JAET

Journal homepage: http://jae-tech.com

ISSN : 2523-6032 ISSN-L : 2523-2924

Journal of Applied Engineering & Technology

CMOS Based SNR Measurement for Wireless Application

Mohd Khuzairi Bin Che Kamarudin[1,*]

[1]Department of Communication Engineering,
Universiti Tun Hussein Onn Malaysia, Parit Raja, Johor, Malaysia

*Corresponding Author

Abstract: This paper presents the design of a CMOS based Signal to Noise Ratio (SNR) detection system. The design system is developed using divider, multiplier and an additional multiplier in a feedback loop. The divider in the designed system produce 1/V of the signal and multiplier produces the average squared SNR signal. The last stage in this design circuit is a low pass filter necessary to implement the desired "average" measure of the signal to noise ratio (SNR). From simulation, the output voltage of SNR is 9.167mVp-p and from practical, the output voltage is 13.2mVp-p.

Keywords: Complementary Metal Oxide Semiconductor; Divider Circuit; Multiplier circuit; Signal to Noise Ratio (SNR).

1. Introduction

The main factor commonly related to optical wireless communication is noise intensity at receiver that interrupting the original signal transmitted [1]. Further application for the output of SNR is to able to determine the quality of the incoming signal, thus affecting the bandwidth of receiver. This means, it is measurement of quantity from the information signal in a wireless communication system and random fluctuations of amplitude on that signal referred to as noise signal occurs when the signal is transmitted from a transmitter to receiver. The noises such as shot noise, dark current noise, Johnson noise and thermal noise that can affect the signal transmitted at the receiver where the signal to noise ratio (SNR) will decrease if the noise intensity increases [2]. In order to measure signal to noise ratio (SNR), the SNR circuit detector was designed to detect signal from transmitter. Usually, signal to noise ratio (SNR) is related to a gain [3]. Nowadays, there are many applications of optical wireless network that we use anywhere either outdoor or indoor, several efforts have been made in the design to reduce noise into the receivers. The receiver noise can be separated into internal and external components, noise produced by the front-end electronics and the ambient noise produced by artificial and natural light sources [4]. In most environments the ambient noise is dominant over the receiver noise. An optical field is mainly an indoor technology on contrary, the optical wireless communication outdoor technology that has many challenging design problems [5-8]. During the transmission, the ambient light noise sources are in line with signal sources at receiver [9]. Due to the directional nature of both signal and noise, the SNR observed by can significantly vary observation angle, and if receiver accept signal and the noise from opposite directions, the SNR will be greater.

2. Background and Literature Review

The signal to noise ratio detector (SNR) is used to detect the incoming signal from the photodiode. In optical wireless network, the photodiode received the signal by converting the incident optical intensity into a photocurrent [10]. The SNR defines the power ratio between a signal and noise [11-13]. This means, it is a measurement of quantity from the information signal in a wireless system and the random fluctuations of amplitude on that signal referred to as noise signal occurs when the signal is transmitted from a transmitter to the receiver. The noise is always represents as unwanted signal in most wireless system application. The noise will bring effect to the original signal where the

Corresponding author: kamarudin_Mohd@siswa.uthm.edu.my

information signal will have distortion and causes the reduction of the amplitude signal [14]. In communication, endeavor to maximize the SNR is considered. The noise will bring effect to the original signal where the information signal will have distortion and causes the reduction of the amplitude signal. However, there are other methods. SNR can be improved using high level of signal output power. Based on the theoretical criterion, SNR is high the signal can be classified as the better signal because the higher the ratio of SNR, the lower the noise signal. Fig. 1 shows the noise spectrum at optical receiver [15].

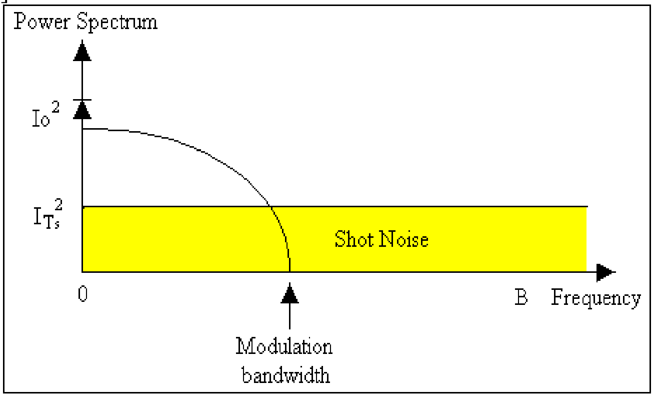

Fig. 1 -Noise Power Spectrum [13]

Optical receiver consists of various noises. They are shot noise, dark current noise, quantum noise, background noise such as fluorescent lamp, ambient light and etc. All the noises are located in the curve of modulation bandwidth. Signal cannot be transmit in the modulation bandwidth because the signal will interfere with the noises. Usually, signal transmitted at higher frequency that mean the signal transmit are outer the modulation curve. Shot noise, ITs occurs along the x-axis. The square function shows the total mean square for shot noise. Signal received represent the photocurrent, Io. Usually photocurrent, Io comes from photodetector. The high intensity of noise is located in curve of modulation bandwidth. In the next, the methodology of designing the CMOS Signal to Noise Ratio Measurement for Wireless application is discussed.

3. Research Methodology

The SNR measurement circuits are designed using dynamic calculation of the signal to noise at the receiver front-end's. Another distinguished definition of SNR measurements is that noise current is proportional to the photodiode current [16].

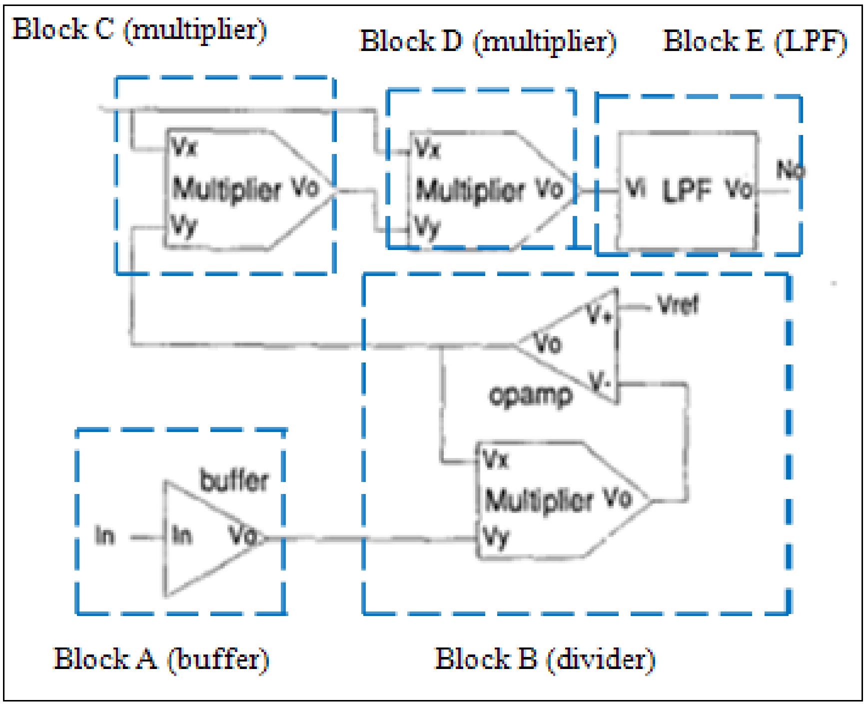

Fig. 2 -Block Diagram for the designed Design of a CMOS Signal to Noise Ratio Measurement for Wireless Application

Fig. 2 show that the circuit for SNR measurement with one divider and two multipliers in a feedback loop with an additional multiplier. 1/Vn of the signal is carried uisng divider and squared SNR result are attined using multipliers. The ouptut of this circuit is given to low pass filter as shown in Fig. 2. To attain the average SNR.

3.1 SNR Measurement Circuit use AD633

SNR measurement circuit of Fig. 3 consist two paths which are the signal path and noise path. Noise path begins from input of Block A to Block B meanwhile signal path begins from Block C to Block D and Block E. The noise path from Block B is combined with the signal path at Block C. Each block provide their own function which is Block A as buffer, Block B as divider and Block E as low pass filter while Block C and D as multipliers.

Furthermore, the photodiode is use detect the signal in Block A. The type of buffer that use in Block A is BUF600X1_BB. The BUF600X1_BB is use in signal to noise ratio (SNR) measurement circuit because its frequency is range about 320MHz so it can support the high frequency of signal that detect at photo detector.

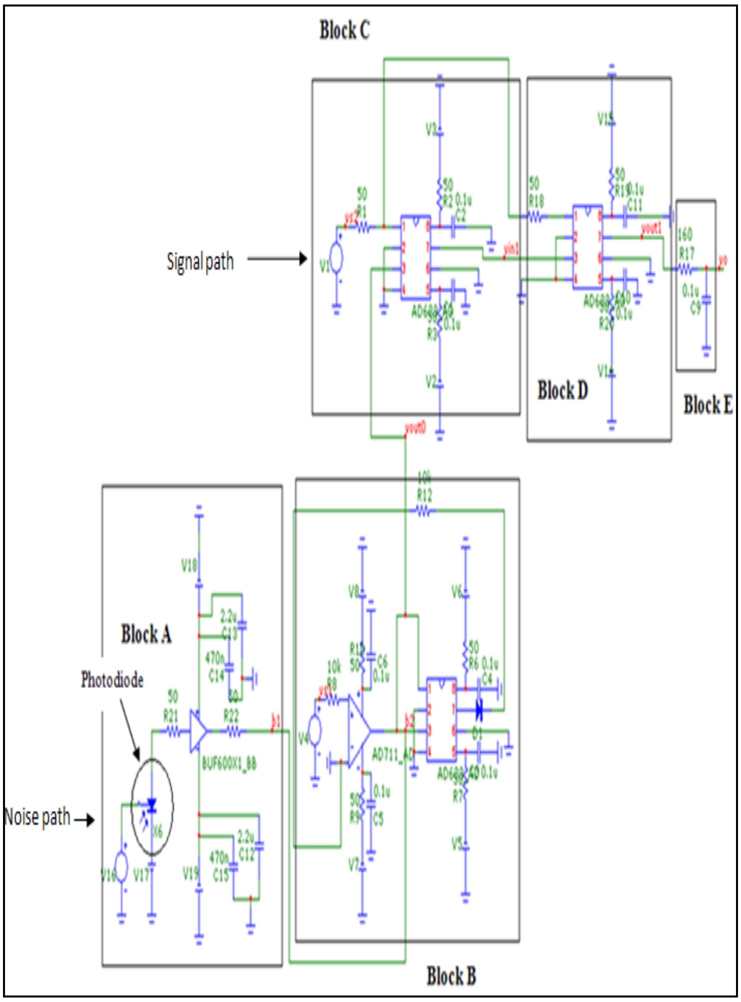

Fig. 3 -SNR Measurement Circuit use AD633

Moreover, in Block B there is use AD711 that combine with multiplier to build the divider circuit. An additional component such as diode is used to make the current flows in one direction only. The diode only allowed current flow from positive to negative. Then, the Block C and D use as multiplier. Otherwise, low pass filter is use in Block E. High signal to noise ratio (SNR) will produce a low noise output signal and high bandwidth at the receiver. In order to produce a good signal to noise ratio (SNR) detector, suitable IC and components must be consider carefully. All the chosen components must be of high efficiency and good performance in order to produce an output identical to theoretical.

3.2 SNR Measurement Circuit use AD734

In this circuit AD734 is use to observed and compare the result of signal to noise ratio (SNR) with AD633. The process is to identify which component is suitable as shown in Fig. 4.

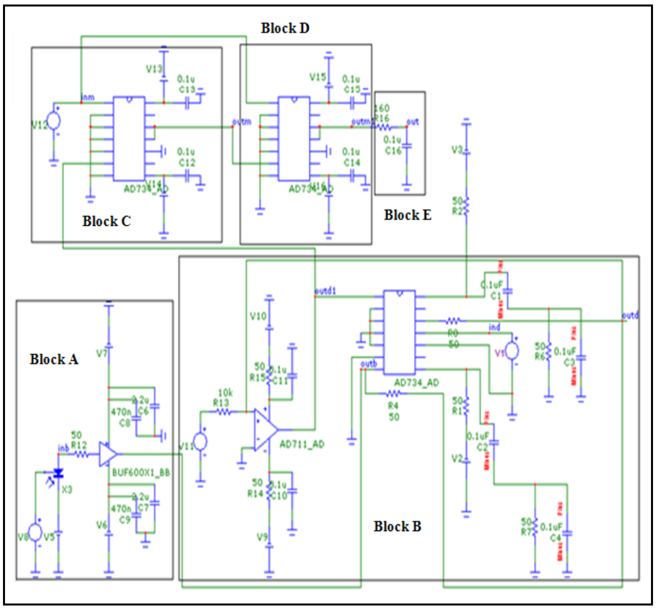

Fig. 4 -SNR Measurement Circuit use AD734

From Fig. 4, the connections at pin of AD734 are totally different with connections at pin of AD633. The other different between AD633 and AD734 are their frequencies. The frequency of AD734 about is 10MHz higher than frequency of AD633 but their function is same to build multiplier and divider circuit. The advanced performance of the AD734 is achieved by a combination of new circuit techniques. The amplifier that use is LMH6624 in non-inverting means it is feedback loop. Its frequency is about 1.5GHz and the function of Block E is to increase the gain of output from multiplier in Block D.

4. Result and Discussion

Output simulation results from the SNR measurement circuit use AD633 is in Fig. 5. All output graphs are arranged according to the changes of waveform from Block A to Block E signal to noise ratio (SNR). The simulation results were plotted in axis of voltage versus time using transient analysis. A 5.0Vp-p input voltage and 10 kHz input frequency was used.

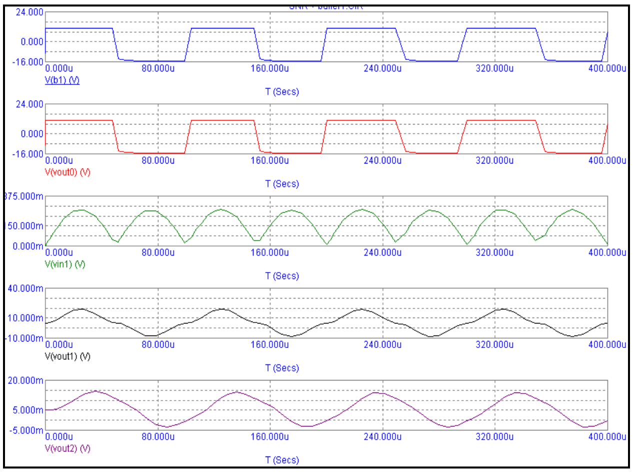

Fig. 5 -Result of SNR Measurement Circuit for AD633

The graph Vb1 which is square blue line represents the output of Block A while the graph Vout0 represents is the output of Block B. The both output are 10Vp. Besides that, the graph Vin1 which is half wave green line represents is the output of Block C. Its output is at 283.019mVp. Then, the graph Vout1 represents output of Block D. The output is at 20.189mVp. Next, the graph Vout2 is sine wave represents the output of Block E where it's output at 14.811mVp.

Based on Fig. 6, there are the outputs of SNR measurement circuit for each block diagram use AD734. The graph Voutb which is square blue line represents the output of Block A. Its output is 16.373Vp while graph Voutd1 is output of Block B where it is drop from positive to negative. Moreover, the graph Voutm is output of Block C at 6.576 Vp and the graph Voutm1 represents output of Block D. Its output is 122.034mVp. Then, graph Vout is the output of Block E and this output is about -823.729mVp.

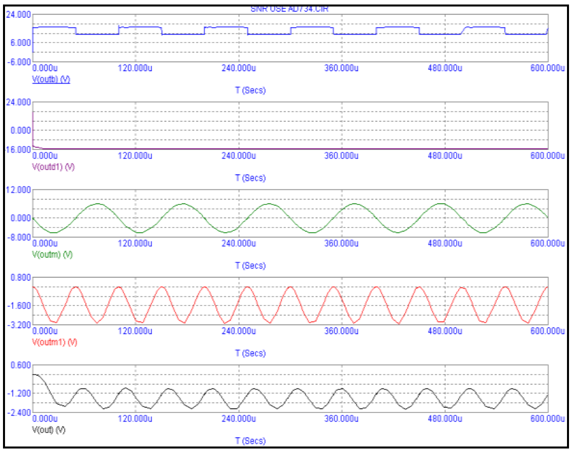

Fig. 6 -Result of SNR Measurement Circuit for AD734

5. Conclusion

This paper presents a signal to noise ratio (SNR) measurement system for an optical wireless. The signal to noise ratio (SNR) measurement system was simulated using Micro-cap software. The designed signal to noise ratio (SNR) system output is use different CMOS multiplier to compare and choose which the better signal to noise ratio (SNR) measurement circuit. From simulation and practical results, the suitable input frequency is 100 MHz and the suitable input voltage is 200mV.

References

[1] P. Patel, M. Sarkar, and S. Nagaraj. (2017). "Wireless channel model of ultra wideband radio signals for implantable biomedical devices," Health and Technology, pp. 1-14.

[2] S. Tamaru, H. Kubota, K. Yakushiji, A. Fukushima, and S. Yuasa. (2017). "Measurement of shot noise in magnetic tunnel junction and its utilization for accurate system calibration," Journal of Applied Physics, 122, p. 193901.

[3] A. Rogalski, Z. Bielecki, and J. MIKOLAJCZYK. (2017). "Detection of optical radiation," Handbook of Optoelectronics: Concepts, Devices, and Techniques, 1, 2017.

[4] L. N. Alves, L. Rodrigues, and J. L. Cura. (2017) "Lighting and Communications: Devices and Systems," Visible Light Communications: Theory and Applications, p. 9.

[5] S. Hranilovic, Wireless optical communication systems: Springer Science & Business Media, 2006.

[6] [M. V. Vuon. (2016), "Cross-layer Design, Analysis, and Optimization for Optical Wireless Communication Networks," The University of Aizu.

[7] H. Kaushal and G. Kaddoum. (2016). "Underwater optical wireless communication," IEEE Access, 4, pp. 1518-1547.

[8] P. Unwin and T. Unwin. (2017). Reclaiming information and communication technologies for development: Oxford University Press.

[9] K. Cui, G. Chen, Z. Xu, and R. D. Roberts. (2010). "Line-of-sight visible light communication system design and demonstration," in Communication Systems Networks and Digital Signal Processing (CSNDSP), 2010 7th International Symposium on, pp. 621-625.

[10] K. Kikuchi. (2006). "Phase-diversity homodyne detection of multilevel optical modulation with digital carrier phase estimation," IEEE Journal of Selected Topics in Quantum Electronics, vol. 12, pp. 563-570.

[11] D. I. Hoult and R. Richards. (1969). "The signal-to-noise ratio of the nuclear magnetic resonance experiment," Journal of Magnetic Resonance, 24, pp. 71-85, 1976.

[12] J.P. Gonzále. (2017). “Adaptive Dynamic Filter using MOSFET Receiver,” J. of Applied Engineering & Technology Vol. 1 No. 1 (2017) p. 9-15.

[13] H.R.A. Rahman, Mohammad Faiz. (2017). “Amplitude and Frequency Shift Keying Infrared Transmitter,” J. of Applied Engineering & Technology Vol. 1 No. 1 (2017) p. 16-21.

[14] C. E. Shannon. (1949). "Communication in the presence of noise," Proceedings of the IRE, vol. 37, pp. 10-21.

[15] W. Moench and E. Loecklin. (2017). "Measurement of optical signal-to-noise-ratio in coherent systems using polarization multiplexed transmission," in Optical Fiber Communications Conference and Exhibition (OFC), pp. 1-3.

[16] D. A. Skoog, F. J. Holler, and S. R. Crouch, Principles of instrumental analysis: Cengage learning, 2017.