Basics of Communication Engineering. COMM.100

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Project Work 3: Transmission system 1.

Task 3.1: calculate the bandwidth of the transmitting signal

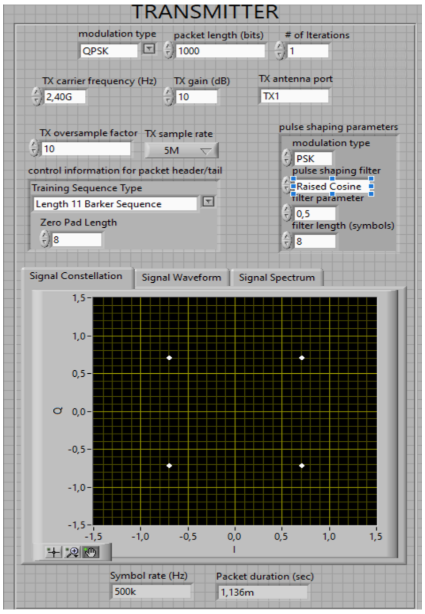

Figure 1: Transmitting signal using QPSK modulation type

Symbol rate: 500.000 Hz
Packet duration:1,136 (sec)
Pulse →QPSK modulation type with raised cosine ($\alpha = 0.5$) and filter length = 8

By Nyquist's theorem bandwidth is calculate as: $B \geq \frac{R}{2}$

Where:

B = minimum bandwidth
R = symbol rate

Therefore:

$B \geq \frac{500.000}{2} = \mathbf{250.000\ Hz}$

With the roll-off factor $\alpha = 0.5$ (raised cosine) minimum bandwidth is calculated as:

$B \geq R \times (1 + \alpha)$

Then:

$B \geq 500.000 \times (1 + 0.5)$
$B \geq 500.000 \times 1.5$
$B = \mathbf{750.000\ Hz}$

Task 3.2: Check the spectrum figure of the transmitted signal.

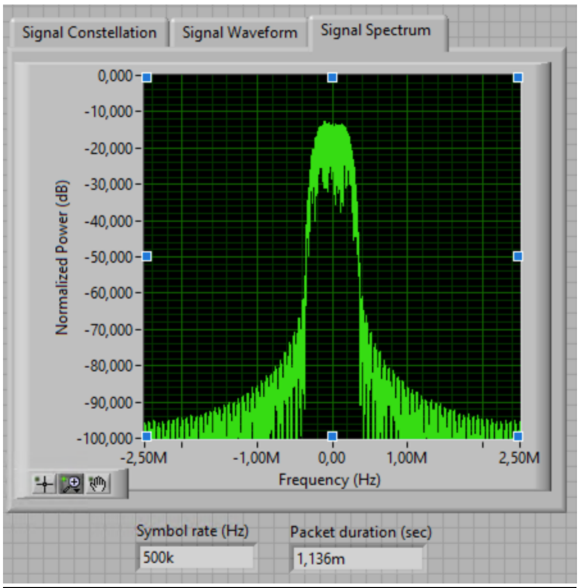

figure 2: signal spectrum (250K Hz)

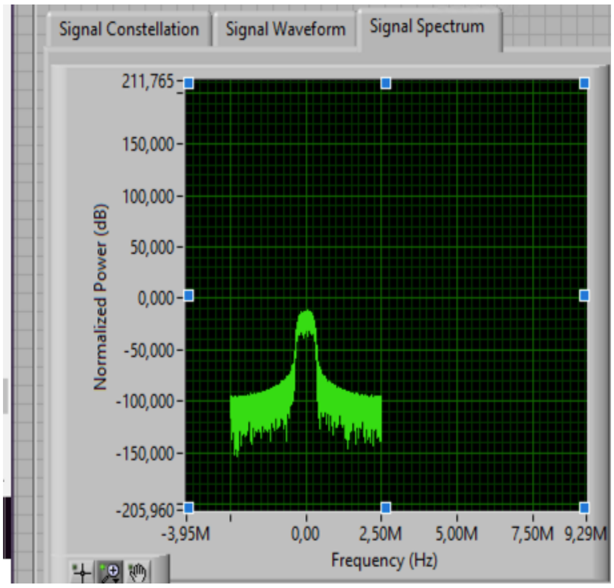

figure 3: signal spectrum (750K Hz)

At this point, I have a little confusion when comparing the spectrum signal and the results obtained for the minimum bandwidth from the Nyquist's theorem. When calculated without the raised cosine, I obtained 250.000 Hz, which matches the signal spectrum in figure 1. However, when I calculated the bandwidth with the roll-off factor ($\alpha = 0.5$), I got 750.000 Hz, which goes over the spectrum (figure 3).

Task 3.3: calculate date rate in bits /seconds for QSPK and BPSK modulation types.

Information data -rate calculated in bits / seconds in the QPSK modulation type.

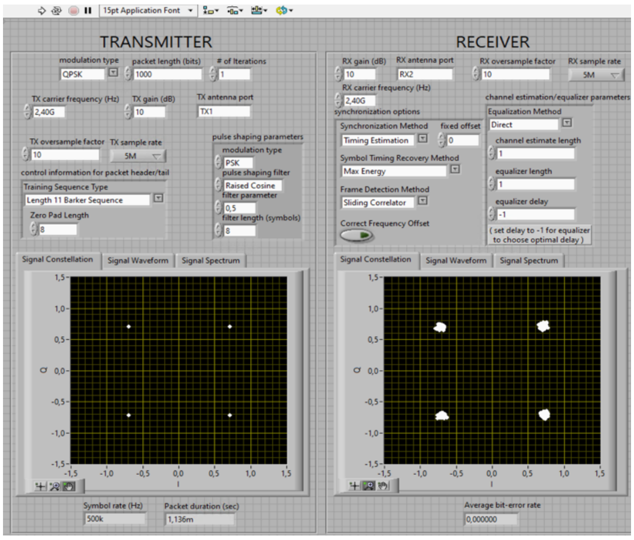

Figure 4: QPSK modulation type

$$R_{data} = \frac{packet\ lenght}{Packet\ duration}$$

R_{data} = data rate
Packet length = 1000 (bits)

Packet duration = 1.136 ms

$R_{data} = \frac{1000\ bits}{1.136\ ms}$ = **880.28 bits /ms**

Information data -rate calculated in bits / seconds in the <u>BPSK modulation type</u>.

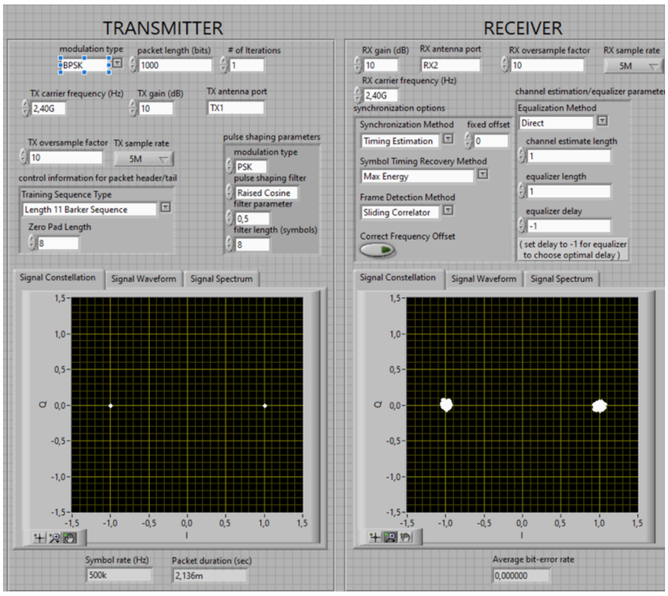

Figure 5: BPSK modulation type

Packet duration = 2.136 ms

$R_{data} = \frac{1000\ bits}{2{,}136\ ms}$ = **468 bits /ms**

<u>Task 3.4: how is the signal bandwidth affected if symbol rate is increased?</u>

Following the Nyquist's theorem, if we set Tx and Rx samples to 10M the symbol rate increases, as well as the minimum bandwidth needed. Namely, we can say that the minimum bandwidth required is directly proportional to the symbol rate. Therefore, higher symbol rate leads to higher bandwidth needed.When it comes to the relationship symbol rate–bit rate, it depends on the modulation type. However in BPSK and QPSK modulations the bit rate increases proportionally to the increase of the bit rate.

By Nyquist's theorem: $B \geq \frac{R}{2}$

Where:
B = minimum bandwidth
R = symbol rate

Therefore:

$B \geq \frac{1000.000}{2}$ = **500.000 Hz**

With the roll-off factor α = 0.5 (raised cosine) minimum bandwidth is calculated as:

$B \geq R \times (1 + \alpha)$

Then:

$B \geq 1.000.000 \times (1 + 0.5)$
$B \geq 1.000.000 \times 1.5$
$B =$ **1.500.000 Hz**

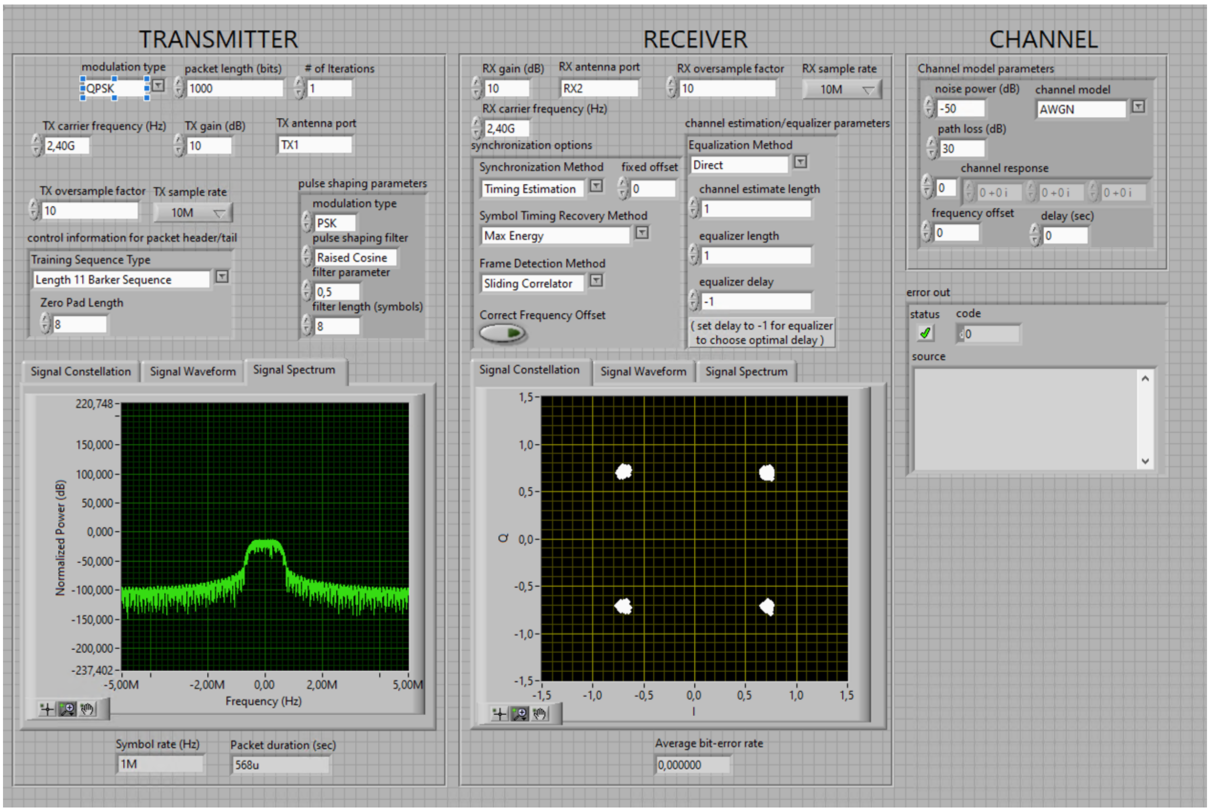

Figure 6: QPSK modulation type with Tx and Rx samples set to 10M.

Packet duration 568 µ /sec / 1000 µ /ms = 0,568 ms

$$R_{\text{data QPSK modulation}} = \frac{packet\ lenght}{Packet\ duration} = \frac{1000\ bits}{0.568\ ms} = \mathbf{1{,}760\ \ bits\ /ms}$$

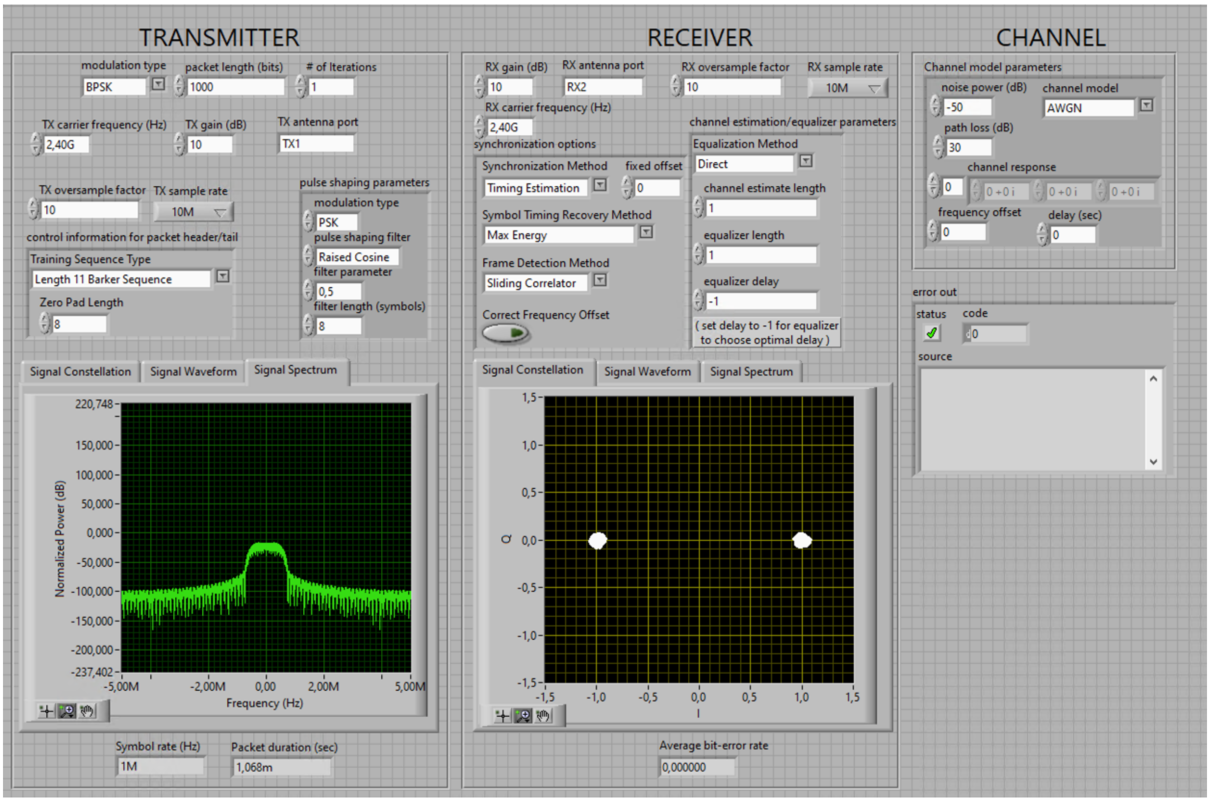

Figure 7: BPSK modulation type with Tx and Rx samples set to 10M.

$$R_{\text{data BPSK modulation}} = \frac{packet\ lenght}{Packet\ duration} = \frac{1000\ bits}{1{,}068\ ms} = \mathbf{936\ bits\ /ms}$$

<u>Task 3.5: If you transmit 1000 bits, how many symbols you transmit using BPSK modulation? How about in case of QPSK?</u>

In BPSK modulation, there are only two phase shifts (0 or 180 degrees), and each bit maps 1 symbol. Therefore, if we transmit 1000 bits, we are sending 1000 symbols. On the other hand, in QPSK modulation, the carrier signal modulates through four phase shifts: 0,90, 180 or 270 degrees. And each symbol transmits 2 bits. Thus, if we for sending 1000 bits, we need to transmit 500 symbols.

<u>Task 3.6: With the symbol rate of 500 kSym/s, it takes 1 ms to transmit 500 QPSK data symbols. However, the transmitter program indicates the *packet duration* to be 1,136 ms. It means that the net data share is then 1 ms⁄1,136 ms ≈ 88 %. This indicates that 88 % of the time is used for sending actual information and rest is system overhead. What would be the net data share (%), if we transmit only 100 bits in one packet? [In other words, check with the transmitter program the *packet duration* for 100 bits when using QPSK and then calculate the net data share. Please note that also 1 ms will change to another number. You must calculate how many QPSK symbols corre- sponds to 100 bits, and then how long it takes to transmit those symbols with given symbol rate.]</u>

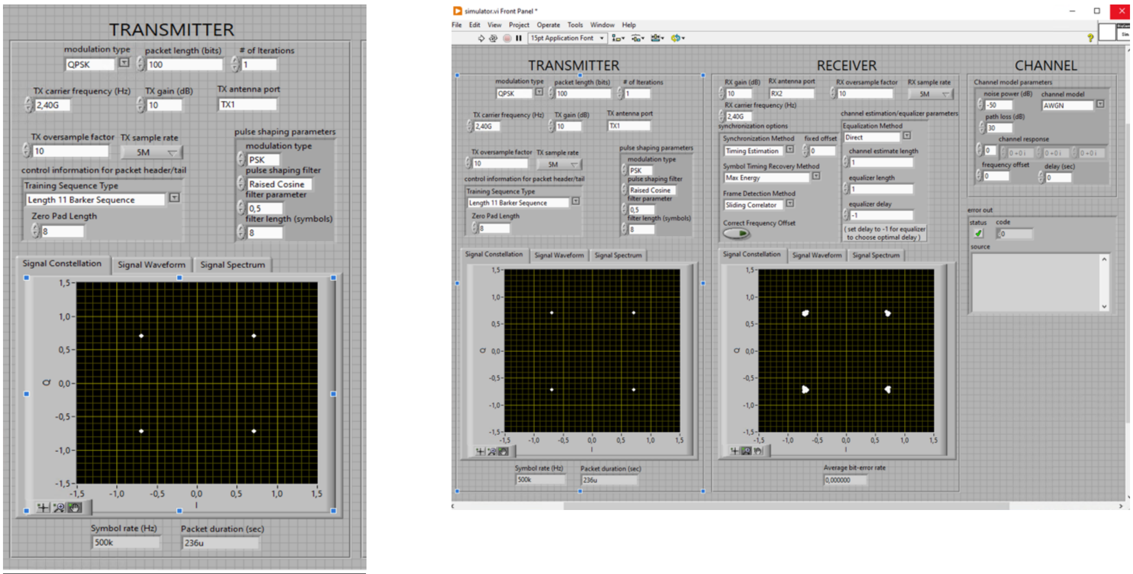

Figure 8: QPSK modulation set at 100 bits.

Packet duration = 236µ /sec → 236µ /sec / 1000 µ /ms = 0.236 ms

Calculate de data rate for the QSPK modulation.

Number of symbols = $\frac{Packt\ length}{Packet\ duration} = \frac{100\ bits}{2\ bits\text{—}symbol} = 50$ symbols

Transmission time for 50 symbols

Transmission time = $\frac{symbol}{symbol\ rate} = \frac{50\ Sym}{500\ KSym/ms} = 0.1$ ms

Net Data Rate = $\left(\frac{Transmission\ time}{packet\ duration}\right) \times 100\% = \left(\frac{0.1\ ms}{0.236\ ms}\right) \times 100\% =$ **42.37**

Net Data rate = 42.37 %