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Wireless And Mobile Networks - ENCS5323

Online Calculator for Wireless and Mobile Networks
Project Report

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Calculator 1- Sampling & Encoding specs:

Scenario 1:

An analog signal with a bandwidth of 4 KHz undergoes sampling at the Nyquist rate, followed by processing through an 8-bit quantizer, a source encoder with a compression rate of 0.25, a channel encoder with a rate of 0.5, and a 1024-bit interleaver.

1. **Calculate the sampling frequency.**
2. **Find the number of quantization levels.**
3. **Determine the bit rate at the output of the source encoder.**
4. **Calculate the bit rate at the output of the channel encoder.**
5. **Calculate the bit rate at the output of the interleaver.**

Inputs:

- **Bandwidth:** 4000 Hz
- **Quantizer Bits:** 8 bits
- **Compression Rate:** 0.25
- **Channel Encoder Rate:** 0.5
- **Interleaver Bits:** 1024 bits

The screenshot shows a web browser with the URL `hammamprog.github.io/Wireless-Equations-Calculator/`. The page has a dark blue header with navigation links: Paraphrasing Tool, ChatGPT, Instructional Techno..., Ritag - Birzeit Univer..., YouTube, Facebook, Google, and Get Int. Below the header is a row of five buttons: Calculator 1 (Sampling & Encoding Specs), Calculator 2 (Resource Element Metrics), Calculator 3 (Flat Environment), Calculator 4 (Multiple Access Throughput), and Calculator 5 (Design Cellular System). The first button is selected.

The main content area is a light gray box containing a calculator interface. On the left, there are five input fields with labels and values:

- Bandwidth(Hz): 4000
- Quantizer Bits: 8
- Source Encoder Rate: 0.25
- Channel Encoder Rate: 0.5
- Interleaver Bits: 1024

Below these fields is a blue "Calculate" button. To the right of the input fields is a white box with a gray border containing the results:

- Sampling Frequency: 8000 Hz
- Number of Quantizer Levels: 256
- Bit Rate at Output of Source Encoder: 16000 bps
- Bit Rate at Output of Channel Encoder: 32000 bps
- Bit Rate at Output of Interleaver: 32000 bps

Figure 1 - Calculator 1 scenario 1

Scenario 2:

An analog signal with a bandwidth of 10 KHz undergoes sampling at the Nyquist rate, followed by processing through a 12-bit quantizer, a source encoder with a compression rate of 0.75, a channel encoder with a rate of 0.8, and a 512-bit interleaver.

1. **Calculate the sampling frequency.**
2. **Find the number of quantization levels.**
3. **Determine the bit rate at the output of the source encoder.**
4. **Calculate the bit rate at the output of the channel encoder.**
5. **Calculate the bit rate at the output of the interleaver.**

Inputs:

- **Bandwidth:** 10000 Hz
- **Quantizer Bits:** 12 bits
- **Compression Rate:** 0.75
- **Channel Encoder Rate:** 0.8
- **Interleaver Bits:** 512 bits

Calculator 1 (Sampling & Encoding Specs)	Calculator 2 (Resource Element Metrics)	Calculator 3 (Flat Environment)	Calculator 4 (Multiple Access Throughput)
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Bandwidth(Hz)

10000

Quantizer Bits

12

Source Encoder Rate

0.75

Channel Encoder Rate

0.8

Interleaver Bits

512

Calculate

Sampling Frequency:

20000 Hz

Number of Quantizer Levels:

4096

Bit Rate at Output of Source Encoder:

180000 bps

Bit Rate at Output of Channel Encoder:

225000 bps

Bit Rate at Output of Interleaver:

225000 bps

Figure 2 - Calculator 1 scenario 2

Scenario 3:

An analog signal with a bandwidth of 20 KHz undergoes sampling at the Nyquist rate, followed by processing through a 12-bit quantizer, a source encoder with a compression rate of 0.5, a channel encoder with a rate of 0.75, and a 512-bit interleaver.

1. Calculate the sampling frequency.
2. Find the number of quantization levels.
3. Determine the bit rate at the output of the source encoder.
4. Calculate the bit rate at the output of the channel encoder.
5. Calculate the bit rate at the output of the interleaver.

Inputs:

- **Bandwidth:** 20000 Hz
- **Quantizer Bits:** 12 bits
- **Compression Rate:** 0.5
- **Channel Encoder Rate:** 0.75
- **Interleaver Bits:** 512 bits

Calculator 1 (Sampling & Encoding Specs)

Calculator 2 (Resource Element Metrics)

Calculator 3 (Flat Environment)

Calculator 4 (Multiple Access Throughput)

Calculator 5 (Design Cellular System)

Bandwidth(Hz)

20000

Quantizer Bits

12

Source Encoder Rate

0.5

Channel Encoder Rate

0.75

Interleaver Bits

512

Calculate

Sampling Frequency:

40000 Hz

Number of Quantizer Levels:

4096

Bit Rate at Output of Source Encoder:

240000 bps

Bit Rate at Output of Channel Encoder:

320000 bps

Bit Rate at Output of Interleaver:

320000 bps

Figure 3 - Calculator 1 scenario 3

Calculator 2- Resource Element Metrics:

Scenario 1

In 4G LTE systems, each resource block has a bandwidth of 180 kHz. The subcarrier spacing is 15 kHz, and there are 7 OFDM symbols per resource block. Assuming each resource block has a duration of 0.5 milliseconds and bits are modulated using 1024-QAM, calculate the following:

1. Determine the number of bits per resource element.
2. Determine the number of bits per OFDM symbol.
3. Determine the number of bits per OFDM resource block.
4. If a user is assigned 4 parallel resource blocks continuously, calculate the maximum transmission rate for this user.

Inputs:

- **Resource Block Bandwidth:** 180 kHz
- **Subcarrier Spacing:** 15 kHz
- **Number of OFDM Symbols per Resource Block:** 7
- **Duration of Resource Block:** 0.5 milliseconds
- **Modulation Scheme:** 1024-QAM
- **Parallel resource blocks:** 4

Calculator 1 (Sampling & Encoding Specs)

Calculator 2 (Resource Element Metrics)

Calculator 3 (Flat Environment)

Calculator 4 (Multiple Access Throughput)

Calculator 5 (Design Cellular System)

Resource block bandwidth (kHz)

180

Subcarrier spacing (kHz)

15

Number of OFDM symbol per resource block

7

Resource block duration (ms)

0.5

Modulation (1024-QAM)

1024

Parallel resource blocks

4

Calculate

Bits per resource element:

10 bits

Bits per OFDM symbol:

120 bits

Bits per resource block:

840 bits/RB

Maximum rate:

6.72 Mbps

Figure 4 - Calculator 2 scenario 1

Scenario 2

In 4G LTE systems, each resource block has a bandwidth of 210 kHz. The subcarrier spacing is 15 kHz, and there are 8 OFDM symbols per resource block. Assuming each resource block has a duration of 0.5 milliseconds and bits are modulated using 256-QAM, calculate the following:

1. Determine the number of bits per resource element.
2. Determine the number of bits per OFDM symbol.
3. Determine the number of bits per OFDM resource block.
4. If a user is assigned 6 parallel resource blocks continuously, calculate the maximum transmission rate for this user.

Inputs:

- **Resource Block Bandwidth:** 210 kHz
- **Subcarrier Spacing:** 15 kHz
- **Number of OFDM Symbols per Resource Block:** 8
- **Duration of Resource Block:** 0.5 milliseconds
- **Modulation Scheme:** 256-QAM
- **Parallel resource blocks:** 5

The calculator interface displays input fields on the left and calculated results on the right. The input fields are: Resource block bandwidth (kHz) with value 210, Subcarrier spacing (kHz) with value 15, Number of OFDM symbol per resource block with value 8, Resource block duration (ms) with value 0.5, Modulation (1024-QAM) with value 256, and Parallel resource blocks with value 5. A blue 'Calculate' button is at the bottom. The results box on the right shows: Bits per resource element: 8 bits, Bits per OFDM symbol: 112 bits, Bits per resource block: 896 bits/RB, and Maximum rate: 8.96 Mbps.

Resource block bandwidth (kHz)	210
Subcarrier spacing (kHz)	15
Number of OFDM symbol per resource block	8
Resource block duration (ms)	0.5
Modulation (1024-QAM)	256
Parallel resource blocks	5
<button>Calculate</button>	

Bits per resource element:	8 bits
Bits per OFDM symbol:	112 bits
Bits per resource block:	896 bits/RB
Maximum rate:	8.96 Mbps

Figure 5 - Calculator 2 scenario 2

Scenario 3

In 4G LTE systems, each resource block has a bandwidth of 180 kHz. The subcarrier spacing is 15 kHz, and there are 7 OFDM symbols per resource block. Assuming each resource block has a duration of 0.5 milliseconds and bits are modulated using 128-QAM, calculate the following:

1. Determine the number of bits per resource element.
2. Determine the number of bits per OFDM symbol.
3. Determine the number of bits per OFDM resource block.
4. If a user is assigned 8 parallel resource blocks continuously, calculate the maximum transmission rate for this user.

Inputs:

- **Resource Block Bandwidth:** 180 kHz
- **Subcarrier Spacing:** 15 kHz
- **Number of OFDM Symbols per Resource Block:** 7
- **Duration of Resource Block:** 0.5 milliseconds
- **Modulation Scheme:** 128-QAM
- **Parallel resource blocks:** 1

The calculator interface displays input fields on the left and calculated results on the right. The input fields are: Resource block bandwidth (kHz) with value 180, Subcarrier spacing (kHz) with value 15, Number of OFDM symbol per resource block with value 7, Resource block duration (ms) with value 0.5, Modulation (1024-QAM) with value 128, and Parallel resource blocks with value 1. A blue 'Calculate' button is at the bottom. The results are shown in a table on the right:

Bits per resource element:	7 bits
Bits per OFDM symbol:	84 bits
Bits per resource block:	588 bits/RB
Maximum rate:	1.176 Mbps

Figure 6 - Calculator 2 scenario 3

Calculator 3-Flat Environment:

Scenario 1:

Given a flat rural environment with a path loss of 140 dB, a frequency of 900 MHz, an 8 dB transmit antenna gain, a 0 dB receive antenna gain, a data rate of 9.6 kbps, 12 dB in antenna feed line loss, 20 dB in other losses, a fade margin of 8 dB, a receiver amplifier gain of 24 dB, a noise figure total of 6 dB, a noise temperature of 290 K, and a link margin of 8 dB. Find the total transmit power required for an 8-PSK modulated signal with a maximum bit error rate of 10^{-4} .

Input:

- Path Loss: 140 dB
- Frequency: 900 MHz
- Transmit Antenna Gain: 8 dB
- Receive Antenna Gain: 0 dB
- Data Rate: 9.6 kbps
- Antenna Feed Line Loss: 12 dB
- Other Losses: 20 dB
- Fade Margin: 8 dB
- Receiver Amplifier Gain: 24 dB
- Noise Figure: 6 dB
- Noise Temperature: 290 K
- Link Margin: 8 dB

The screenshot shows a web-based calculator interface for a flat environment. On the left, there are input fields for various parameters: Path Loss (dB), Frequency (MHz), Transmit Antenna Gain (dB), Receive Antenna Gain (dB), Data Rate (kbps), Antenna Feed Line Loss (dB), Other Losses (dB), Fade Margin (dB), Receiver Amplifier Gain (dB), Noise Total Figure (dB), Noise temperature (Kelvin), Link Margin (dB), Modulation Type (BPSK), and Max Bit Error Rate. On the right, a summary box displays the calculated results: Received Power: -141.8 dBm, Transmitted Power: 6.2 dBm, and Transmitted Power (Watt): 4.2 W. A 'Calculate' button is at the bottom.

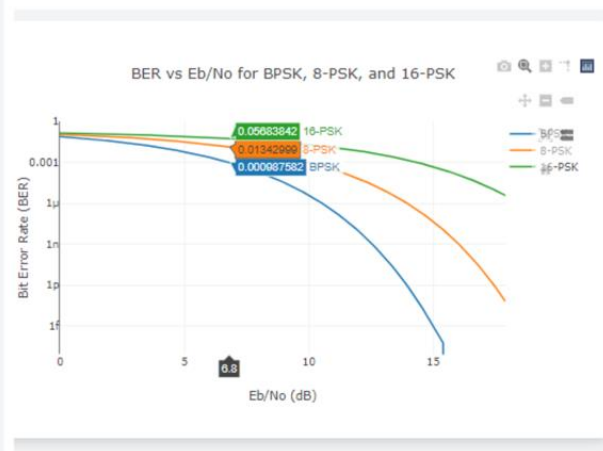


Figure 7 - Calculator 3 scenario 1

Scenario 2:

Given a flat rural environment with a path loss of 130 dB, a frequency of 800 MHz, a 8 dB transmit antenna gain, a 4 dB receive antenna gain, a data rate of 15 kbps, 10 dB in antenna feed line loss, 15 dB in other losses, a fade margin of 5 dB, a receiver amplifier gain of 20 dB, a noise figure total of 5 dB, a noise temperature of 310 K, and a link margin of 10 dB. Find the total transmit power required for an 8-PSK modulated signal with a maximum bit error rate of 10^{-4} .

Input:

- Path Loss: 130 dB
- Frequency: 800 MHz
- Transmit Antenna Gain: 8 dB
- Receive Antenna Gain: 4 dB
- Data Rate: 15 kbps
- Antenna Feed Line Loss: 10 dB
- Other Losses: 15 dB
- Fade Margin: 5 dB
- Receiver Amplifier Gain: 20 dB
- Noise Figure: 5 dB
- Noise Temperature: 310 K
- Link Margin: 10 dB

The screenshot shows a calculator interface with the following input fields and results:

Input Field	Value
Path Loss (dB)	130
Frequency (MHz)	800
Transmit Antenna Gain (dB)	8
Receive Antenna Gain (dB)	4
Data Rate (kbps)	15
Antenna Feed Line Loss (dB)	10
Other Losses (dB)	15
Fade Margin (dB)	5
Receiver Amplifier Gain (dB)	20
Noise Total Figure (dB)	5
Noise temperature (Kelven)	310
Link Margin (dB)	10
Modulation Type	8-PSK
Max Bit Error Rate	10^{-4}

Calculated Result	Value
Received Power:	-135.2 dBm
Transmitted Power:	-7.2 dBm
Transmitted Power (Watt):	0.2 W

Calculate

Figure 8 - Calculator 3 scenario 2

Scenario 3:

Given a flat rural environment with a path loss of 150 dB, a frequency of 1500 MHz, a 6 dB transmit antenna gain, a 0 dB receive antenna gain, a data rate of 22 kbps, 8 dB in antenna feed line loss, 30 dB in other losses, a fade margin of 10 dB, a receiver amplifier gain of 30 dB, a noise figure total of 8 dB, a noise temperature of 290 K, and a link margin of 12 dB. Find the total transmit power required for an 16-PSK modulated signal with a maximum bit error rate of 10^{-4} .

Input:

- Path Loss: 150 dB
- Frequency: 1500 MHz
- Transmit Antenna Gain: 6 dB
- Receive Antenna Gain: 0 dB
- Data Rate: 22 kbps
- Antenna Feed Line Loss: 8 dB
- Other Losses: 30 dB
- Fade Margin: 10 dB
- Receiver Amplifier Gain: 30 dB
- Noise Figure: 8 dB
- Noise Temperature: 290 K
- Link Margin: 12 dB

The screenshot shows a web-based calculator interface with the following inputs and results:

Parameter	Value
Path Loss (dB)	150
Frequency (MHz)	1500
Transmit Antenna Gain (dB)	6
Receive Antenna Gain (dB)	0
Data Rate (kbps)	22
Antenna Feed Line Loss (dB)	8
Other Losses (dB)	30
Fade Margin (dB)	10
Receiver Amplifier Gain (dB)	30
Noise Total Figure (dB)	8
Noise temperature (Kelvin)	290
Link Margin (dB)	12
Modulation Type	16-PSK
Max Bit Error Rate	10^{-4}

Result	Value
Received Power:	-124.4 dBm
Transmitted Power:	37.6 dBm
Transmitted Power (Watt):	5743.5 W

Calculate

Figure 9 - Calculator 3 scenario 3

Calculator 4-Multiplr Access Throughput:

Scenario 1:

A network has a data transmission bandwidth of 20 Mbps. It uses unslotted nonpersistent CSMA in the MAC layer. The maximum signal propagation time from one node to another is 40 μ s. Determine the throughput in percent assuming 10 Kbit frame size and a frame rate of 5 Kfps.

Input:

- Data Transmission Bandwidth: 20 Mbps
- Maximum Signal Propagation Time: 40 μ s
- Frame Size: 10 Kbit
- Frame Rate: 5 Kfps
- unslotted

Data transmission bandwidth (Mbps)	20
Max signal propagation time from one node to another (micro sec)	40
Frame Size (kbit)	10
Frame Rate (Kfps)	5
Protocol Type	UnSlotted
Calculate	

Bit Period (Tb):	5e-8 s
Tframe:	0.0005 s
G:	2.500
Alpha:	0.080
Throughput (Sth):	0.765

Figure 10 - Calculator 4 scenario 1

Scenario 2:

A network has a data transmission bandwidth of 15 Mbps. It uses slotted nonpersistent CSMA in the MAC layer. The maximum signal propagation time from one node to another is 40 μ s. Determine the throughput in percent assuming 10 Kbit frame size and a frame rate of 5 Kfps.

Input:

- Data Transmission Bandwidth: 15 Mbps
- Maximum Signal Propagation Time: 40 μ s
- Frame Size: 10 Kbit
- Frame Rate: 5 Kfps
- slotted

Calculator 2 (Resource Element Metrics)

Calculator 3 (Flat Environment)

Calculator 4 (Multiple Access Throughput)

Data transmission bandwidth (Mbps)

15

Max signal propagation time from one node to another (micro sec)

40

Frame Size (kbit)

10

Frame Rate (Kfps)

5

Protocol Type

Slotted

Calculate

Bit Period (Tb):

5e-8 s

Tframe:

0.0005 s

G:

2.500

Alpha:

0.080

Throughput (Sth):

0.672

Figure 11 - Calculator 4 scenario 2

Scenario 3:

A network has a data transmission bandwidth of 25 Mbps. It uses unslotted nonpersistent CSMA in the MAC layer. The maximum signal propagation time from one node to another is 70 μ s. Determine the throughput in percent assuming 14 Kbit frame size and a frame rate of 6 Kfps.

Input:

- Data Transmission Bandwidth: 25 Mbps
- Maximum Signal Propagation Time: 70 μ s
- Frame Size: 14 Kbit
- Frame Rate: 6 Kfps
- unslotted

Calculator 2 (Resource Element Metrics)

Calculator 3 (Flat Environment)

Calculator 4 (Multiple Access Throughput)

Data transmission bandwidth (Mbps)

Max signal propagation time from one node to another (micro sec)

Frame Size (kbit)

Frame Rate (Kfps)

Protocol Type

Calculate

Bit Period (Tb):
4e-8 s

Tframe:
0.0006 s

G:
3.360

Alpha:
0.125

Throughput (Sth):
0.897

Figure 12 - Calculator 4 scenario 3

Calculator 5-Design Cellular System:

Scenario 1:

A new mobile network provider acquired the license to provide full-rate duplex voice communication using GSM900 technology in a certain city (8 timeslots per carrier). The area of the city is equal to 4 km² (4,000,000 m²). The mobile network provider is interested in providing service to 80 thousand subscribers. Subscribers in this city make an average of 8 calls per day, and the average call duration is 3 minutes. The service provider is interested in providing the subscribers with a quality of service that guarantees a call drop probability equal to 0.02. The minimum SIR needed to correctly provide the service is equal to 13 dB. Assuming -22.0 dB power is measured at a reference distance of 10 meters from base stations, the path loss exponent equals 3 (cellular urban area), and the receiver sensitivity is 7×10^{-6} watts.

Outputs:

City Area (Km2)	4
Number of Subscribers	80000
Average calls per day per subscriber	8
Average call duration (minutes)	3
Call drop probability	0.02
Minimum SIR (dB)	13
Reference Power (dB)	-22
Reference Distance (meters)	10
Path Loss Exponent	3
Number of time slots per carrier	8
Receiver Sensitivity (watts)	7.00000E-06
<input type="button" value="Calculate"/>	

Ref Power (Watt):	0.0063 W
Max Distance:	96.5978 meters
Max Cell Size:	24243.0092 Km2
Number of Cells:	164.9960
Traffic Load System:	1333.3333
Traffic Load Cell:	8.0810
Number of Channels from Erlang B:	14.0000
Number of Carrier Per Cell:	2.0000
Number of Carrier Per System:	18.0000

Figure 13 - Calculator 5 scenario 1

Scenario 2:

A new mobile network provider acquired the license to provide full-rate duplex voice communication using GSM900 technology in a certain city (8 timeslots per carrier). The area of the city is equal to 2 km² (2,000,000 m²). The mobile network provider is interested in providing service to 100 thousand subscribers. Subscribers in this city make an average of 8 calls per day, and the average call duration is 3 minutes. The service provider is interested in providing the subscribers with a quality of service that guarantees a call drop probability equal to 0.02. The minimum SIR needed to correctly provide the service is equal to 13 dB. Assuming -22.0 dB power is measured at a reference distance of 10 meters from base stations, the path loss exponent equals 3 (cellular urban area), and the receiver sensitivity is 7×10^{-6} watts.

Outputs:

City Area (Km2)	2
Number of Subscribers	100000
Average calls per day per subscriber	8
Average call duration (minutes)	3
Call drop probability	0.02
Minimum SIR (dB)	13
Reference Power (dB)	-22
Reference Distance (meters)	10
Path Loss Exponent	3
Number of time slots per carrier	8
Receiver Sensitivity (watts)	7e-06
<button>Calculate</button>	

Ref Power (Watt):	0.0063 W
Max Distance:	96.5978 meters
Max Cell Size:	24243.0092 Km2
Number of Cells:	82.4980
Traffic Load System:	1666.6667
Traffic Load Cell:	20.2025
Number of Channels from Erlang B:	29.0000
Number of Carrier Per Cell:	4.0000
Number of Carrier Per System:	36.0000

Figure 14 - Calculator 5 scenario 2

Scenario 3:

A new mobile network provider acquired the license to provide full-rate duplex voice communication using GSM900 technology in a certain city (8 timeslots per carrier). The area of the city is equal to 4 km² (4,000,000 m²). The mobile network provider is interested in providing service to 80 thousand subscribers. Subscribers in this city make an average of 14 calls per day, and the average call duration is 4 minutes. The service provider is interested in providing the subscribers with a quality of service that guarantees a call drop probability equal to 0.06. The minimum SIR needed to correctly provide the service is equal to 13 dB. Assuming -22.0 dB power is measured at a reference distance of 10 meters from base stations, the path loss exponent equals 3 (cellular urban area), and the receiver sensitivity is 7×10^{-6} watts.

Output:

City Area (Km2)	4
Number of Subscribers	80000
Average calls per day per subscriber	14
Average call duration (minutes)	4
Call drop probability	0.06
Minimum SIR (dB)	13
Reference Power (dB)	-22
Reference Distance (meters)	10
Path Loss Exponent	3
Number of time slots per carrier	16
Receiver Sensitivity (watts)	7e-06
Calculate	

Ref Power (Watt):	0.0063 W
Max Distance:	96.5978 meters
Max Cell Size:	24243.0092 Km2
Number of Cells:	164.9960
Traffic Load System:	3111.1111
Traffic Load Cell:	18.8557
Number of Channels from Erlang B:	24.0000
Number of Carrier Per Cell:	2.0000
Number of Carrier Per System:	18.0000

Figure 15 - Calculator 5 scenario 3