Journal of Information Engineering and Applications
ISSN 2224-5782 (print) ISSN 2225-0506 (online)
Vol. 2, No.11, 2012

Computer-Based Study of the Effect of Phase Noise in 256-Quadrature Amplitude Modulation Using Error-Rate Calculation Block -- A Comparative Study

Ezinna Lucky Efurumibe[1*] and Anyalewechi Daniel Asiegbu[1]

[1] Department of Physics, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.

efurumibeezinna@yahoo.com

ABSTRACT

This work is aimed at verifying the result obtained by Efuribe and Asiegbu. In the study carried out by Efuribe and Asiegbu, it was discovered that the effect of phase noise on transmitted signal is more when the phase noise level densities are high. These were shown vividly on the display of the scatter plot scopes, which where used for the study. But in this case, it was decided to use the values generated by the Error-rate Calculation block, and compare the results using the same parameters for simulation; as were used in the former case. Values generated by the Error-rate block for different noise levels where shown in table 4.1. The phase noise level density (PNLD) was varied from -20dBc/Hz to -120dBc/Hz in step of -20dBc/Hz; as was the case in the previous work. For each substitution, the model was simulated and results obtained and tabulated. In all, results showed that phase noise on transmitted signal decreases as values of PNLDs in the Phase Noise block decreases. This agrees with result obtained earlier on by Efuribe and Asiegbu.

Keywords: Phase, Noise, Quadrature, Amplitude, Modulation, Error-rate

1. INTRODUCTION

This work served as a confirmatory test to the result obtained earlier by Efuribe and Asiegbu [7]. Here, instead of using scatter plot scopes (as was used in the first study) it was decided to use values generated by the Error-rate Calculation block. The same parameters as were used in the first study were maintained here, only that values from the Error-rate Calculation block were considered instead of display of the scatter plot scopes. Values of the PNLDs (in the range -20dBc/Hz to -120dBc/Hz) in step of -20dBc/Hz, were substituted into the Phase Noise block. Simulation was performed for each PNLD value. Results were obtained and tabulated. Results showed that the rate at which error was occurring between the transmitted signal and the received signal was proportional to the PNLD. The form of QAM considered here is the 256-QAM.

2. PHASE NOISE

Phase noise is a type of noise that affects the phase of carrier signals. Here, the noise (whose phase is random) causes the phase of the carrier signal to be random. When phase noise is introduced into a carrier signal, it causes angular displacement of the carrier signal (see figure 8). Phase noise is usually associated with oscillators. In the digital 256-QAM (which was studied), phase noise is generated when the constellation points are oscillating; and that at a very high frequency (about 10MHz). It is a very important parameter one needs to consider when designing such devices as satellite repeaters, sensitive communication receivers such as the mobile stations.

Phase noise like other noises can only be described statistically, because of its random nature. Nevertheless its amplitude can be expressed in RMS volts ($Ao/\sqrt{2}$). Phase noise is typically expressed in units of dBc/Hz at various offsets from the carrier frequency. This is usually referred to as Phase Noise Level Density (PNLD). And it can be expressed mathematically as:

$$PNLD = -10 \log I/Io$$

where, I = noise intensity level in dB

Io = 10^-12 is a reference noise intensity level

For example, if the noise intensity level is 10^-4dB at a frequency offset of 1000Hz then, PNLD = -10 log (10^-4/10^-12) = -80 dBc/Hz

3. Materials used

Materials used for this work include: a dedicated high-speed and large capacity (40 Gbit hard disk size) personal computer, with a Pentium 3 microprocessor and RAM memory size of 512 Mbit. The computer has a clock frequency of 547 MHz and the operating system working in the computer is Microsoft window XP professional, version 2002. Accessories to the computer include: a 16 inches Acer monitor, a 19.0 Gbit hard disk drive, a 2.0 Gbit removable hard drive, a Microsoft mouse and a Touch mate keyboard.

The software package used in this work is MATLAB 7.1 Version. This software contains, “similink”, which is a tool (sub-software) that helps one simulate models after varying desired parameters in the models. Similink turns our computer into a laboratory for performing experiments. It encourages one to try things out. For example, one can build a model from the scratch using simulink. One can also take up existing models in the similink environment and add to it. These and more are what similink can offer.

4. Methodology

The experiments were performed using a similink model (contained in MATLAB 7.1) that is capable of simulating the Effect of Phase Noise in Quadrature Amplitude Modulation. The model is shown in figure 3.

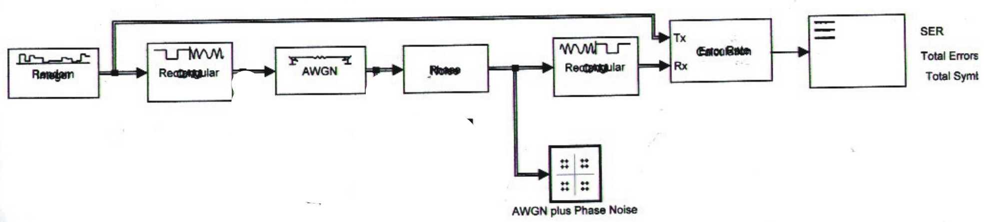

Figure 1: A similink model that is capable of simulating the Effect of Phase Noise in 256-QAM.

This model was then used to study how phase noise affects quadrature amplitude modulation via Error Rate Calculation Block. Before proceeding with the experiments, the value of the signal to noise ratio in the AWGN channel was first of all raised to 100dB, such that the channel itself would not have any effect on the modulated signal. This was confirmed by attaching two scatter plot scopes before and after the AWGN channel (see figures 6 and 7 respectively). These two scopes enabled the view of the signal before and after passing through the channel (see figure 4).

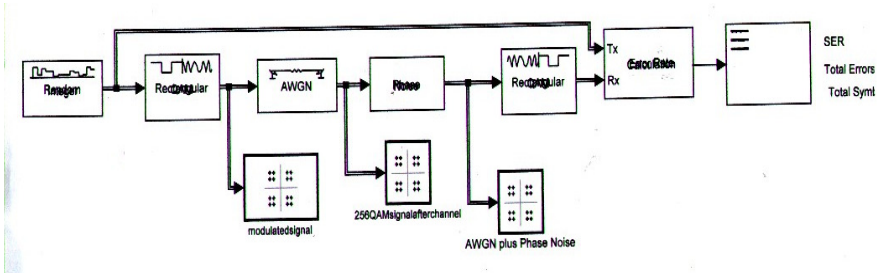

Figure 2: Two scatter plot scopes attached to the original simulink model

After these, the experiment was performed taking values of PNLD from –20 dBc/Hz to – 120dBc/Hz, in step of – 20dBc/Hz; for frequency offset of 200Hz. With each variation, the model was simulated. Results were displayed by the Error rate calculation Block. Before proceeding to the results, let us first of all look at the 'parameters' that were used in each of the Blocks for the simulation (which were the same parameters use by Efuribe and Asiegbu).

5. Parameters used for simulation

The following parameters were used in each block for the simulation:

For the Random Integer Generator Blocks we have:

a. M-ary number = 256

b. Initial seed = 12345

c. Sample time = 0.001s

d. Output status = Frame-based

e. Number of samples per frame = 500

f. Output data type used = unit 8.

For the Rectangular QAM Block, we have:

a. M-ary number = 256

b. Input type = Integer

c. Constellation ordering = Binary

d. Normalization method = Average power

e. Average power = 1 watts

f. Phase offset = 0 rad

g. Output data type = Single.

For the Rectangular QAM Demodulation Baseband Block we have:

a. M-ary number = 256

b. Output type = Integer

c. Constellation ordering = Binary

d. Normalization method = Average power

e. Average power = 1 watts

f. Phase offset = 0 rad

g. Output data type = Unit 8.

For the AWGN Channel we have:

a. Initial seed = 54321

b. Mode = signal-to-noise ratio (Es/No)

Es/No = 100 dB

Input signal power = 1 watts

Symbol period = 0.001s

For the Error Rate Calculation Block we have:

a. Receive delay = 0

b. Computation delay = 0

c. Computation mode = entire frame

d. Output data to = port

For the Discrete-Time Scatter Plot Scope we have:

a. Min X-axis = 1.5

b. Max X-axis = 1.5

c. Min Y-axis valve = 1.5

d Max Y-axis valve = 1.5

e. In-phase x-axis label = In-phase Amplitude

f. Quadrature Y-axis label = Quadrature Amplitude

g. Scope position = [32 306 240 240]

h. Title = scatter plot.

The same parameters were set for the three scatter plot scopes we have in the model. They were all set to "open scope at start of simulation". In this case, the scopes open on their own immediately simulation starts.

For the configuration parameters we have:

a. Simulation time: Start time: 0.0 stop time: 10

b. Solver = Ode 45

c. Relative tolerance = ie-3 = 0.001

d. Absolute tolerance = auto

Solver Options

Type = variable step

Max step size = auto

Min step size = auto

Initial step size = auto

Zero crossing control = use local settings.

6. Results of the Error Rate Calculation Block

The results of the Error Rate Calculation Block helped to give numerical analysis of the effect of the phase noise in the quadrature amplitude modulated signal for each substituted phase noise density value. The results are shown in table 4.1

Table 4.1: simulation results for a frequency offset of 200Hz.

PNLD(dBc/Hz)	Number of Symbols Compared	Number of Errors that Occurred	Error rate
-20	10500	10100	0.9619
-40	10500	8828	0.8408
-60	10500	1456	0.1387
-80	10500	0	0
-100	10500	0	0
-120	10500	0	0

The Error Rate Calculation Block gave varying results as the values of the PNLD were varied from -20dBc/Hz to -120dBc/Hz. The first value obtained for PNLD of -20dBc/Hz gave a high rate of error occurrence (of 0.9619). The number of errors that occurred at that noise level was also high (equal to 10100). As the noise level was reduced to -40dBc/Hz there was a significant reduction (value obtained equals 0.8408) in the rate at which error was occurring in the calculation. The number of error calculation at that level was significantly low (value equals 8828) as well. When the noise level was further reduced to -60dBc/Hz, the number of errors that occurred at that point was seen to be: 1456 (which is significantly low when compared to the previous two results). The same thing applies to the calculated rate at which the error was occurring. The value of the error rate obtained for -60dBc/Hz noise level was: 0.1387. When the noise level was reduce to -80dBc/Hz and down to -120dBc/Hz, zero error was calculated by the Error Rate Calculation Block.

This result is similar to what Efuribe and Asiegbu obtained when they used scatter plot scopes in their investigation of the same concept. In their investigation they observed that effect of phase noise on transmitted signal decreases as phase noise level densities decreases. This was the case when the Error Rate Calculation Block was used. When the phase noise level densities were high, more number of errors occurred showing that the transmitted signal was greatly affected and that negatively. But when the noise level densities were reduced, little/no errors were calculated. This went ahead to confirm the work done by Efuribe and Asiegbu as true.

8. CONCLUSION

It was discovered that quadrature amplitude modulation was greatly affected by phase noise, particularly in cases where the phase noise level densities were high. This should be checked in communication system to enable signal transmission with little or no distortion.

REFERENCES

1. Akpan A.O and Onuu, M.U. "Industrial Noise in Nigeria; Measurement, Analysis, Dose and Effects", Journal of Building Acoustics 2006, 13, 180 pages.

2. Akpan, A.I. and Onuu, M.U. "Environmental Noise Pollution in Nigeria Universities. A Case study of the University of Calabar, Calabar, Nigeria", Journal of Nigerian Environmental Society 2004, 2 (1), 100-109.

3. Asiegbu, A.D., "Computer-Aided studies of telephone traffic in Umuahia-South East Nigeria". PhD Dissertation, Michael Okpara University of Agriculture, Umudike, 2005, 90 pages.

4. Asiegbu, A.D., "Communication Systems", Lecture Note, Michael Okpara University of Agriculture, Umudike 2006, Unpublished, 1 – 22.

5. Bello, K. "Telecommunication", Nitel Journal 1999, 26. 38-42.

6. Bernard, D. and George, K. "Electronic Communication System", 4th ed. McGraw Hill Company ltd, New Delhi 1999, 2-60

7. Efuribe, E.L. and Asiegbu, A.D. "Computer-Based Study of the Effect of Phase Noise in 256-Quadrature Amplitude Modulation using Scatter Plot Scopes", Nigerian journal of Physics 2008, 20 (1): 49-58.

8. Froehlich, F. "Encyclopedia of Telecommunication", Marcel Dekker Publishers 1999, 11, 512.

9. Menkiti, A.I., "Logic Circuits, Devices and Applications", Eftimo Nigeria Press, Calabar 2000.

10. Mitra, S.K., "Digital Signal Processing", McGraw-Hill Inc, London 2001, 4.

11. NITEL, "Telecommunication" Radio and Transmission School, Oshodi, Lagos 1989, 5.

12. Onugbolu, N.B., “Modern Telecommunication Network in Nigeria”. A paper presented to the Nigeria Society of Engineers Ibadan Branch, Unpublished 2003, 1-26

13. Onuu, M.U and Abang, N.T “Industrial Noise Studies in quarries and Neighboring Communities”, unpublished 2005, 26 pages

14. Onuu, M.U., “Environmental Noise Control, Review and Assessment of Theories and

Model”, Nigerian Journal of Physics 1999, 11(183), 91-96

15. Onuu, M.U., “Road Traffic Noise in Nigeria. Measurement, Analysis and Evaluation of Nuisance”, Journal of Sound and Vibration (2000), 233 (3), 391-405.

16. Onuu, M.U. and Effiong, O.O., “Airport Acoustics. Aircraft Noise Distribution and Modeling of some Aircraft Parameters”, in Press, 2004, 7 Pages.

17. Onuu, M.U. and Inyang, A, “Environmental Noise Pollution in Nigerian Universities: A Case Study of the University of Calabar, Calabar, Nigeria”, Nigerian Journal of Physics 2004, 2 (1) 100.

18. Sheldon, T., “Encyclopedia of Networking & Telecommunications”, McGraw Hill Inc. 2001, 87.