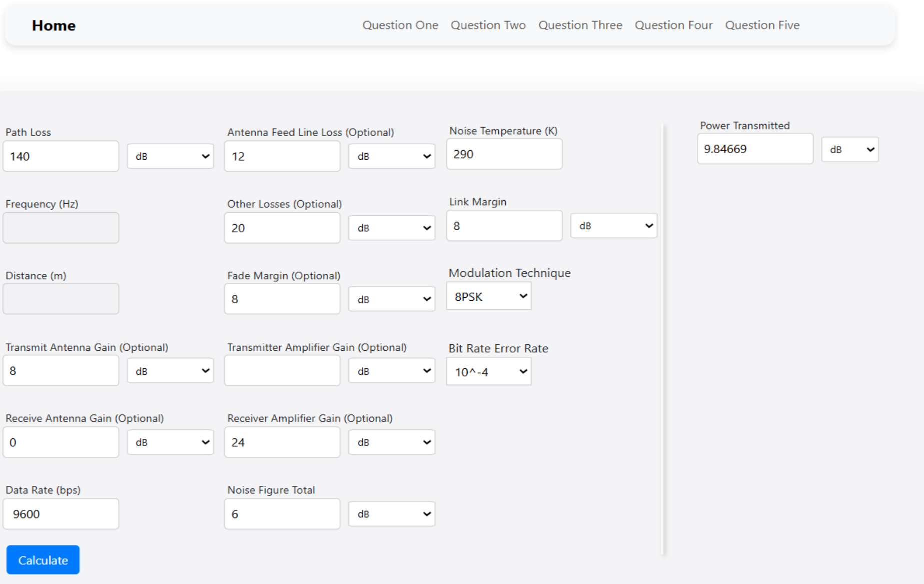
$$P_{t,db} = K + T + N_{f,total} + R + (E_b/N_o)_{req} + L_p + L_f + L_o + F_{margin} + M - G_t - G_r - A_t - A_r$$

All values in this equation are in dB. The required (Eb/No) is calculated based on the modulation technique and the specified Bit Error Rate (BER) value intersection. Any gain or loss (except path loss) that is unspecified will be assumed to be 0 dB and not included in the calculation.

Also, if the user enters the path loss value, the fields for frequency and distance will be disabled. Conversely, if the user enters the frequency and distance, the path loss can be calculated from these inputs.



Scenario 1

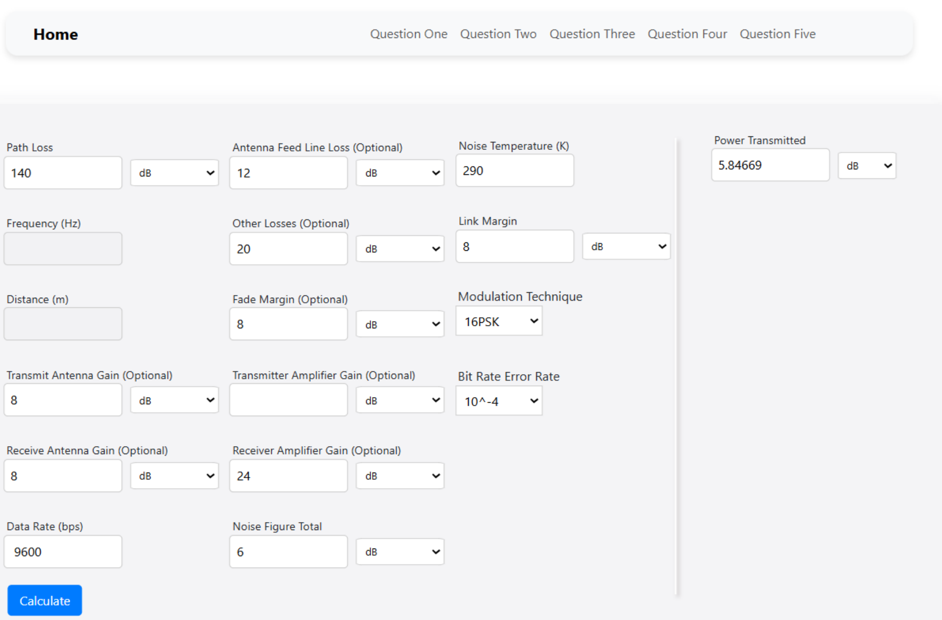


In this scenario, (Eb/No) req = 12 which is the intersection between 8psk and 10^-4.

Pt,db = K + T+ Nf,total + R + (Eb/No)req + Lp + Lf + Lo+ Fmargin + M – Gt – Gr –At – Ar

=-228.6 db +(10 $\log_{10} 290$ = 24.623 db) +6db+ (10 $\log_{10} 9.6k$ = 39.8 db) + 12db + 140db+ 12 db + 20 db + 8 db +8db -8db -0 -0 -24db

Scenario 2

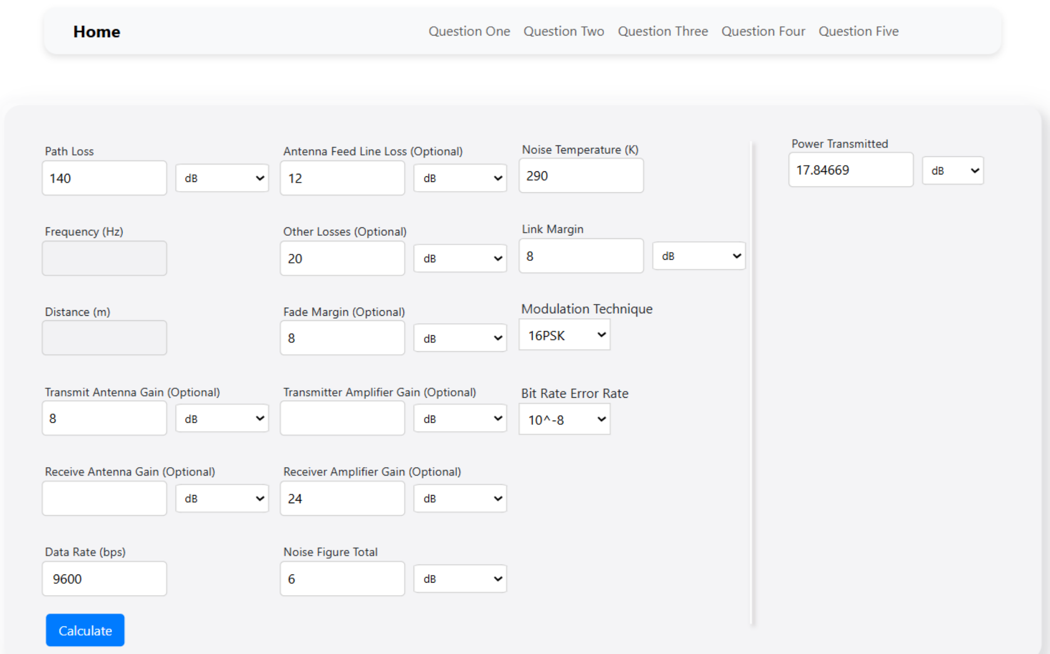


In this scenario, we have switched to 16PSK modulation with a BER of 10^-4, resulting in an intersection value of 16 dB. Additionally, the receive antenna gain has been adjusted to 8 dB.

Pt,db = K + T+ Nf,total + R + (Eb/No)req + Lp + Lf + Lo+ Fmargin + M – Gt – Gr –At – Ar

=-228.6 db +($10 \log_{10} 290$ = 24.623 db) +6db+ ($10 \log_{10} 9.6k$ = 39.8 db) + 16db + 140db+ 12 db + 20 db + 8 db +8db -8db -8db -0 -24db

Scenario 3

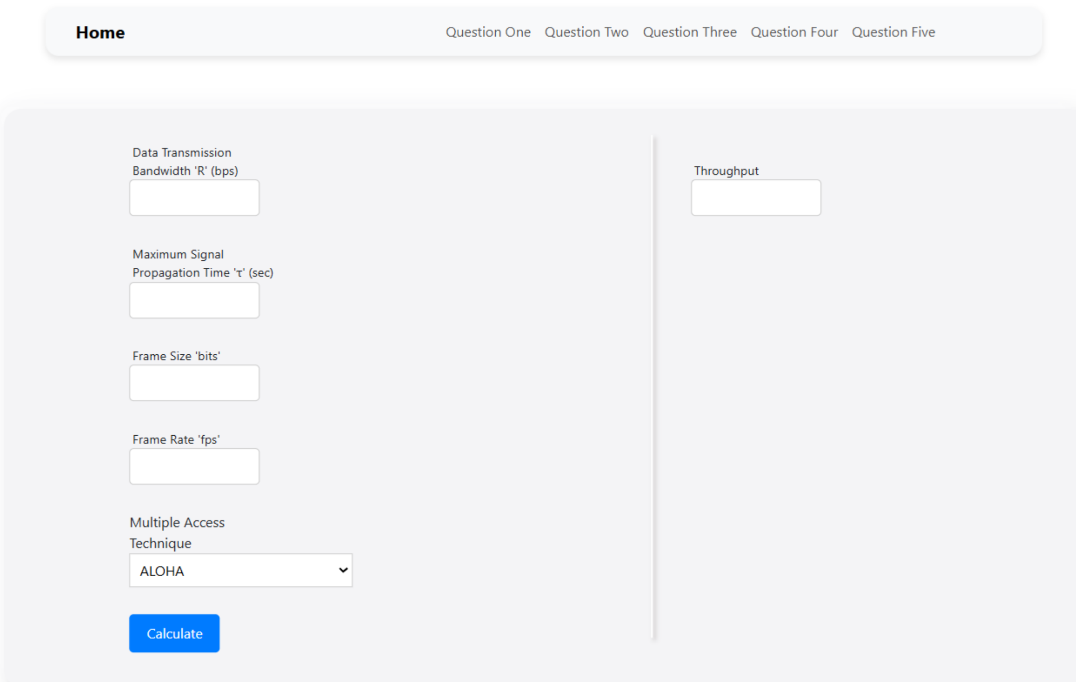


In this scenario, we have switched to 16PSK modulation with a BER of 10^-8, resulting in an intersection value of 20 dB, and the receive antenna gain has been adjusted to 0 Db again.

Pt,db = K + T+ Nf,total + R + (Eb/No)req + Lp + Lf + Lo+ Fmargin + M – Gt – Gr –At – Ar

=-228.6 db +($10 \log_{10} 290$ = 24.623 db) +6db+ ($10 \log_{10} 9.6k$ = 39.8 db) + 20db + 140db+ 12 db + 20 db + 8 db +8db -8db -0db -0 -24db

Question Four



In this calculator, users input several parameters including data transmission bandwidth (R), maximum signal propagation time (taw), frame size, frame rate, and select one of multiple access technique: ALOHA, SLOTTED ALOHA, UNSLOTTED NONPERSISTENT CSMA, SLOTTED NONPERSISTENT CSMA, UNSLOTTED 1-PERSISTENT CSMA, SLOTTED 1-PERSISTENT CSMA. Upon clicking the "Calculate" button, the system computes the throughput.

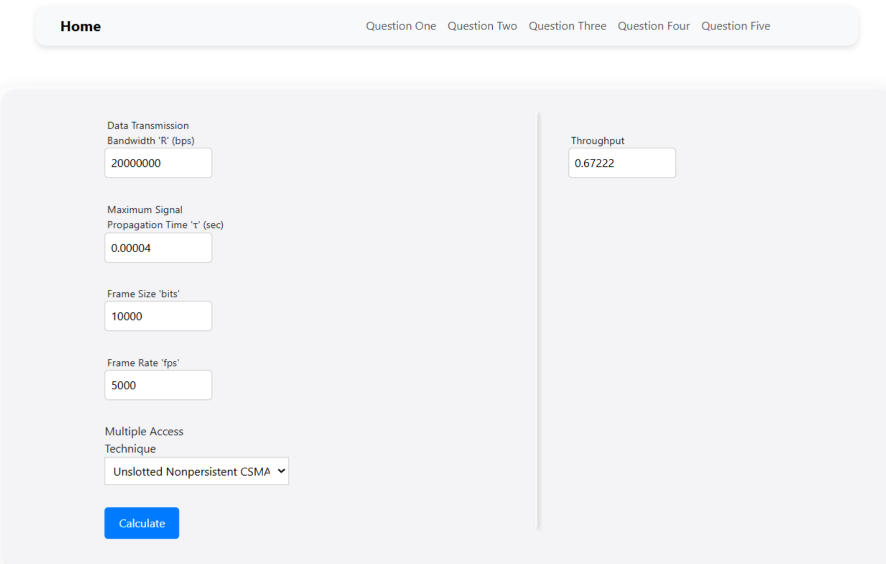
For example, to calculate the throughput using ALOHA, Sth = Ge^-2G

G = gT; g = frame rate, T = frame period

T = Tb * frame size

Alpha = taw/T → used in other multiple access techniques such as UNSLOTTED NONPERSISTENT CSMA

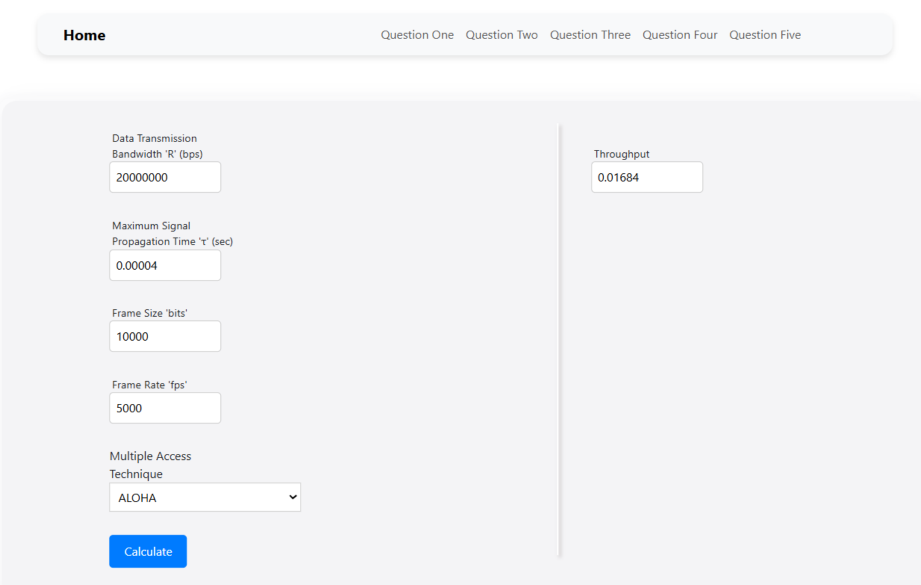
Scenario 1



The throughput of un-slotted non-persistent csma:

$$\boxed{S_{th} = \frac{Ge^{-2\alpha T}}{G(1+2\alpha)+e^{-\alpha G}}}$$

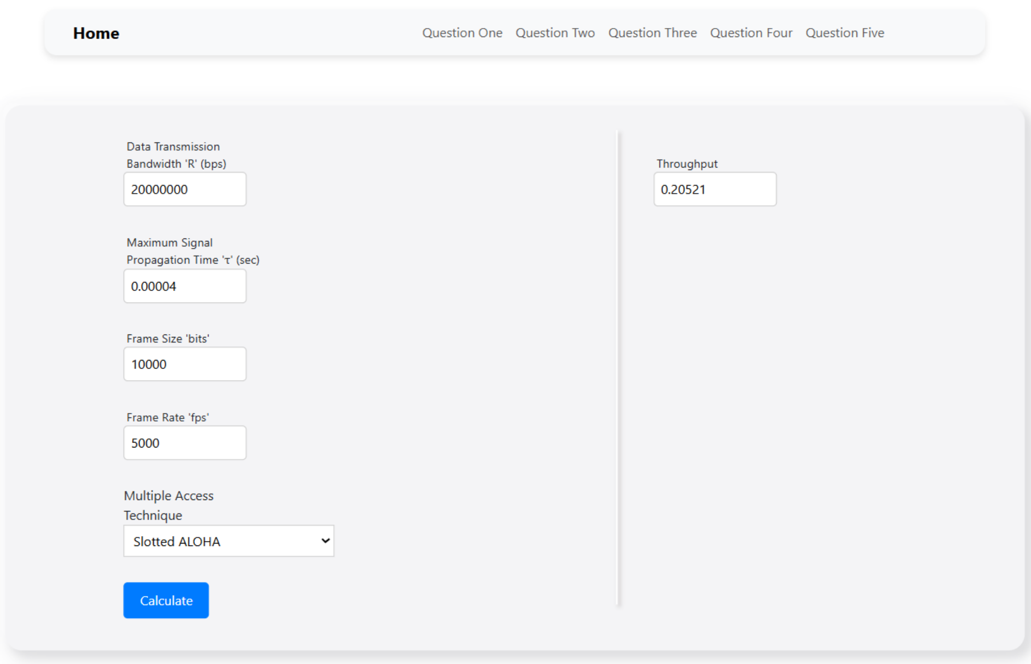
Scenario 2



The throughput of aloha:

$$\boxed{S_{th} = Ge^{-2G}}$$

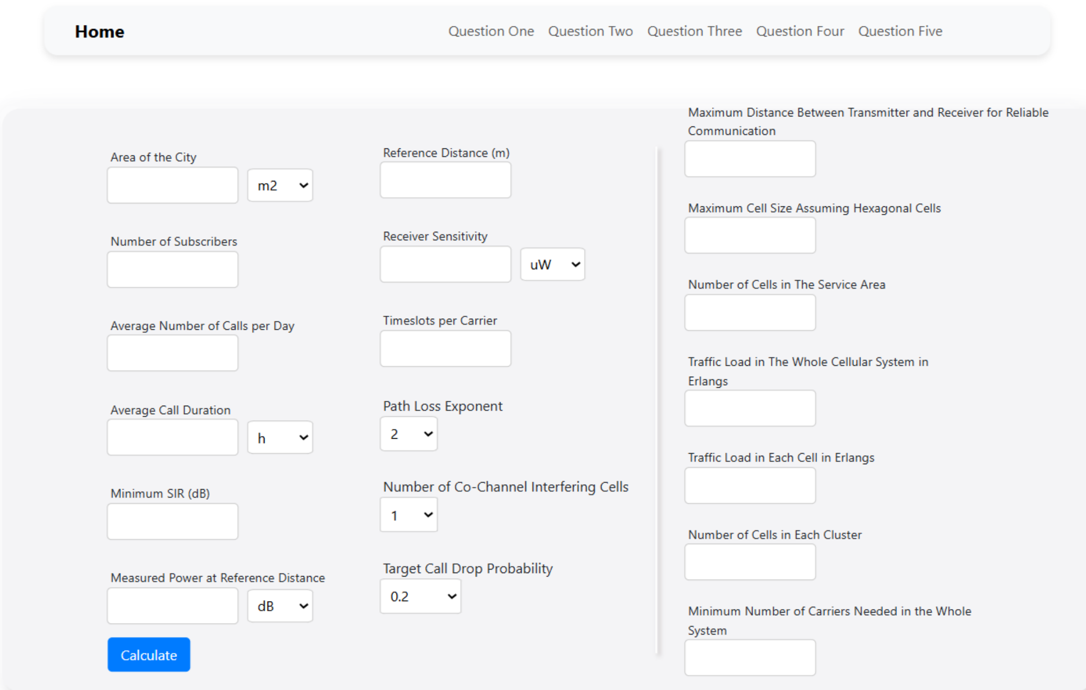
Scenario 3



The throughput of un-slotted aloha:

$$\boxed{S_{th} = Ge^{-G}}$$

Question Five



In this calculator, users input various parameters such as the area of the city, number of subscribers, average number of calls per day, average call duration, minimum SIR, measured power at reference distance, reference distance, receiver sensitivity, timeslots per carrier, path loss exponent (values between 2-4), number of co-channel interfering cells (6, 2, or 1), and target call drop probability. When the “Calculate” button is clicked, the system computes seven key outputs.

Firstly, the Maximum Distance Between Transmitter and Receiver for Reliable Communication is calculated by multiplying the reference distance by (measured power at that reference distance/ receiver sensitivity in watt)$^{1/\text{ path loss exponent value}}$.

Secondly, the Maximum Cell Size Assuming Hexagonal Cells is calculated using the formula: $\frac{3\sqrt{3}}{2}\ R^2$ where R is derived from the first output.

Thirdly, the Number of Cells in The Service Area is determined by dividing the area by the cell size.

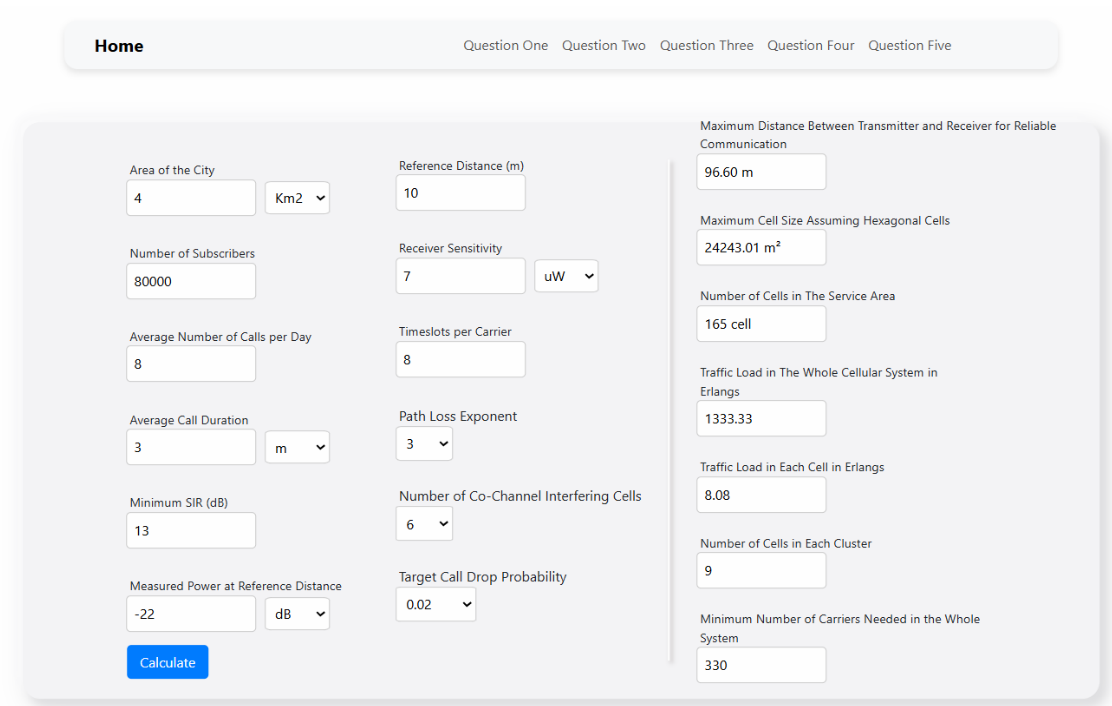
Fourthly, the Traffic Load in The Whole Cellular System in Erlangs (Au) is calculated by multiplying the average number of calls per hour by the average call duration in hours, and then calculating A = UAU, where u is the total number of subscribers.

Fifthly, the Traffic Load in Each Cell in Erlangs is obtained by dividing the Traffic Load in The Whole Cellular System in Erlangs by the number of cells.

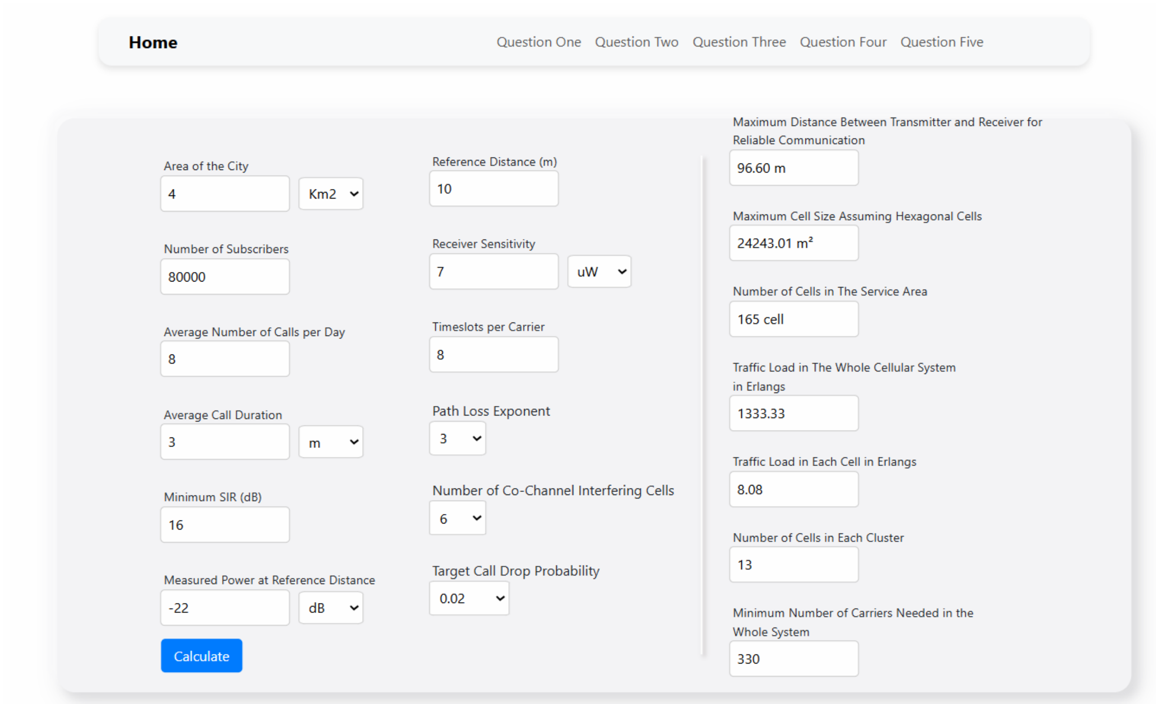
Sixthly, the Signal to Interference Ratio (SIR) is calculated by $\frac{1}{3}$(number of co-channel interfering cells * $10^{SIR/10}$)^2/ path loss exponent value.

Finally, the Minimum Number of Carriers Needed in the Whole System is determined using the Erlang B curve. The intersection between the probability of a call being blocked and the traffic intensity per cell gives the number of channels per cell. Dividing this number by the timeslots per carrier gives the number of carriers needed per cell. Multiplying this by the number of cells in the system gives the minimum number of carriers needed in the whole system.

Scenario 1

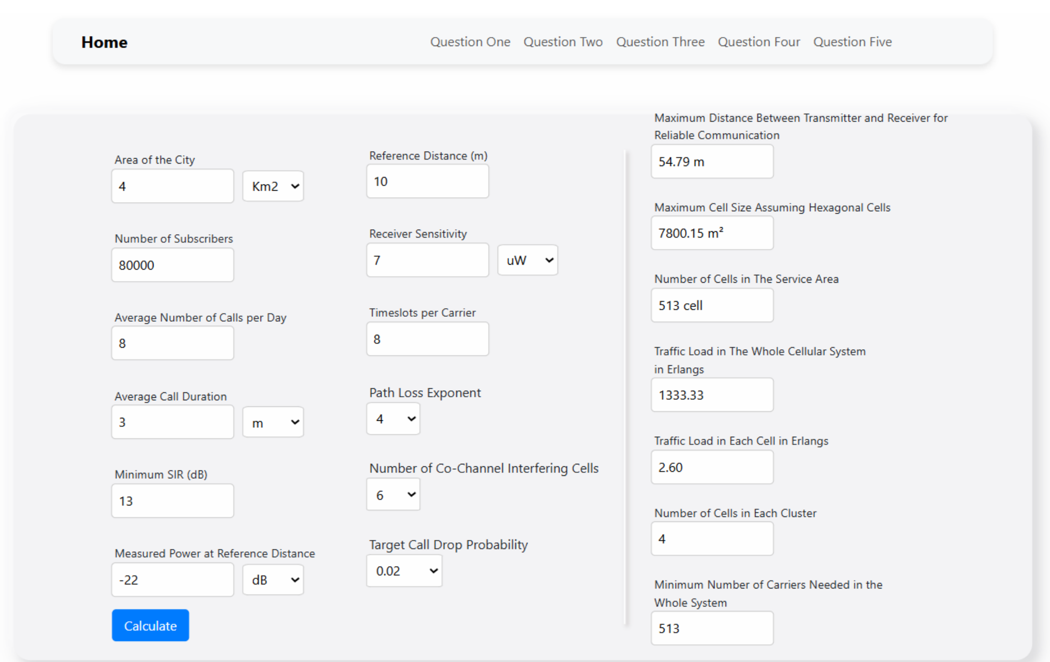


Scenario 2



In this scenario, we increase the SIR value to 16. This change primarily affects the number of cells in each cluster (N), which also increases as the SIR value goes up. An increased signal-to-noise ratio means reduced interference, which is achieved by adding more cells to each cluster, thereby increasing the distance between clusters.

Scenario 3



In this scenario, increasing the path loss exponent from 3 to 4 impacts several outputs. The “Maximum Distance Between Transmitter and Receiver for Reliable Communication” decreases because the formula depends on the path loss exponent. So, the cell radius “distance Between Transmitter and Receiver” decreases since the signal attenuates more quickly, reducing the effective communication distance.

Also, the number of cells in each cluster decreases. This is because a higher path loss exponent means less interference between cells using the same frequencies, allowing for a smaller reuse factor (N).