ITCS323 Computer Data Communication

Programming Assignment: Error code

Submitted to

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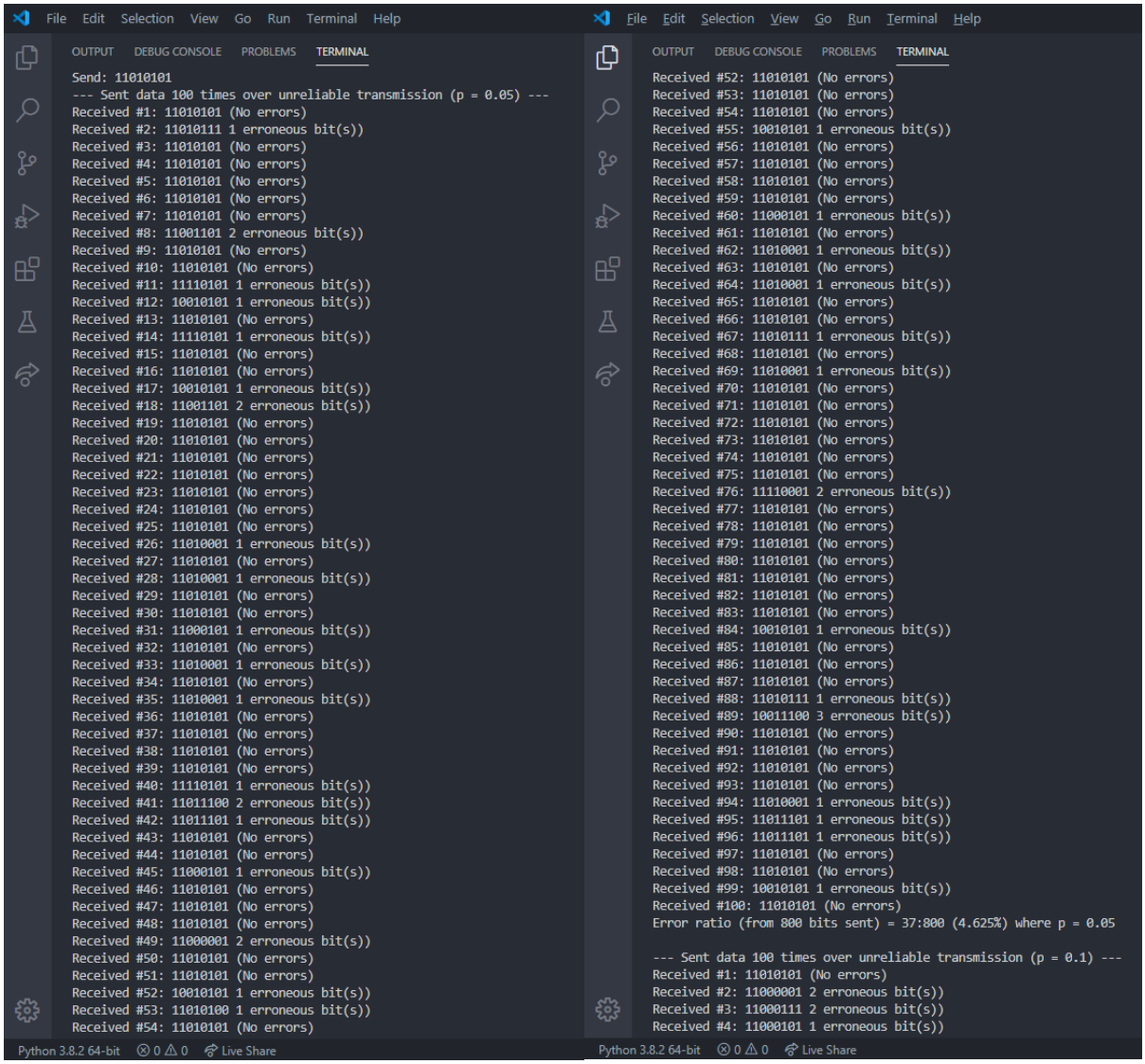
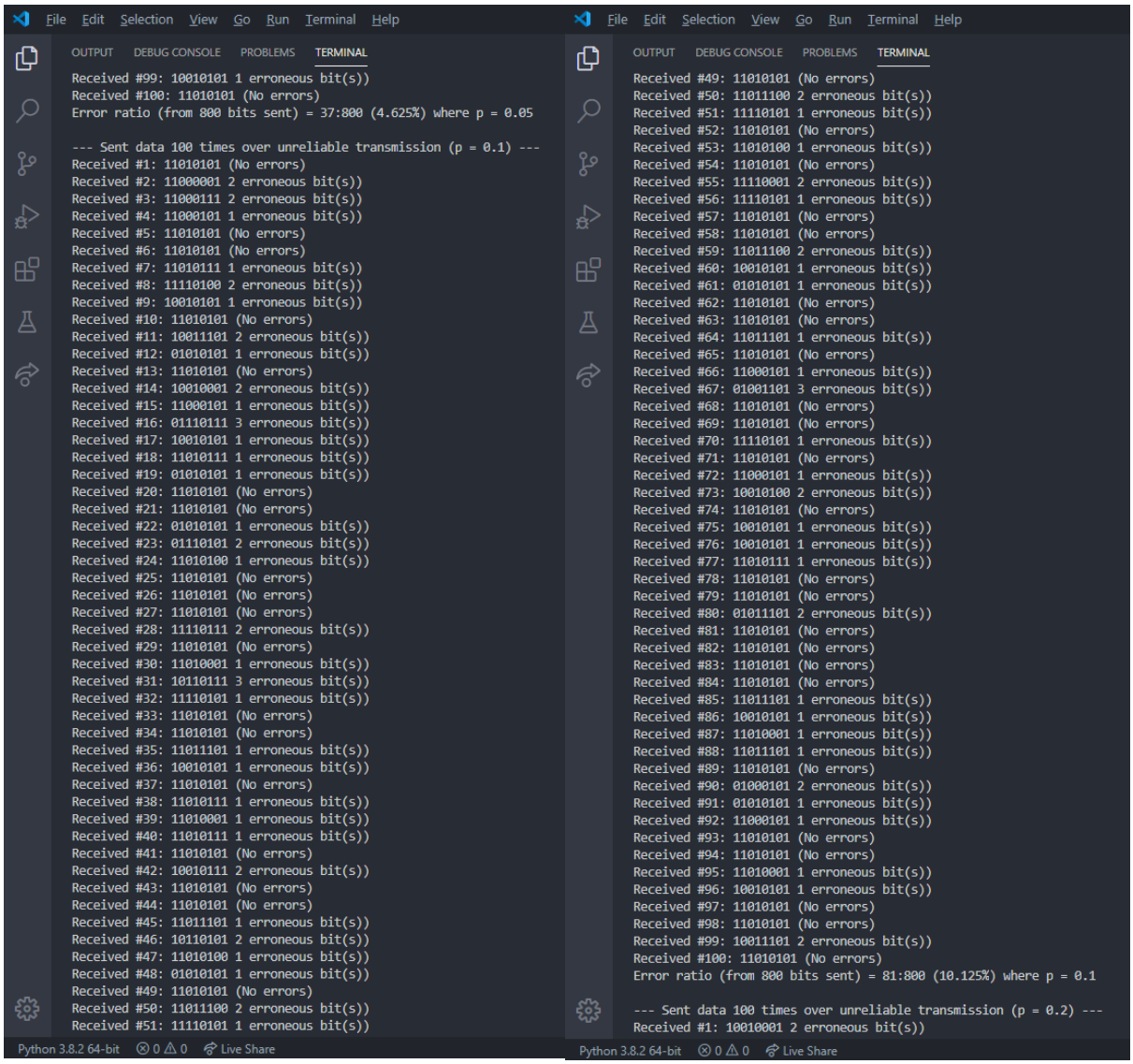
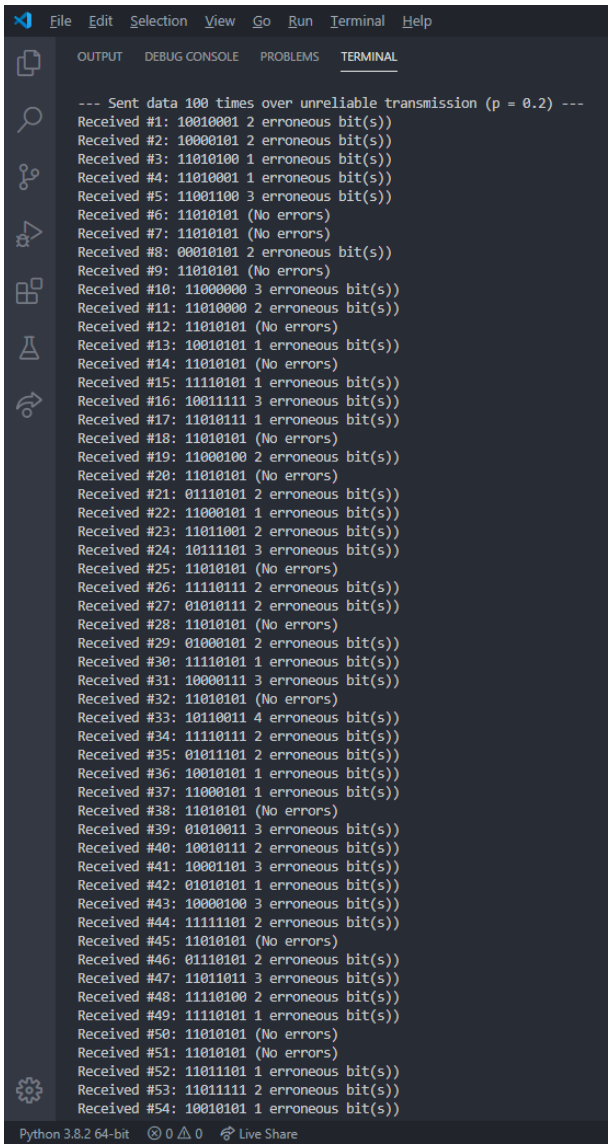
Unreliable Transmission

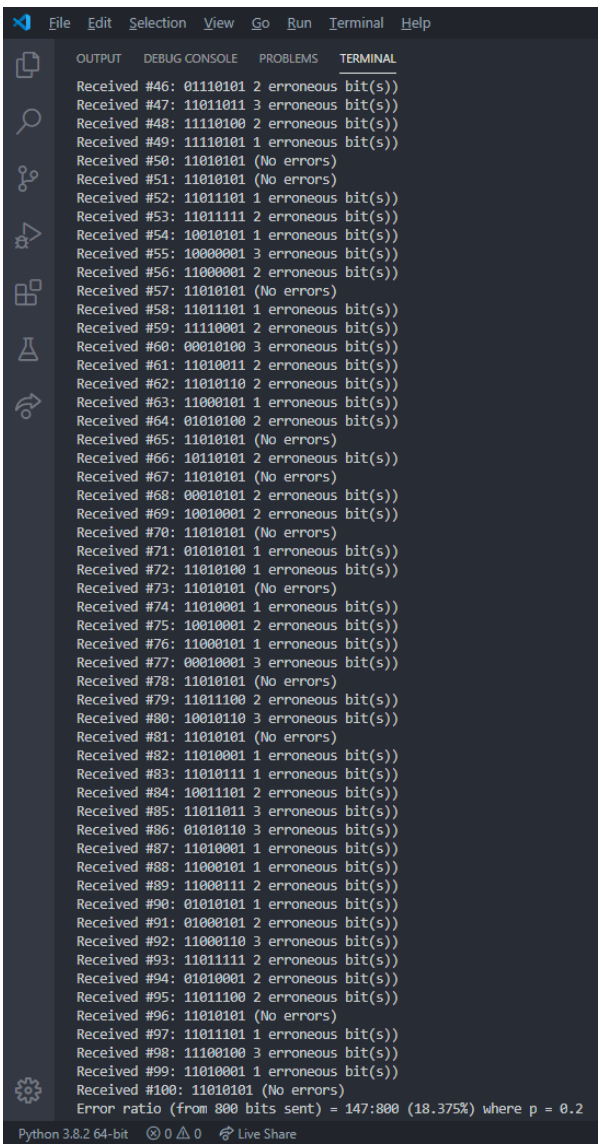
How to run the program (UnreliableTransmission.py): In `__main__`, you can change the input codeword by changing the value of `codeword` (line 24). Then, you can run via VS Code or the command line.

Testing Results:




File Edit Selection View Go Run Terminal Help
OUTPUT DEBUG CONSOLE PROBLEMS TERMINAL
Received #99: 10010101 1 erroneous bit(s))
Received #100: 11010101 (No errors)
Error ratio (from 800 bits sent) = 37:800 (4.625%) where p = 0.05
--- Sent data 100 times over unreliable transmission (p = 0.1) ---
Received #1: 11010101 (No errors)
Received #2: 11000001 2 erroneous bit(s))
Received #3: 11000111 2 erroneous bit(s))
Received #4: 11000101 1 erroneous bit(s))
Received #5: 11010101 (No errors)
Received #6: 11010101 (No errors)
Received #7: 11010111 1 erroneous bit(s))
Received #8: 11110100 2 erroneous bit(s))
Received #9: 10010101 1 erroneous bit(s))
Received #10: 11010101 (No errors)
Received #11: 10011101 2 erroneous bit(s))
Received #12: 01010101 1 erroneous bit(s))
Received #13: 11010101 (No errors)
Received #14: 10010001 2 erroneous bit(s))
Received #15: 11000101 1 erroneous bit(s))
Received #16: 01110111 3 erroneous bit(s))
Received #17: 10010101 1 erroneous bit(s))
Received #18: 11010111 1 erroneous bit(s))
Received #19: 01010101 1 erroneous bit(s))
Received #20: 11010101 (No errors)
Received #21: 11010101 (No errors)
Received #22: 01010101 1 erroneous bit(s))
Received #23: 01110101 2 erroneous bit(s))
Received #24: 11010100 1 erroneous bit(s))
Received #25: 11010101 (No errors)
Received #26: 11010101 (No errors)
Received #27: 11010101 (No errors)
Received #28: 11110111 2 erroneous bit(s))
Received #29: 11010101 (No errors)
Received #30: 11010001 1 erroneous bit(s))
Received #31: 10110111 3 erroneous bit(s))
Received #32: 11110101 1 erroneous bit(s))
Received #33: 11010101 (No errors)
Received #34: 11010101 (No errors)
Received #35: 11011101 1 erroneous bit(s))
Received #36: 10010101 1 erroneous bit(s))
Received #37: 11010101 (No errors)
Received #38: 11010111 1 erroneous bit(s))
Received #39: 11010001 1 erroneous bit(s))
Received #40: 11010111 1 erroneous bit(s))
Received #41: 11010101 (No errors)
Received #42: 10010111 2 erroneous bit(s))
Received #43: 11010101 (No errors)
Received #44: 11010101 (No errors)
Received #45: 11011101 1 erroneous bit(s))
Received #46: 10110101 2 erroneous bit(s))
Received #47: 11010100 1 erroneous bit(s))
Received #48: 01010101 1 erroneous bit(s))
Received #49: 11010101 (No errors)
Received #50: 11011100 2 erroneous bit(s))
Received #51: 11110101 1 erroneous bit(s))
Python 3.8.2 64-bit ⊗ 0 ⚠ 0 Live Share
File Edit Selection View Go Run Terminal Help
OUTPUT DEBUG CONSOLE PROBLEMS TERMINAL
Received #49: 11010101 (No errors)
Received #50: 11011100 2 erroneous bit(s))
Received #51: 11110101 1 erroneous bit(s))
Received #52: 11010101 (No errors)
Received #53: 11010100 1 erroneous bit(s))
Received #54: 11010101 (No errors)
Received #55: 11110001 2 erroneous bit(s))
Received #56: 11110101 1 erroneous bit(s))
Received #57: 11010101 (No errors)
Received #58: 11010101 (No errors)
Received #59: 11011100 2 erroneous bit(s))
Received #60: 10010101 1 erroneous bit(s))
Received #61: 01010101 1 erroneous bit(s))
Received #62: 11010101 (No errors)
Received #63: 11010101 (No errors)
Received #64: 11011101 1 erroneous bit(s))
Received #65: 11010101 (No errors)
Received #66: 11000101 1 erroneous bit(s))
Received #67: 01001101 3 erroneous bit(s))
Received #68: 11010101 (No errors)
Received #69: 11010101 (No errors)
Received #70: 11110101 1 erroneous bit(s))
Received #71: 11010101 (No errors)
Received #72: 11000101 1 erroneous bit(s))
Received #73: 10010100 2 erroneous bit(s))
Received #74: 11010101 (No errors)
Received #75: 10010101 1 erroneous bit(s))
Received #76: 10010101 1 erroneous bit(s))
Received #77: 11010111 1 erroneous bit(s))
Received #78: 11010101 (No errors)
Received #79: 11010101 (No errors)
Received #80: 01011101 2 erroneous bit(s))
Received #81: 11010101 (No errors)
Received #82: 11010101 (No errors)
Received #83: 11010101 (No errors)
Received #84: 11010101 (No errors)
Received #85: 11011101 1 erroneous bit(s))
Received #86: 10010101 1 erroneous bit(s))
Received #87: 11010001 1 erroneous bit(s))
Received #88: 11011101 1 erroneous bit(s))
Received #89: 11010101 (No errors)
Received #90: 01000101 2 erroneous bit(s))
Received #91: 01010101 1 erroneous bit(s))
Received #92: 11000101 1 erroneous bit(s))
Received #93: 11010101 (No errors)
Received #94: 11010101 (No errors)
Received #95: 11010001 1 erroneous bit(s))
Received #96: 10010101 1 erroneous bit(s))
Received #97: 11010101 (No errors)
Received #98: 11010101 (No errors)
Received #99: 10011101 2 erroneous bit(s))
Received #100: 11010101 (No errors)
Error ratio (from 800 bits sent) = 81:800 (10.125%) where p = 0.1
--- Sent data 100 times over unreliable transmission (p = 0.2) ---
Received #1: 10010001 2 erroneous bit(s))
Python 3.8.2 64-bit ⊗ 0 ⚠ 0 Live Share


File Edit Selection View Go Run Terminal Help
OUTPUT DEBUG CONSOLE PROBLEMS TERMINAL
--- Sent data 100 times over unreliable transmission (p = 0.2) ---
Received #1: 10010001 2 erroneous bit(s))
Received #2: 10000101 2 erroneous bit(s))
Received #3: 11010100 1 erroneous bit(s))
Received #4: 11010001 1 erroneous bit(s))
Received #5: 11001100 3 erroneous bit(s))
Received #6: 11010101 (No errors)
Received #7: 11010101 (No errors)
Received #8: 00010101 2 erroneous bit(s))
Received #9: 11010101 (No errors)
Received #10: 11000000 3 erroneous bit(s))
Received #11: 11010000 2 erroneous bit(s))
Received #12: 11010101 (No errors)
Received #13: 10010101 1 erroneous bit(s))
Received #14: 11010101 (No errors)
Received #15: 11110101 1 erroneous bit(s))
Received #16: 10011111 3 erroneous bit(s))
Received #17: 11010111 1 erroneous bit(s))
Received #18: 11010101 (No errors)
Received #19: 11000100 2 erroneous bit(s))
Received #20: 11010101 (No errors)
Received #21: 01110101 2 erroneous bit(s))
Received #22: 11000101 1 erroneous bit(s))
Received #23: 11011001 2 erroneous bit(s))
Received #24: 10111101 3 erroneous bit(s))
Received #25: 11010101 (No errors)
Received #26: 11110111 2 erroneous bit(s))
Received #27: 01010111 2 erroneous bit(s))
Received #28: 11010101 (No errors)
Received #29: 01000101 2 erroneous bit(s))
Received #30: 11110101 1 erroneous bit(s))
Received #31: 10000111 3 erroneous bit(s))
Received #32: 11010101 (No errors)
Received #33: 10110011 4 erroneous bit(s))
Received #34: 11110111 2 erroneous bit(s))
Received #35: 01011101 2 erroneous bit(s))
Received #36: 10010101 1 erroneous bit(s))
Received #37: 11000101 1 erroneous bit(s))
Received #38: 11010101 (No errors)
Received #39: 01010011 3 erroneous bit(s))
Received #40: 10010111 2 erroneous bit(s))
Received #41: 10001101 3 erroneous bit(s))
Received #42: 01010101 1 erroneous bit(s))
Received #43: 10000100 3 erroneous bit(s))
Received #44: 11111101 2 erroneous bit(s))
Received #45: 11010101 (No errors)
Received #46: 01110101 2 erroneous bit(s))
Received #47: 11011011 3 erroneous bit(s))
Received #48: 11110100 2 erroneous bit(s))
Received #49: 11110101 1 erroneous bit(s))
Received #50: 11010101 (No errors)
Received #51: 11010101 (No errors)
Received #52: 11011101 1 erroneous bit(s))
Received #53: 11011111 2 erroneous bit(s))
Received #54: 10010101 1 erroneous bit(s))
Python 3.8.2 64-bit
0 0
Live Share


File Edit Selection View Go Run Terminal Help
OUTPUT DEBUG CONSOLE PROBLEMS TERMINAL
Received #46: 01110101 2 erroneous bit(s))
Received #47: 11011011 3 erroneous bit(s))
Received #48: 11110100 2 erroneous bit(s))
Received #49: 11110101 1 erroneous bit(s))
Received #50: 11010101 (No errors)
Received #51: 11010101 (No errors)
Received #52: 11011101 1 erroneous bit(s))
Received #53: 11011111 2 erroneous bit(s))
Received #54: 10010101 1 erroneous bit(s))
Received #55: 10000001 3 erroneous bit(s))
Received #56: 11000001 2 erroneous bit(s))
Received #57: 11010101 (No errors)
Received #58: 11011101 1 erroneous bit(s))
Received #59: 11110001 2 erroneous bit(s))
Received #60: 00010100 3 erroneous bit(s))
Received #61: 11010011 2 erroneous bit(s))
Received #62: 11010110 2 erroneous bit(s))
Received #63: 11000101 1 erroneous bit(s))
Received #64: 01010100 2 erroneous bit(s))
Received #65: 11010101 (No errors)
Received #66: 10110101 2 erroneous bit(s))
Received #67: 11010101 (No errors)
Received #68: 00010101 2 erroneous bit(s))
Received #69: 10010001 2 erroneous bit(s))
Received #70: 11010101 (No errors)
Received #71: 01010101 1 erroneous bit(s))
Received #72: 11010100 1 erroneous bit(s))
Received #73: 11010101 (No errors)
Received #74: 11010001 1 erroneous bit(s))
Received #75: 10010001 2 erroneous bit(s))
Received #76: 11000101 1 erroneous bit(s))
Received #77: 00010001 3 erroneous bit(s))
Received #78: 11010101 (No errors)
Received #79: 11011100 2 erroneous bit(s))
Received #80: 10010110 3 erroneous bit(s))
Received #81: 11010101 (No errors)
Received #82: 11010001 1 erroneous bit(s))
Received #83: 11010111 1 erroneous bit(s))
Received #84: 10011101 2 erroneous bit(s))
Received #85: 11011011 3 erroneous bit(s))
Received #86: 01010110 3 erroneous bit(s))
Received #87: 11010001 1 erroneous bit(s))
Received #88: 11000101 1 erroneous bit(s))
Received #89: 11000111 2 erroneous bit(s))
Received #90: 01010101 1 erroneous bit(s))
Received #91: 01000101 2 erroneous bit(s))
Received #92: 11000110 3 erroneous bit(s))
Received #93: 11011111 2 erroneous bit(s))
Received #94: 01010001 2 erroneous bit(s))
Received #95: 11011100 2 erroneous bit(s))
Received #96: 11010101 (No errors)
Received #97: 11011101 1 erroneous bit(s))
Received #98: 11100100 3 erroneous bit(s))
Received #99: 11010001 1 erroneous bit(s))
Received #100: 11010101 (No errors)
Error ratio (from 800 bits sent) = 147:800 (18.375%) where p = 0.2
Python 3.8.2 64-bit
0 0
Live Share

Parity Bit

How to run the program (Parity.py): In `__main__`, you can change the input dataword for 1D parity by changing the value of `dataword_input` (line 189). For 2D party, you can change the input dataword and the size of block by changing the value of `dataword_input` (line 220) and `size` (line 222). Then, you can run via VS Code or the command line.

Testing Results:

```
--- Even ---
Dataword: 11011100
Send: 110111001
Received (5% Error):  110111001 (Valid)
Received (10% Error): 010111001 (Invalid)
Received (20% Error): 110011011 (Valid)
--- Odd ---
Dataword: 11011100
Send: 110111000
Received (5% Error):  110111000 (Valid)
Received (10% Error): 100110000 (Valid)
Received (20% Error): 110011001 (Valid)
--- Two Dimensional Even ---
Dataword: 1100111 1011101 0111001
Send: ['11001111', '10111011', '01110010', '00000110']
Received (5% Error):  ['11011111', '10111011', '01111010', '00000110'] (Invalid)
Received (10% Error): ['11100011', '10101011', '01110010', '00100110'] (Invalid)
Received (20% Error): ['11001111', '10011011', '00110110', '00000110'] (Invalid)
['11001110', '10111010', '01110011', '11111000']
['01000110', '10111010', '01110011', '11111000']
--- Two Dimensional Odd ---
Dataword: 1100111 1011101 0111001
Send: ['11001110', '10111010', '01110011', '11111000']
Received (5% Error):  ['11001110', '10111010', '01110011', '11111000'] (Valid)
Received (10% Error): ['01000110', '10111010', '01110011', '11111000'] (Invalid)
Received (20% Error): ['11011111', '11111010', '00110011', '11111000'] (Invalid)
```

```
--- Even ---
Dataword: 11011100 11011100
Send: 11011100110111000
Received (5% Error):  11011100110111000 (Valid)
Received (10% Error): 11010100010110000 (Invalid)
Received (20% Error): 11011100100110000 (Valid)
--- Odd ---
Dataword: 11011100 11011100
Send: 11011100110111001
Received (5% Error):  11001100110111001 (Invalid)
Received (10% Error): 11010101110111001 (Valid)
Received (20% Error): 10011100101111001 (Invalid)
--- Two Dimensional Even ---
Dataword: 1100111 1011101 0111001 0101001
Send: ['11001111', '10111011', '01110010', '01010011', '01010101']
Received (5% Error):  ['11001111', '10111011', '01110010', '01010011', '01010101'] (Valid)
Received (10% Error): ['11001111', '10111000', '01010010', '01010011', '01010101'] (Invalid)
Received (20% Error): ['11001111', '10101011', '00010000', '01000011', '01110001'] (Invalid)
--- Two Dimensional Odd ---
Dataword: 1100111 1011101 0111001 0101001
Send: ['11001110', '10111010', '01110011', '01010010', '10101010']
Received (5% Error):  ['11001110', '10111010', '01110011', '00010010', '10101010'] (Invalid)
Received (10% Error): ['11001100', '10111011', '01110001', '01010010', '10101000'] (Invalid)
Received (20% Error): ['11000110', '00111000', '11110011', '11010000', '10001011'] (Invalid)
```

```
--- Even ---
Dataword: 1100010101001
Send: 11000101010010
Received (5% Error):  11000101010000 (Invalid)
Received (10% Error): 11010101010000 (Valid)
Received (20% Error): 11001101011010 (Valid)
--- Odd ---
Dataword: 1100010101001
Send: 11000101010011
Received (5% Error):  11000101010001 (Invalid)
Received (10% Error): 11000111010001 (Valid)
Received (20% Error): 11011111000011 (Valid)
--- Two Dimensional Even ---
Dataword: 11001110 10110101 01101001 10010110
Send: ['110011101', '101101011', '011010010', '100101100', '100001000']
Received (5% Error):  ['110011101', '101101011', '011010010', '100101100', '100001000'] (Valid)
Received (10% Error): ['000011101', '101111011', '011110010', '100101100', '100000000'] (Invalid)
Received (20% Error): ['111111101', '101111010', '001011010', '110101100', '000100000'] (Invalid)
--- Two Dimensional Odd ---
Dataword: 11001110 10110101 01101001 10010110
Send: ['110011100', '101101010', '011010011', '100101101', '011110111']
Received (5% Error):  ['110011100', '101101010', '011010111', '100101101', '011110111'] (Invalid)
Received (10% Error): ['110011100', '101101010', '010010011', '100101101', '011110111'] (Invalid)
Received (20% Error): ['110011000', '101100010', '011110011', '100110101', '011110101'] (Invalid)
```

CRC

How to run the program (CRC.py): In `__main__`, you can change the input dataword for by changing the value of `dataword ` (line 103). Then, you can run via VS Code or the command line.

Testing Results:

```
--- CRC-4 ---
Dataword: 1110110
Send: 11101100101
Received (5% Error):  11101100101 (Valid)
Received (10% Error): 11101100101 (Valid)
Received (20% Error): 01001101100 (Valid)

--- CRC-8 ---
Dataword: 1110110
Send: 111011011101010
Received (5% Error):  111011001101010 (Invalid)
Received (10% Error): 111011011101010 (Valid)
Received (20% Error): 111011011101010 (Valid)

--- ReCRC-16 ---
Dataword: 1110110
Send: 1110110010000010110111
Received (5% Error):  1110110010000010110111 (Valid)
Received (10% Error): 1110110010000110110111 (Invalid)
Received (20% Error): 1110111011000000100011 (Invalid)

--- CRC-16 ---
Dataword: 1110110
Send: 1110110100000100110111
Received (5% Error):  1110101100000100110111 (Invalid)
Received (10% Error): 1110010100000100110111 (Invalid)
Received (20% Error): 0110110100000011110111 (Invalid)

--- CRC-24 ---
Dataword: 1110110
Send: 111011010010011001010110101011011
Received (5% Error):  111001010010011001010100101011011 (Invalid)
Received (10% Error): 111111010010011010011001011011 (Invalid)
Received (20% Error): 011111111010011001000110011011 (Invalid)

--- CRC-32 ---
Dataword: 1110110
Send: 11101101111101000110010010100000101010101
Received (5% Error):  11101101111101000110010010100000101010101 (Valid)
Received (10% Error): 11101101111011000110010010100000011001 (Invalid)
Received (20% Error): 11101011111101000110010011101000101010100 (Invalid)
```

```
--- CRC-4 ---
Dataword: 11001010
Send: 110010100110
Received (5% Error):  110010100110 (Valid)
Received (10% Error): 110010100100 (Invalid)
Received (20% Error): 110010100100 (Invalid)

--- CRC-8 ---
Dataword: 11001010
Send: 1100101000100100
Received (5% Error):  1100001000100100 (Invalid)
Received (10% Error): 1100100000100100 (Invalid)
Received (20% Error): 1100101001000101 (Invalid)

--- ReCRC-16 ---
Dataword: 11001010
Send: 1100101011000001000011001
Received (5% Error):  1000101011000001100011001 (Invalid)
Received (10% Error): 1100101011100101000111001 (Invalid)
Received (20% Error): 1101011000010000000101001 (Invalid)

--- CRC-16 ---
Dataword: 11001010
Send: 1100101000000001010111100
Received (5% Error):  1010101000000001010110100 (Invalid)
Received (10% Error): 0110101100100000010111100 (Invalid)
Received (20% Error): 1100001101001010101111100 (Invalid)

--- CRC-24 ---
Dataword: 11001010
Send: 110010100010101101001100010001100
Received (5% Error):  110110100010101101001100000101100 (Invalid)
Received (10% Error): 100010100010001101001101000001100 (Invalid)
Received (20% Error): 110000100011101101000000011010111 (Invalid)

--- CRC-32 ---
Dataword: 11001010
Send: 11001010011100100000000001000110010011111
Received (5% Error):  11001010011100100010000001000110010011111 (Invalid)
Received (10% Error): 11000110010100100101000001000110010011111 (Invalid)
Received (20% Error): 10001010111100110010101001011011111111 (Invalid)
```

Checksum

How to run the program (Checksum.py): In `__main__`, you can change the input dataword, word size, and number of blocks by changing the value of `dataword_input` (line 92), `word_size` (line 94), and `num_blocks` (line 95). Then, you can run via VS Code or the command line.

Test Results:

```
--- Checksum ---
Dataword: 10011001 11100010 00100100 10000100
Send: ['10011001', '11100010', '00100100', '10000100', '11011010']
Received (5% Error)  ['10011001', '01100010', '10100100', '10000100', '11011010'] ( Valid )
Received (10% Error) ['10011001', '11000011', '00101100', '10000100', '10011000'] ( Invalid )
Received (20% Error) ['10010001', '11010010', '01100010', '10000000', '11010010'] ( Invalid )
```

```
--- Checksum ---
Dataword: 00111101 00101001 11001001 11100101
Send: ['00111101', '00101001', '11001001', '11100101', '11101001']
Received (5% Error)  ['00110111', '00101001', '11001001', '11100101', '11101100'] ( Invalid )
Received (10% Error) ['00111101', '00101001', '11001001', '11100101', '11101001'] ( Valid )
Received (20% Error) ['01111101', '00100001', '01000101', '01100110', '11111101'] ( Invalid )
```

```
--- Checksum ---
Dataword: 10101001 00111001
Send: ['10101001', '00111001', '00011101']
Received (5% Error)  ['10111000', '00101001', '00011101'] ( Invalid )
Received (10% Error) ['10101001', '00111001', '00011101'] ( Valid )
Received (20% Error) ['00101011', '00111000', '00011101'] ( Invalid )
```

```
--- Checksum ---
Dataword: 00111010 11111111
Send: ['00111010', '11111111', '11000101']
Received (5% Error)  ['00111011', '11111111', '11000101'] ( Invalid )
Received (10% Error) ['00111010', '11111111', '11000101'] ( Valid )
Received (20% Error) ['01111010', '11110111', '11000101'] ( Invalid )
```

```
--- Checksum ---
Dataword: 00000000 11111111
Send: ['00000000', '11111111', '00000000']
Received (5% Error)  ['00000000', '11111111', '00000000'] ( Valid )
Received (10% Error) ['00110000', '11111111', '00000000'] ( Invalid )
Received (20% Error) ['11000000', '11111101', '01011000'] ( Invalid )
```

```
--- Checksum ---
Dataword: 00011000 11100111
Send: ['00011000', '11100111', '00000000']
Received (5% Error)  ['00011000', '11100111', '00000000'] ( Valid )
Received (10% Error) ['00111000', '11100101', '00000000'] ( Invalid )
Received (20% Error) ['00011100', '01110101', '00001100'] ( Invalid )
```

```
--- Checksum ---
Dataword: 01010110 11010101
Send: ['01010110', '11010101', '11010011']
Received (5% Error)  ['01010110', '11010101', '10010011'] ( Invalid )
Received (10% Error) ['01010110', '11010101', '11010011'] ( Valid )
Received (20% Error) ['01010110', '11000001', '10010100'] ( Invalid )
```

```
--- Checksum ---
Dataword: 01010110 11010101 11010101
Send: ['01010110', '11010101', '11010101', '11111101']
Received (5% Error)  ['01010110', '11010101', '11010101', '11111101'] ( Valid )
Received (10% Error) ['01010110', '11010101', '11010100', '11111101'] ( Invalid )
Received (20% Error) ['01000010', '11010100', '11110111', '11101101'] ( Invalid )
```

```
--- Checksum ---
Dataword: 10101011 01110101 00111101
Send: ['10101011', '01110101', '00111101', '10100001']
Received (5% Error)  ['10101111', '01110101', '00111100', '10100001'] ( Invalid )
Received (10% Error) ['10101011', '01110101', '00111101', '10100001'] ( Valid )
Received (20% Error) ['00101111', '00010101', '00111101', '10101101'] ( Invalid )
```

```
--- Checksum ---
Dataword: 11111111 00000000 11111111
Send: ['11111111', '00000000', '11111111', '00000000']
Received (5% Error)  ['11111011', '00000000', '11111111', '00000000'] ( Invalid )
Received (10% Error) ['11111111', '00000000', '11111111', '00000000'] ( Valid )
Received (20% Error) ['11110110', '00110001', '11101111', '00010001'] ( Invalid )
```

Hamming Code

How to run the program (HammingCode.py): In `__main__`, you can change the input dataword by changing the value of `dataword ` (line 102). Then, you can run via VS Code or the command line.

```
--- Hamming Code ---
Dataword: 1001101
Send: 10011100101
Received (5% Error): 10011100101 (Error Position -1)
Received (10% Error): 10011110101 (Error Position 5)
Received (20% Error): 11011100101 (Error Position 10)
```

```
--- Hamming Code ---
Dataword: 1001101
Send: 10011100101
Received (5% Error):  10011100101 (Error Position -1)
Received (10% Error): 10001100101 (Error Position 8)
Received (20% Error): 11011100101 (Error Position 10)
```

```
--- Hamming Code ---
Dataword: 0011100001
Send: 00111010001110
Received (5% Error):  00111010001010 (Error Position 3)
Received (10% Error): 00111010001110 (Error Position -1)
Received (20% Error): 00110010001110 (Error Position 10)
```

```
--- Hamming Code ---
Dataword: 1011010101
Send: 10110100101101
Received (5% Error):  10110100101101 (Error Position -1)
Received (10% Error): 10110101101101 (Error Position 7)
Received (20% Error): 11110100101101 (Error Position 13)
```

```
--- Hamming Code ---
Dataword: 1001010101011110
Send: 10010010101010110011
Received (5% Error):  10000010101010110011 (Error Position 18)
Received (10% Error): 10010110101010110011 (Error Position 16)
Received (20% Error): 10010010001010110011 (Error Position 13)
```

```
--- Hamming Code ---
Dataword: 11010
Send: 111010011
Received (5% Error):  111011011 (Error Position 4)
Received (10% Error): 111010011 (Error Position -1)
Received (20% Error): 111110011 (Error Position 6)
```

```
--- Hamming Code ---
Dataword: 11011101
Send: 110111101100
Received (5% Error):  110111101100 (Error Position -1)
Received (10% Error): 010111101100 (Error Position 12)
Received (20% Error): 111111101100 (Error Position 10)
```

```
--- Hamming Code ---
Dataword: 11101101
Send: 111011101111
Received (5% Error):  111001101111 (Error Position 8)
Received (10% Error): 011011101111 (Error Position 12)
Received (20% Error): 111011111111 (Error Position 5)
```

```
--- Hamming Code ---
Dataword: 110110
Send: 1100110000
Received (5% Error):  0100110000 (Error Position 10)
Received (10% Error): 1100110000 (Error Position -1)
Received (20% Error): 1100100000 (Error Position 5)
```

```
--- Hamming Code ---
Dataword: 1111
Send: 1111111
Received (5% Error):  1111111 (Error Position -1)
Received (10% Error): 1111011 (Error Position 3)
Received (20% Error): 1110111 (Error Position 4)
```