BPSK system

November 1, 2016

This document describes the simulation BPSK system in back-to-back configuration.

1 Functional Description

A simplified diagram of the system being simulated is presented in the Figure 1. The system simulated takes a random binary string and encodes it in an optical bandpass signal, signal that afterwards is decoded in order to re-obtain the original binary string.

The decoding of the optical signal is accomplished by an homodyne receiver, which combines the signal with a local oscillator with a user-determined phase. The homodyne receiver block output is then fed into a block that compares it with the original binary string and computes the Bit Error Rate (BER) along with it's upper and lower bounds for a certain user defined confidence level.

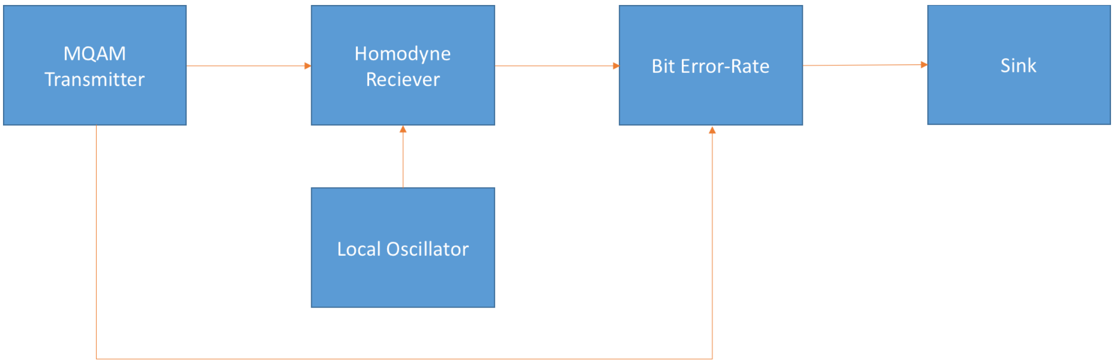


Figure 1: Overview of the BPSK system being simulated.

2 Simulation Results

The following results were obtained from the simulation using the following parameters:

NumberOfBits=	1000
SamplesPerSymbol=	16
pLength=	5
iqAmplitudesValues=	{ { 1, 0 }, { -1, 0 } }
outOpticalPower_dBm=	-20
LOoutOpticalPower_dBm=	-10
LocalOscillatorPhase=	0
TransferMatrix=	{ { 1/sqrt(2), 1/sqrt(2), 1/sqrt(2), -1/sqrt(2) } }
Responsivity=	1
Amplification=	1e6
NoiseAmplitude=	15.397586549153788
Delay=	9

The system took the binary string presented in Figure 2 and encoded it into the optical signal in Figure 3. Notice the BPSK constelation of the signal, presented in Figure 4.

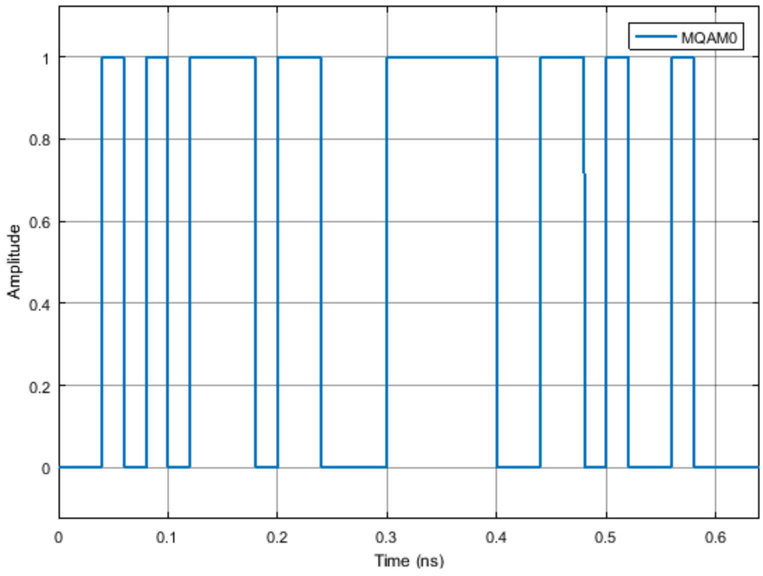


Figure 2: Sent binary key.

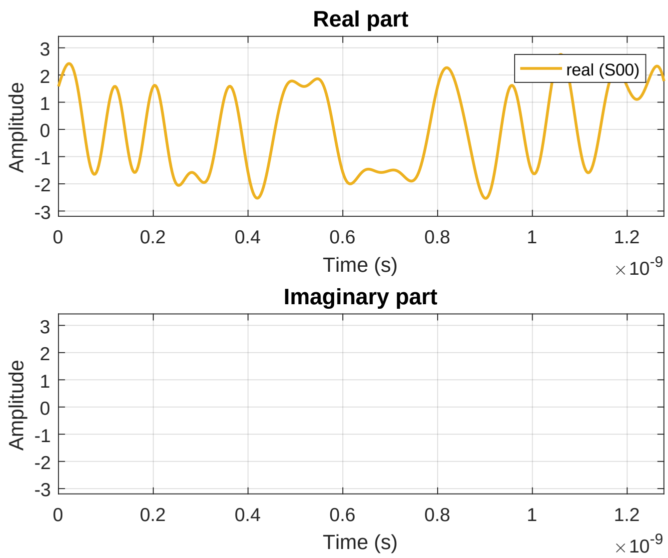


Figure 3: Sent signal.

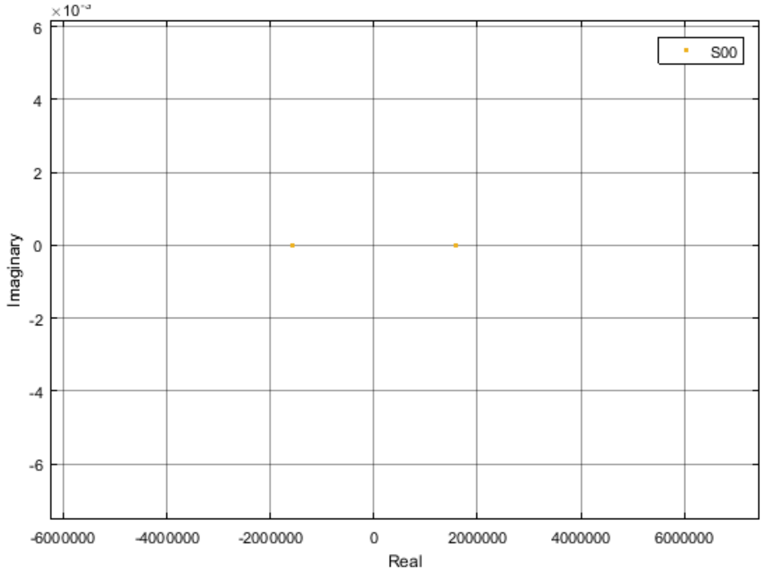


Figure 4: Constellation of the sent signal.

Homodyne detection is then performed, using to that effect the local oscillator signal presented in Figure 5. Figures 6 and 7 show the addition of noise to the signal.

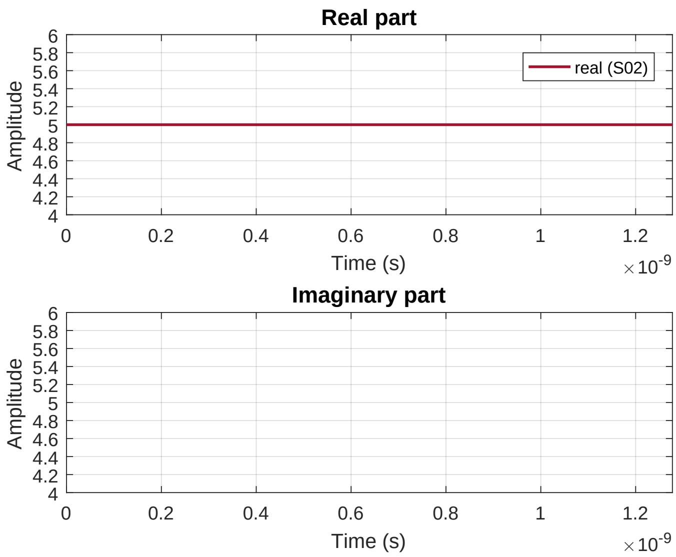


Figure 5: Homodyne receiver internal signal: local oscillator used for Homodyne detection.

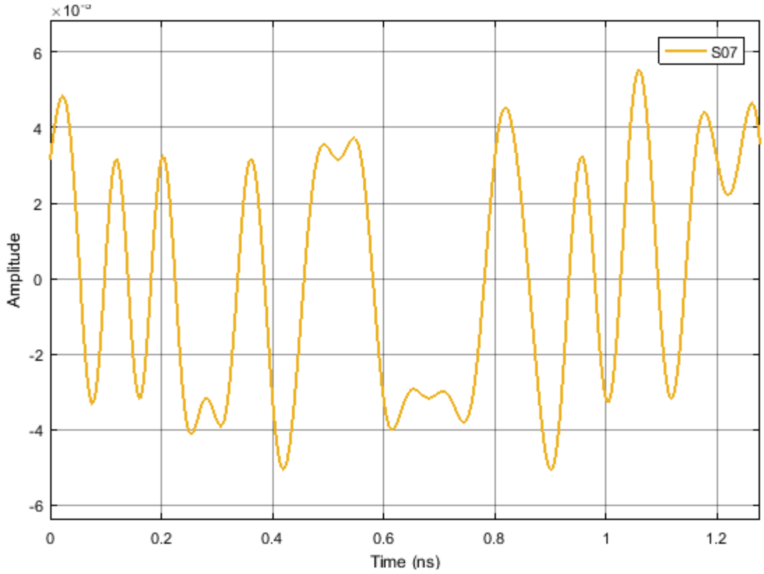


Figure 6: Homodyne receiver internal signal: subtraction of the signals outputted by the photodiodes.

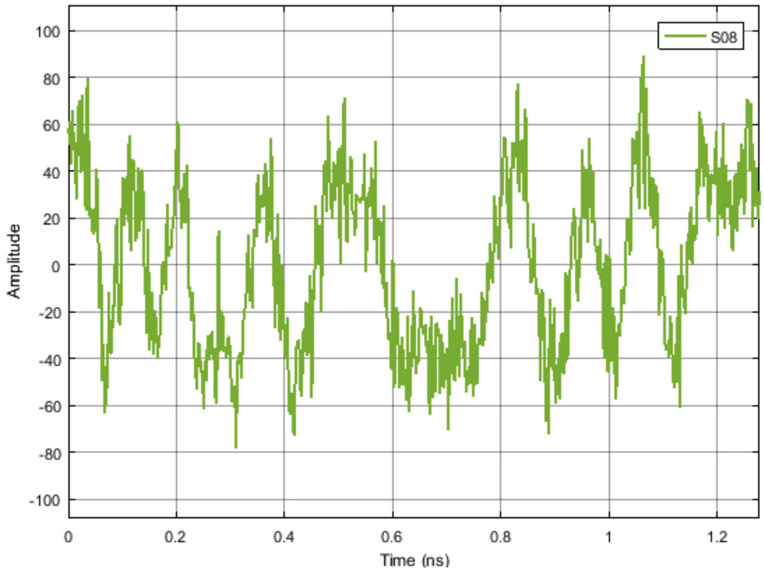


Figure 7: Homodyne receiver internal signal: amplification of the signal in Figure 6 with added noise.

The result of the homodyne detection is the binary string presented in 8, which is then compared to the original binary string by the BER block, which outputs the report presented in Figure 9.

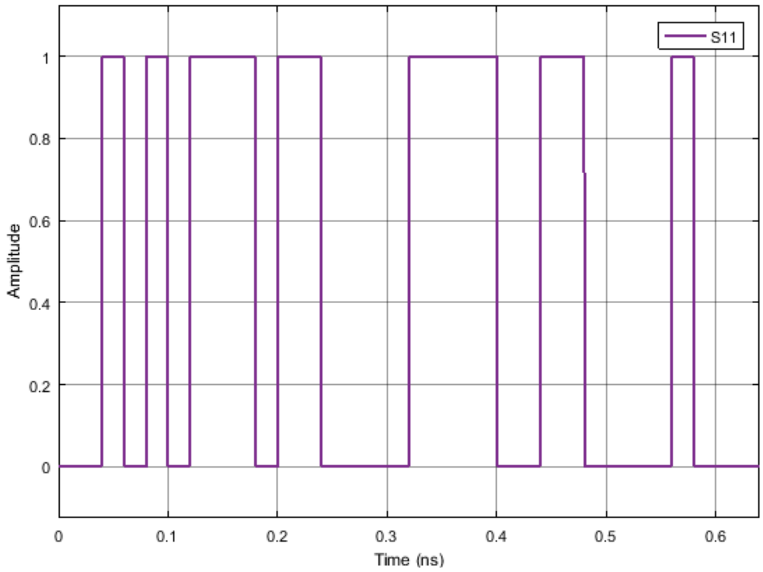
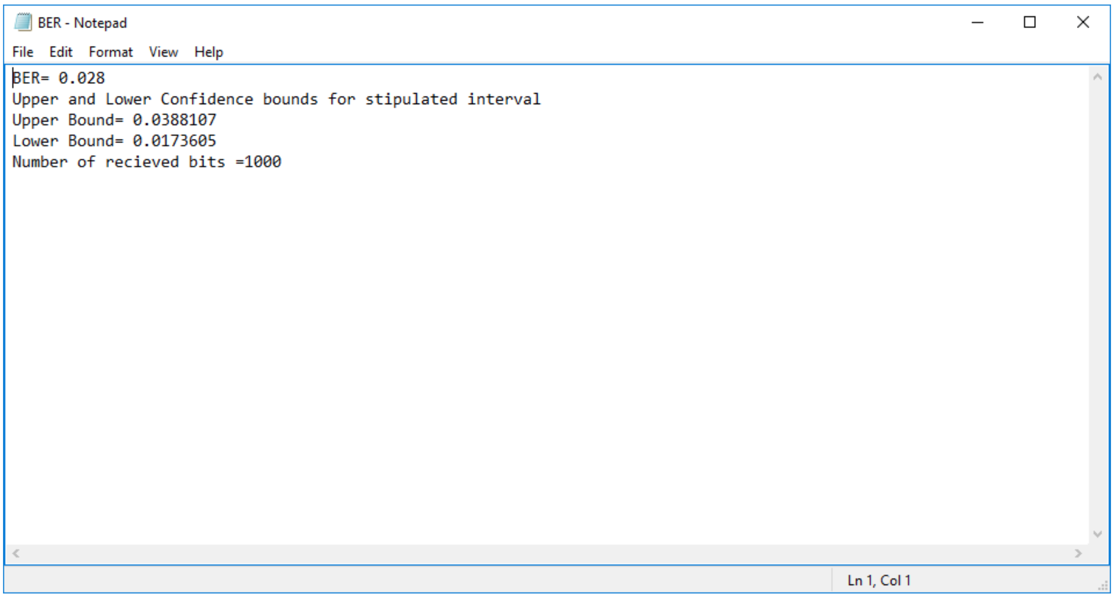


Figure 8: Decoded binary string, output of the Homodyne receiver block.



BER - Notepad

File Edit Format View Help

```
BER= 0.028
Upper and Lower Confidence bounds for stipulated interval
Upper Bound= 0.0388107
Lower Bound= 0.0173605
Number of recieved bits =1000
```

Ln 1, Col 1

Figure 9: Bit-Error-Rate report.

3 Block Description

3.1 MQAM Transmitter

3.2 Homodyne Receiver

This super-block compresses the function of the following blocks:

- Local Oscillator;
- Balanced Beamsplitter;
- Photodiode;
- Subtractor;
- Amplifier;
- Discretizer;
- Delayer
- Bit Decider;

This compression allows for a cleaner code.

Input Parameters

- LocalOscillatorOpticalPower
- LocalOscillatorOpticalPower_dBm
- LocalOscillatorPhase
- TransferMatrix
- Responsivity
- Amplification
- NoiseAmplitude
- SamplingRate
- Delay
- ReferenceValue

Functional Description

The input signal is evaluated and a binary string is generated from this evaluation.

Input Signals

Number: 1
Type: Sequence of impulses modulated by the filter (OpticalSignal)

Output Signals

Number: 1
Type: Binary String (Binary)

3.3 Bit Error-Rate

Input Parameters

- setZ

Functional Description

This block accepts two binary strings and outputs a binary string, outputting a 1 if the two input samples are equal to each other and 0 if not. This block also outputs a *.txt* file with a report of the calculate BER as well as the estimated Confidence bounds for a given probability $1 - \alpha$. The probability for the confidence bounds is determined by the $z_{1-\frac{\alpha}{2}}$ percentile of a standard gaussian distribution, value which has to be fed into the block.

Input Signals

Number: 1
  Type: Binary (DiscreteTimeDiscreteAmplitude)

Output Signals

Number: 1
  Type: Binary (DiscreteTimeDiscreteAmplitude)
  BBi