

Birzeit University



Faculty of Engineering and Technology

Electrical and Computer Engineering Department

WIRELESS AND MOBILE NETWORKS

ENCS5323

Course Project:

Online Calculator for Wireless and Mobile Networks

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Section: 1

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Calculator 1:

1.1 This is the scenario that we solved in the midterm exam.

Digital Communication System Calculator

Bandwidth:

Number of bits for quantizer:
Source encoder rate:
Channel encoder rate:
Interleaver number of bits:

Results

Sampling Frequency: 8 kHz
Number of Quantization Levels: 256
Bit Rate at Source Encoder Output: 16 kbps
Bit Rate at Channel Encoder Output: 32 kbps
Bit Rate at Interleaver Output: 32 kbps

Click on the units to change them

1.2: For the second scenario, I used the following inputs

1: $2 \times 2 = 4\text{kHz}$, 2: $2^4 = 16$, 3: $4 \times 4 = 16 \times 0.25 = 4$, 4: $4/0.5 = 8$

Digital Communication System Calculator

Bandwidth:

Number of bits for quantizer:
Source encoder rate:
Channel encoder rate:
Interleaver number of bits:

Results

Sampling Frequency: 4,000 Hz
Number of Quantization Levels: 16
Bit Rate at Source Encoder Output: 4 kbps
Bit Rate at Channel Encoder Output: 8 kbps
Bit Rate at Interleaver Output: 8 kbps

Click on the units to change them

1.3: For the last scenario, I used the following inputs

To verify the result,

1: $5 \times 2 = 10\text{KHZ}$, 2: $2^7 = 128$, 3: $10 \times 7 = 70 \times 0.15 = 10.5$, 4: $10.5 / 0.3 = 35$

Digital Communication System Calculator

Bandwidth:

kHz

Number of bits for quantizer:

Source encoder rate:

Channel encoder rate:

Interleaver number of bits:

Calculate

Results

Sampling Frequency: 10,000 Hz

Number of Quantization Levels: 128

Bit Rate at Source Encoder Output: 10.5 kbps

Bit Rate at Channel Encoder Output: 35,000 bps

Bit Rate at Interleaver Output: 35 kbps

Click on the units to change them

Calculator 2:

2.1: This is the scenario that we solved in the midterm exam.

4G LTE Calculator

Resource Block Bandwidth: 180 kHz

Subcarrier Spacing: 15 kHz

Number of OFDM symbols per resource block: 7

Resource Block Duration: 0.5 ms

Number of Parallel Resource Blocks: 4

Bits are modulated using: 1024

Calculate

Results

Number of Bits per Resource Element: 12

Number of Bits per OFDM Symbol: 120

Number of Bits per OFDM Resource Block: 840

Maximum Transmission Rate: 6.72 Mbps (click to change units)

2.2: For the second scenario, I tried to enter non-integer numbers in the Bandwidth and Subcarrier spacing Text Fields, also I tried to modulate the bits using input not accepted for log base 2 as shown below.

4G LTE Calculator

Resource Block Bandwidth: 180 kHz

Subcarrier Spacing: 15.5 kHz

Number of OFDM symbols per resource block: 7

Resource Block Duration: 0.5 ms

Number of Parallel Resource Blocks: 4

Bits are modulated using: 1024

Calculate

This page says
Resource Block Bandwidth and Subcarrier Spacing must be integers.

4G LTE Calculator

Resource Block Bandwidth: 180 kHz

Subcarrier Spacing: 15 kHz

Number of OFDM symbols per resource block: 7

Resource Block Duration: 0.5 ms

Number of Parallel Resource Blocks: 4

Bits are modulated using: 125

Calculate

This page says
QAM type must be a power of 2

2.3: For the last scenario, I used the following inputs:

To verify the result,

$0.044\text{MHz} = 44000\text{Hz}$, $0.000011\text{GHz} = 11000\text{Hz}$

1: $44000 / 11000 = 4$, 2: $4 * \log(256) = 4 * 8 = 32$, 3: $32 * 10 = 320$, 4: $10 * 320 / 700 * 10^{-6} = 4571428.571$
bps= 4.571Mbps

4G LTE Calculator	Results
Resource Block Bandwidth:	Number of Bits per Resource Element: 4
<input type="text" value="0.044"/>	Number of Bits per OFDM Symbol: 32
<input type="text" value="MHz"/>	Number of Bits per OFDM Resource Block: 320
Subcarrier Spacing:	Maximum Transmission Rate: 4,571,428.571 bps (click to change units)
<input type="text" value="0.000011"/>	
<input type="text" value="GHz"/>	
Number of OFDM symbols per resource block:	
<input type="text" value="10"/>	
Resource Block Duration:	
<input type="text" value="700"/>	
<input type="text" value="micros"/>	
Number of Parallel Resource Blocks:	
<input type="text" value="10"/>	
Bits are modulated using:	
<input type="text" value="256"/>	
<input type="button" value="Calculate"/>	

Calculator 3:

3.1: This is the scenario that we solved in the midterm exam.

Path Loss and Link Margin Calculator

Receive Amplifier Gain (Ar):	<input type="text" value="24"/>	<input type="text" value="dB"/>	Transmit Amplifier Gain (At):	<input type="text" value="8"/>	<input type="text" value="dB"/>
Transmit Antenna Gain (Gt):	<input type="text" value="0"/>	<input type="text" value="Unitless"/>	Receive Antenna Gain (Gr):	<input type="text" value="0"/>	<input type="text" value="Unitless"/>
Distance (d):	<input type="text" value="0"/>	<input type="text" value="m"/>	Data Rate (R):	<input type="text" value="9.6"/>	<input type="text" value="Kbps"/>
Frequency (F):	<input type="text" value="900"/>	<input type="text" value="MHz"/>	Path Loss (Lp):	<input type="text" value="140"/>	<input type="text" value="dB"/>
Feeder Loss (Lf):	<input type="text" value="12"/>	<input type="text" value="dB"/>	Other Losses (Lo):	<input type="text" value="20"/>	<input type="text" value="dB"/>
Fade Margin (Fmargin):	<input type="text" value="8"/>	<input type="text" value="dB"/>	Noise Figure (NF):	<input type="text" value="6"/>	<input type="text" value="dB"/>
Noise Temperature (Kelvin):	<input type="text" value="290"/>		Link Margin (M):	<input type="text" value="8"/>	<input type="text" value="dB"/>
Modulation Type:	<input type="text" value="8-PSK"/>		Maximum Bit Error Rate (BER):	<input type="text" value="10^-4"/>	

Calculate

Results

Power transmitted (Pt): 9.66 W

Click on the units to change them

The graph shows the Bit Error Rate (BER) on a logarithmic scale from 10^-8 to 10^0 versus the energy per bit to noise power spectral density ratio (Eb/N0) in dB on a linear scale from 0 to 18. Three curves are plotted: BPSK/QPSK (blue line with circles), 8-PSK (green line with squares), and 16-PSK (red line with diamonds). All curves show a decreasing trend of BER as Eb/N0 increases. BPSK/QPSK has the lowest BER for a given Eb/N0, followed by 8-PSK, and then 16-PSK.

E_b/N_0 (dB)	BPSK/QPSK BER	8-PSK BER	16-PSK BER
0	~0.1	~0.2	~0.3
2	~0.02	~0.05	~0.1
4	~0.005	~0.015	~0.03
6	~0.001	~0.005	~0.01
8	~0.0002	~0.0015	~0.003
10	~2e-5	~0.0005	~0.001
12	~2e-6	~0.00015	~0.0003
14	~2e-7	~5e-5	~0.0001
16	~2e-8	~1.5e-5	~3e-5

3.2 For the second scenario, I used the previous inputs, but I changed the units.



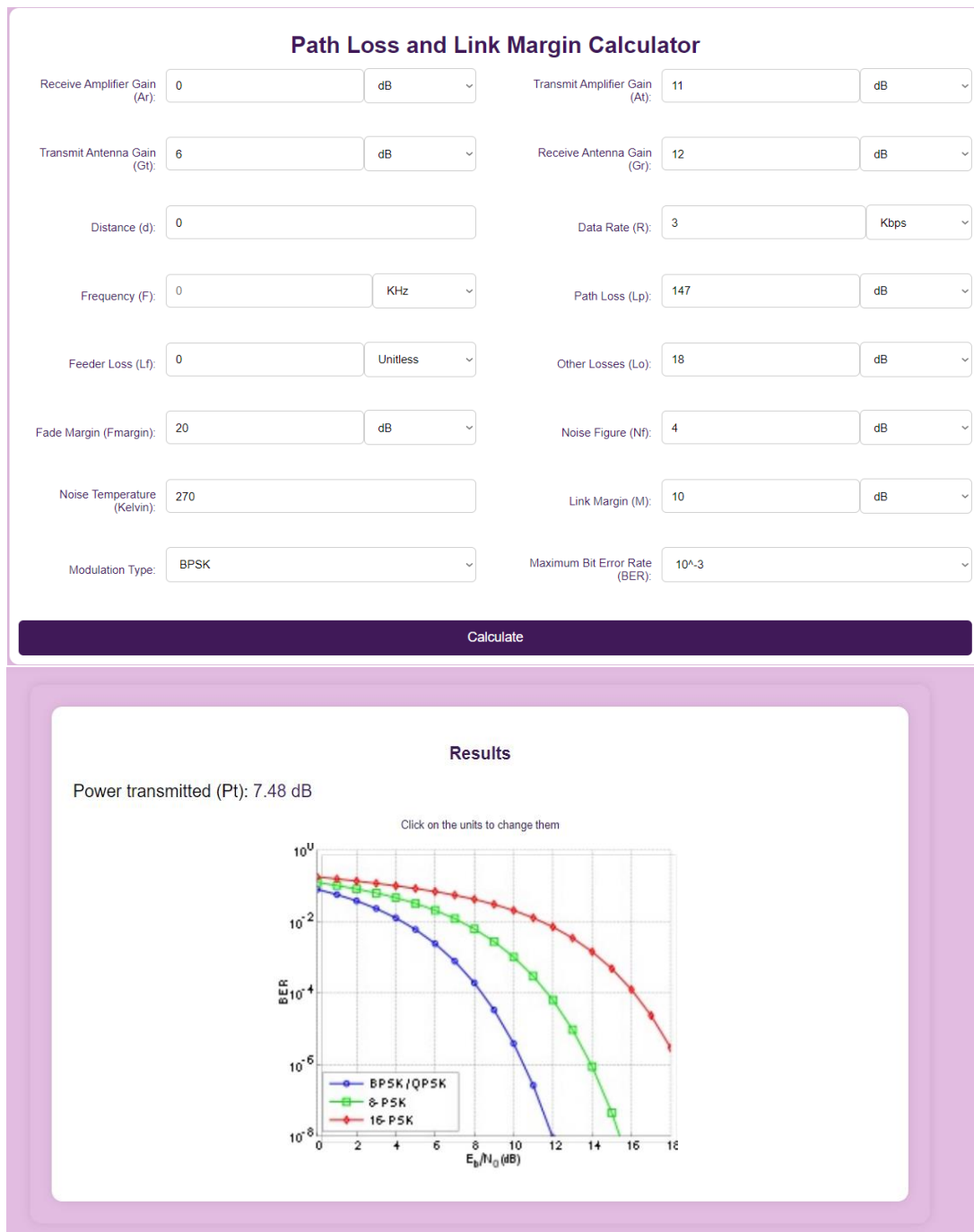
3.3: For the last scenario, I used the following inputs:

To verify the result,

$$P_t = M - G_t - G_r - A_r - A_t + L_p + L_f + L_o - K + T + N_f + E_b/N_0 + R$$

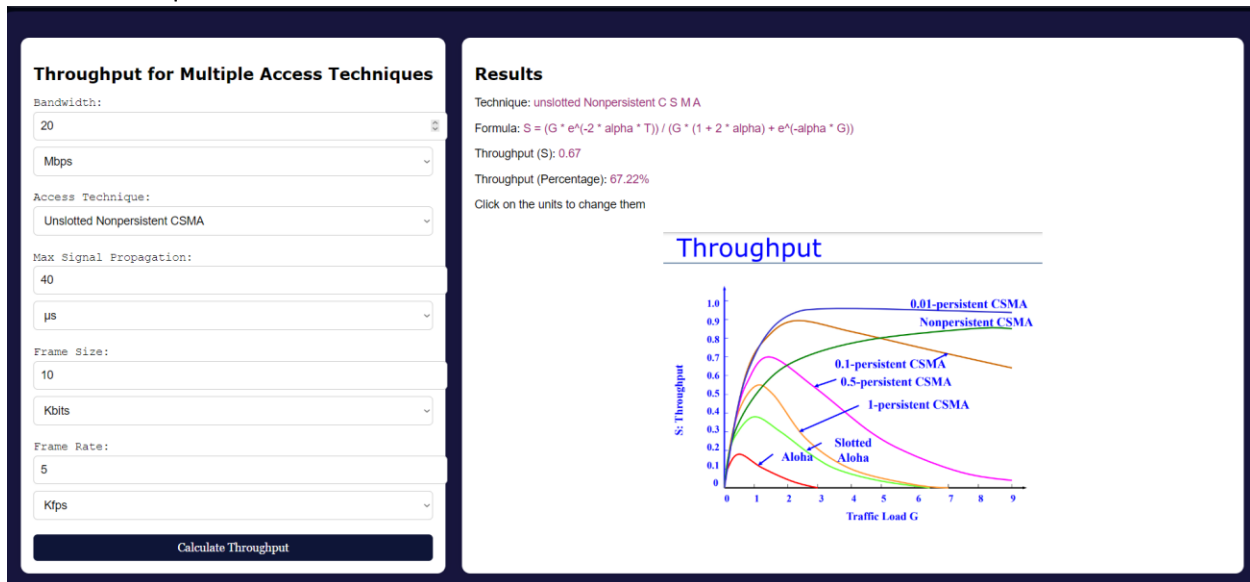
From the plot we can find E_b/N_0 when BPSK is used = 7 ,

$P_t = 10 - 6 - 12 - 11 + 147 + 20 + 18 - 228.6 + 24.3 + 4 + 7 + 34 = 7.89 \text{ dB}$ which is 5.60Watt as shown below.



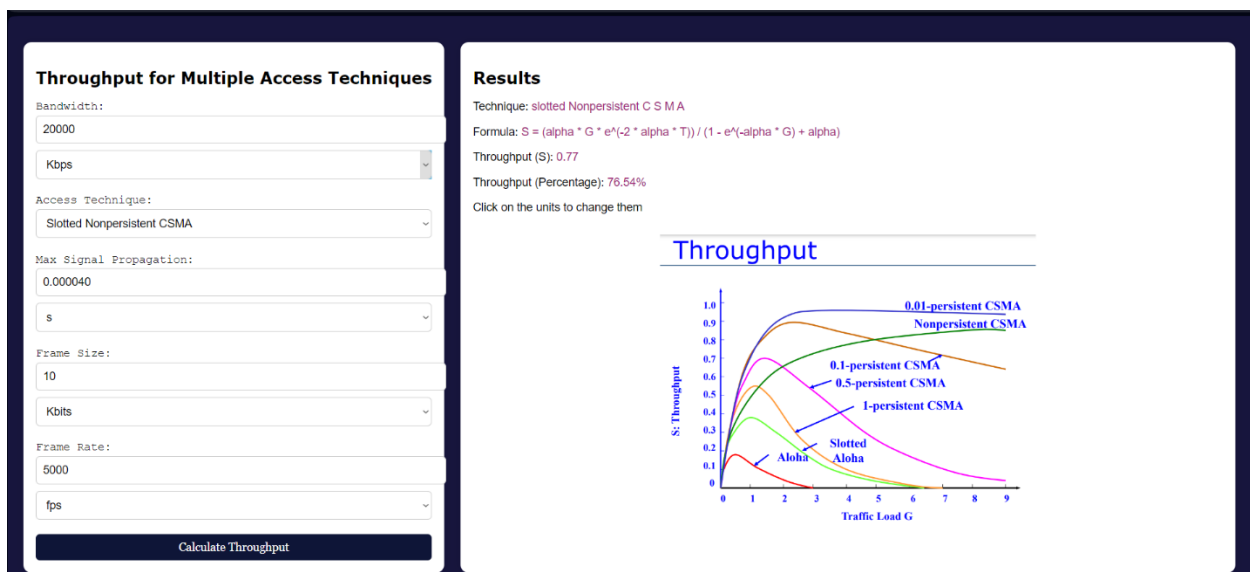
Calculator 4:

4.1 This is the scenario that we solved in the midterm exam. Using **Unslotted Nonpersistent CSMA** access technique.



4.2: For the second scenario, I used the previous inputs , but I changed the units and the access technique to **Slotted Nonpersistent CSMA**

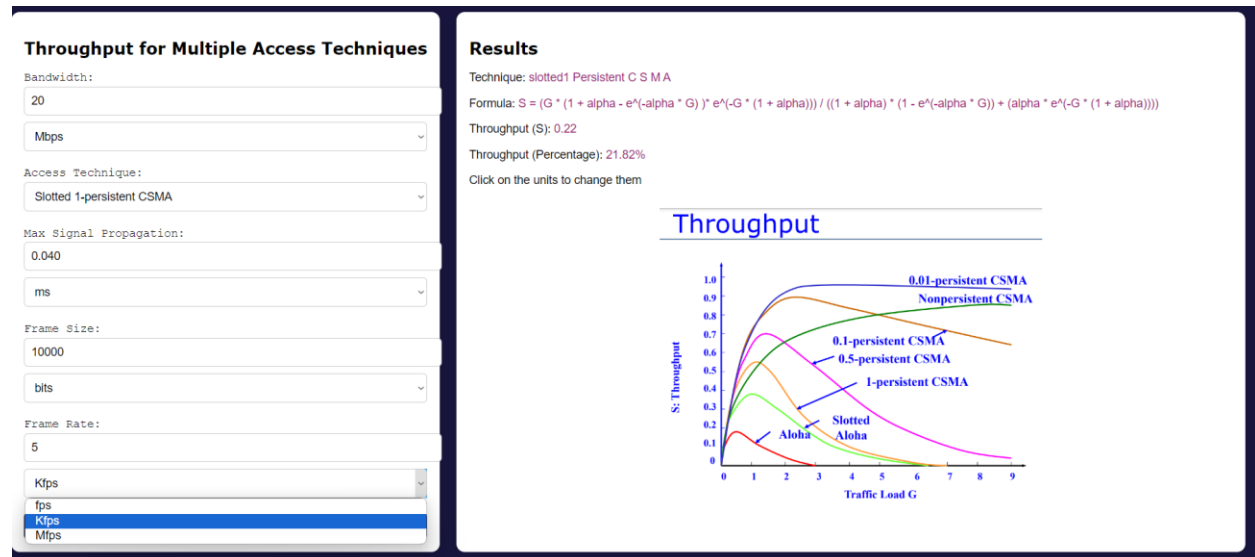
To verify the result, using the formula: $S = (\alpha * G * e^{(-2 * \alpha * T)}) / (1 - e^{(-\alpha * G)} + \alpha)$
 $= (0.08 * 2.5 * e^{(-2 * 0.08 * 0.5 * 10^{-3})}) / (1 - e^{(-0.08 * 2.5)} + 0.08) = 76\%$, where
 $T = 10 * 10^3 / 20 * 10^6 = 0.5 * 10^{-3}$, $\alpha = 40 * 10^{-6} / 0.5 * 10^{-3} = 0.08$, $G = 5 * 10^3 * 0.5 * 10^{-3} = 2.5$



4.3: For the last scenario, I used the same data, the access technique to **Slotted Nonpersistent CSMA**

To prove the result , using the formula $S = (G * (1 + \alpha - e^{-(\alpha * G)}) * e^{-G * (1 + \alpha)}) / ((1 + \alpha) * (1 - e^{-(\alpha * G)}) + (\alpha * e^{-G * (1 + \alpha)}))$

$$= (2.5 * (1 + 0.08 - e^{-(0.08 * 2.5)}) * e^{-2.5 * (1 + 0.08)}) / ((1 + 0.08) * (1 - e^{-(0.08 * 2.5)} + (0.08 * e^{-2.5 * (1 + 0.08)}))) = 21\%$$



Calculator 5:

5.1 This is the scenario that we solved in the Homework.

Design of Cellular System

Slots per Carrier 8	Area of the City (Km ²) 4
Number of Users 80000	Average Call per Day (calls/day) 8
Average Call Duration 3 Minutes	Probability of Call Dropped (Erlang) 0.02
Minimum SIR Needed (dB/dBm/Watt) 13 dB	Power at Reference Distance -22 dB
Reference Distance 10 Meters	Path Loss Component 3
Receiver Sensitivity 7 uW	

Calculate

Maximum Distance between Transmitter and Receiver for Reliable Communication: **96.60 meters**

Maximum Cell Size: **24243.01 m²**

Number of Cells in the Service Area: **165 cells**

Traffic Load in the Whole Cellular System: **1333.33 Erlangs**

Traffic Load in Each Cell: **8.08 Erlangs**

Number of Cells in Each Cluster: **9**

Minimum Number of Carriers Needed (in the whole system): **18 carriers**

Minimum Number of Carriers Needed if the GOS is changed to 5%: **18 carriers**

5.2

For the last scenario, I used the following inputs:

Design of Cellular System

Slots per Carrier 12	Area of the City (Km ²) 5
Number of Users 100000	Average Call per Day (calls/day) 5
Average Call Duration 5 Minutes	Probability of Call Dropped (Erlang) 0.02
Minimum SIR Needed (dB/dBm/Watt) 13 dB	Power at Reference Distance -40 dB
Reference Distance 40 Meters	Path Loss Component 3
Receiver Sensitivity 6 uW	

Calculate

Maximum Distance between Transmitter and Receiver for Reliable Communication: **102.17 meters**

Maximum Cell Size: **27123.00 m²**

Number of Cells in the Service Area: **185 cells**

Traffic Load in the Whole Cellular System: **1736.11 Erlangs**

Traffic Load in Each Cell: **9.38 Erlangs**

Number of Cells in Each Cluster: **9**

Minimum Number of Carriers Needed (in the whole system): **12 carriers**

Minimum Number of Carriers Needed if the GOS is changed to 5%: **11 carriers**

To verify the result,

$$D = 40 / (6 \cdot 10^{-6})^{1/3} = 102.17 \text{ meter}, \text{ cellSize} = 3\sqrt{3} / 2 (102.17)^2 = 27123 \text{ m}^2$$

$$\# \text{ of Cells} = 5000000 / 27123 = 185 \text{ cell}, A = 100000 / (5 \cdot 5 / 6 \cdot 24) = 1736.1 \text{ erlang}$$

$$A_{\text{cell}} = 1736.1 / 185 = 9.38 \text{ erlang}, N \Rightarrow 13 \text{ db} = (\sqrt{3N})^3 / 6 \rightarrow N = 9$$

$$\text{at Gos} = 0.02 \rightarrow \# \text{ of channels} = 16 \Rightarrow (16/12) \cdot 9 = 12 \text{ carrier}$$

$$\text{at Gos} = 0.05 \rightarrow \# \text{ of channels} = 14 \Rightarrow (14/12) \cdot 9 = 11 \text{ carrier}$$