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Different CMOS Nano Technology Size for Enhancement of Transimpedance Amplifier Performance Operation Efficiency

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Abstract— ***This paper has deeply investigated transimpedance amplifier performance evaluation based on different CMOS technology size for various optical communication systems applications. Electrical output power, and radio frequency spectrum have been studied using optiwave system simulation based on 0.25 µm CMOS is compared with literature review results with 0.8 µm CMOS. Signal quality factor and bit error rate are the major interesting performance parameters in different optical communication system applications. Our simulated results have shown that 0.25 µm CMOS technology is provides higher performance efficiency than 0.8 µm CMOS technology.***

Index Terms— Transimpedance amplifier, 800 nm CMOS, 250 nm CMOS, and CMOS based on Nano technology.

I. INTRODUCTION

Transimpedance amplifier (TIA), as a first element following the photodiode, is the most critical element on the receiving side of an optical link. Both noise performance and time domain response have to be considered when the sensitivity of an optical receiver is optimized [1, 2]. A transimpedance amplifier finds use in audio applications, band gap reference circuits, instrumentation systems and various other electronic circuits but its use in receivers of optical communication leads. The design of an optoelectronic front end which consists of photo detector diode and transimpedance amplifier is a challenging task. High speed transimpedance amplifiers (TIAs) used in optical fiber receivers present design challenges in the form of trade-offs between input noise, current, speed, transimpedance gain, power dissipation, and supply voltage[1]. The function of a transimpedance amplifier is to convert the generated current from photo detector diode into voltage signal with a level that is capable of driving an automatic gain controller post amplifier circuit [3]. Various configurations of transimpedance amplifier were used to compute the performance of transimpedance amplifier in CMOS optical preamplifier design using graphical circuit analysis [3].

The recent rapid progress of data transportation volume and speed has brought great demands of high bandwidth, low cost and low power integrated optical communication circuits [4]. A high speed optical receiver generally consists of a photodiode, a transimpedance amplifier (TIA) and a limiting amplifier (LA). The TIA, which converts and amplifies the induced photo current into voltage for following signal processing, must has a large bandwidth to support high-bit rate applications. In the design of a low cost and low power TIA for optical communication system, deep sub-micron CMOS technology is the primary candidate for its low cost and easy of fully-integration [5].

II. BASIC SIMULATION MODEL

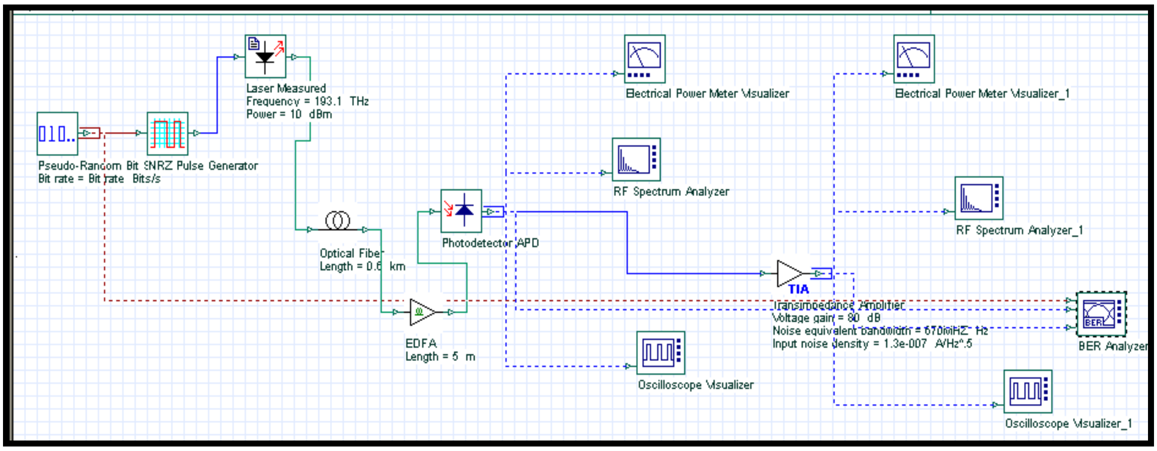


Fig. 1. Basic simulation model for 0.25µm CMOS transimpedance amplifier.

Most optical communication systems employ binary amplitude modulation of the lightwave for easy of detection . So we use the pseudo random bits (PRBs) in this model. Each (PRBS) is in fact a repetition of a pattern that itself consists of a random sequence of a number of bits. In this model the pseudo random bit outputs are applied to a non return to zero (NRZ) pulse generator which out puts is (anon return to zero data format) and acts as an electrical inputs to the laser diode. The laser diode converts this electrical signal and outputs an optical signal at frequency of 193.1THz enters the optical fiber. The optical fiber and the erbium doped fiber amplifier (EDFA) act as the communication channel because fibers can transmit light with a relatively small amount of power loss and the EDFA amplify this light after receiving at the receiver front end. The Photo detectors avalanche photodiode (APD) at the receiver detect and convert this optical signal to an electrical current signal. This current signal acts as the input signal to the TIA. This Transimpedance Amplifier converts this applied current signal to a voltage signal, and we take the output data from the electrical power meter visualizer , RF spectrum analyzer , oscilloscope visualize and the BER analyzer.

III. SIMULATION RESULTS AND DISCUSSIONS

We have investigated the high performance of transimpedance amplifier performance efficiency measurement based different CMOS technology size for various optical communication systems applications under the set of the wide range of the affecting and operating parameters as shown in Table 1 is listed below.

Table 1: Proposed operating parameters for our suggested transmission systems [3, 6].

Transimpedance Amplifier	Band Width	Gain	Noise Density
0.8 μm CMOS	120 MHz	150 KΩ	1 pa/(Hz)$^{0.5}$
0.25 μm CMOS	670 MHz	43.8 KΩ	1.3 pa/(Hz)$^{0.5}$

Based on the simulation model set up with assumed set of the operating parameters which are listed in the Table 1 above, and based on the series of the Figs from 2 to 14, the following facts are assured:

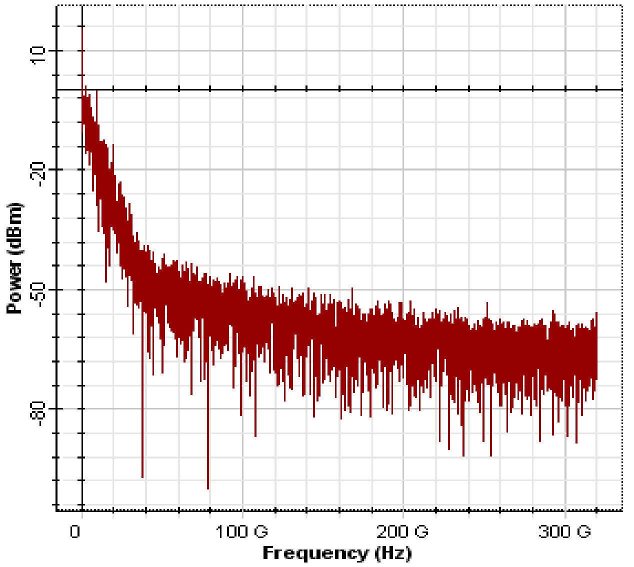


Fig. 2. Input power signal in related to operating frequency for TIA.

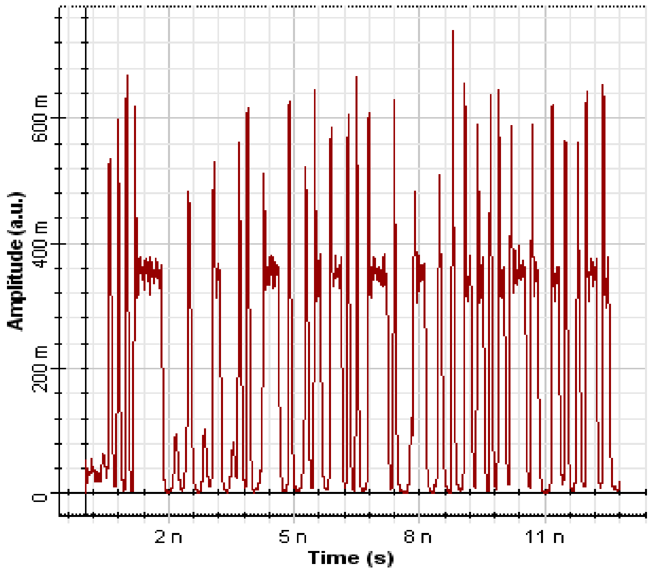
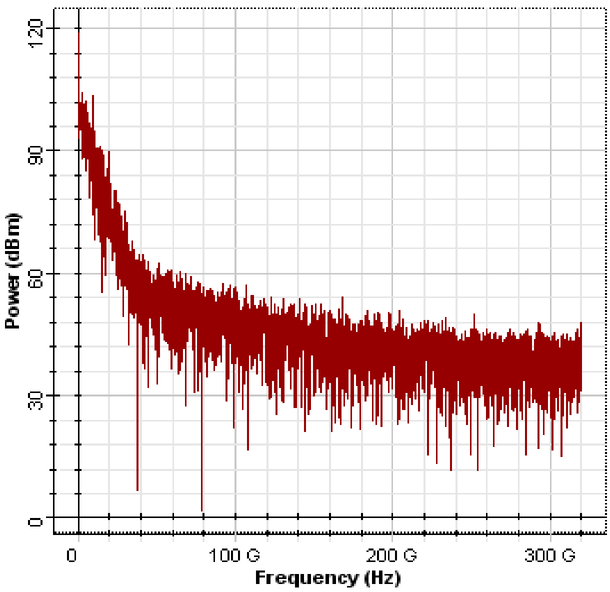


Fig. 3. Input amplitude signal in related to time for TIA.



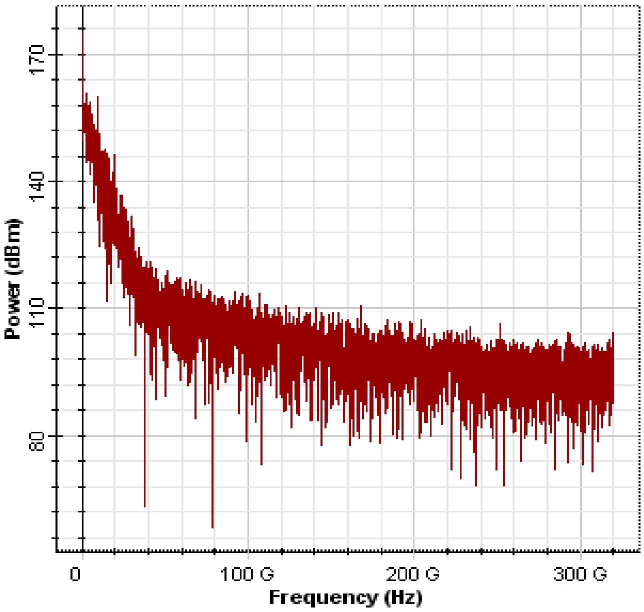


Fig. 4. Output power in related to frequency for 0.8 μm CMOS technology.

Fig. 5. Output power in related to frequency for 0.25 μm CMOS technology

As shown in figs. (2, 3), it is observed that the input power within the range from -80 to 5 dBm and the input amplitude within the range from 0 to 600 mA. As well as shown in figs (4, 5), it is indicated that for the 0.8 μm CMOS technology based on TIA the output power within the range from 30 to 120 dBm while in the case of 0.25 μm CMOS technology, the output power is within the range from 80 to 170 dBm. It is found that 0.25 μm CMOS technology has presented higher output power than 0.8 μm CMOS.

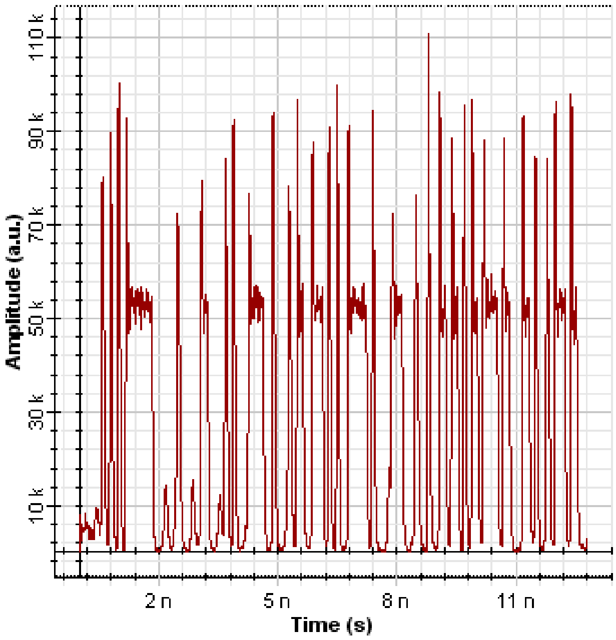


Fig. 6. Output amplitude for 0.8 μm CMOS technology.

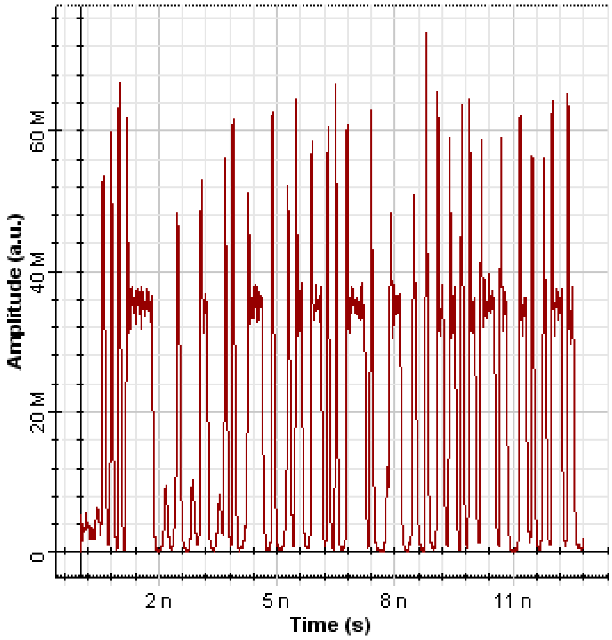


Fig. 7. Output amplitude for 0.25 μm CMOS technology.

As shown in figs. (6, 7), it is indicated that for the 0.8 μm CMOS technology based on TIA the output amplitude is within the range from10 to 100 kv while in the case of 0.25 μm CMOS technology . where the output amplitude within the range from 0 to 60 Mv. It is found that 0.25 μm CMOS technology has presented higher output amplitude than 0.8 μm CMOS.

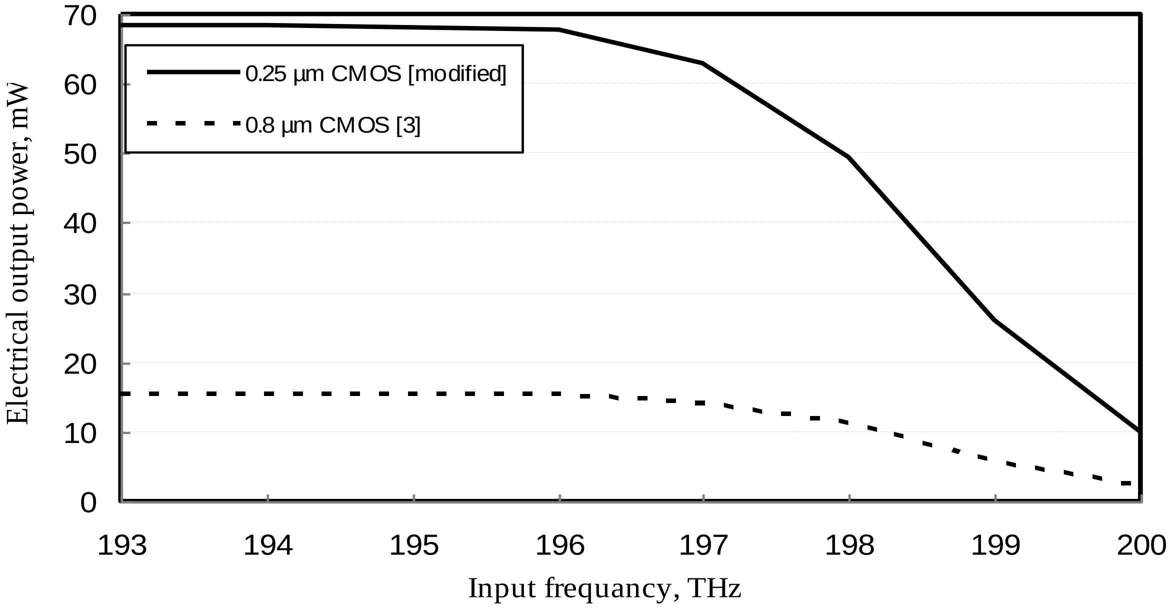


Fig. 8. Output power versus frequency for different CMOS technology size based TIA.

As shown in fig. 8, it is indicated that the output power decreases with increasing operating frequency in near infrared region for both CMOS technology sizes. Our results have been indicated better than the results in Ref. [3].

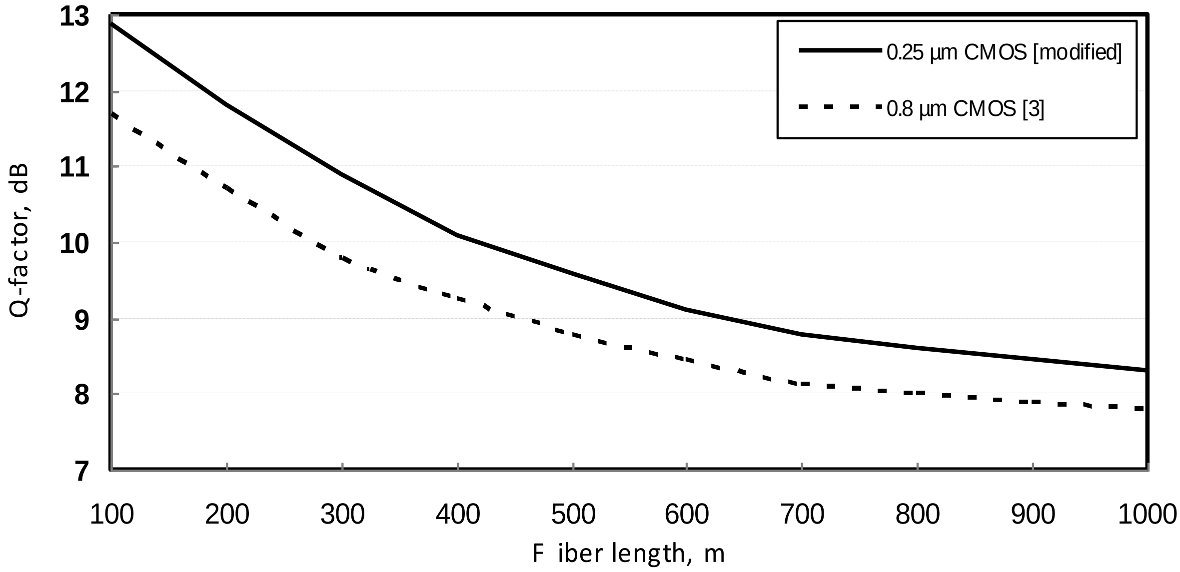


Fig. 9. Variations of Q- factor against variations of fiber length for different CMOS technology size based on TIA in the case of indoor applications.

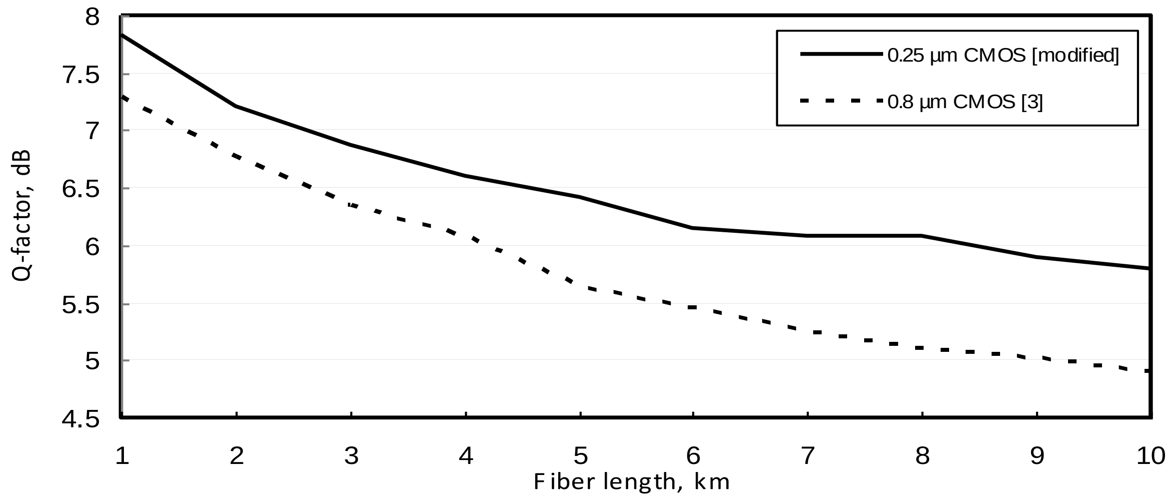


Fig. 10. Variations of Q- factor against variations of fiber length for different CMOS technology size based on TIA in the case of local area applications.

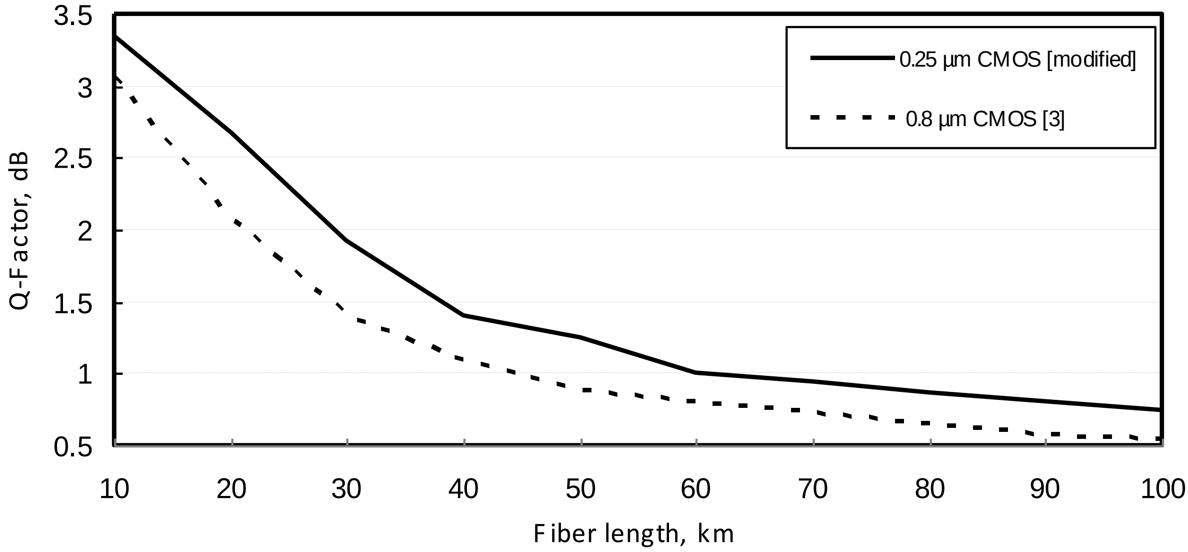


Fig. 11. Variations of Q- factor against variations of fiber length for different CMOS technology size based on TIA in the case of long haul applications.

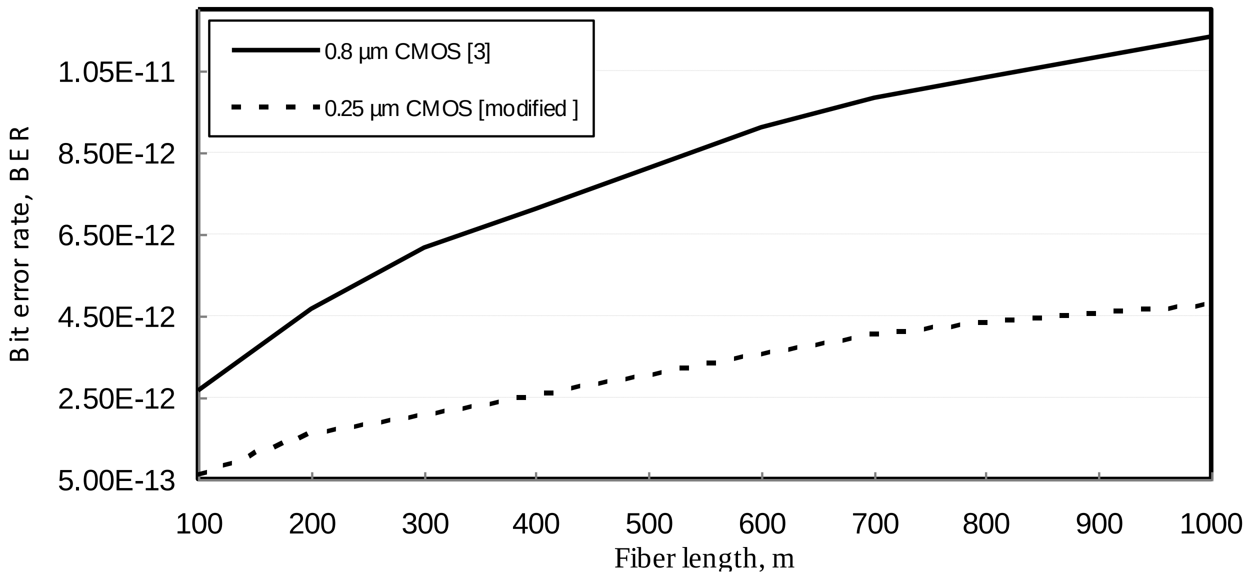


Fig. 12. Variations of BER against variations of fiber length for different CMOS technology size based on TIA in the case of indoor applications.

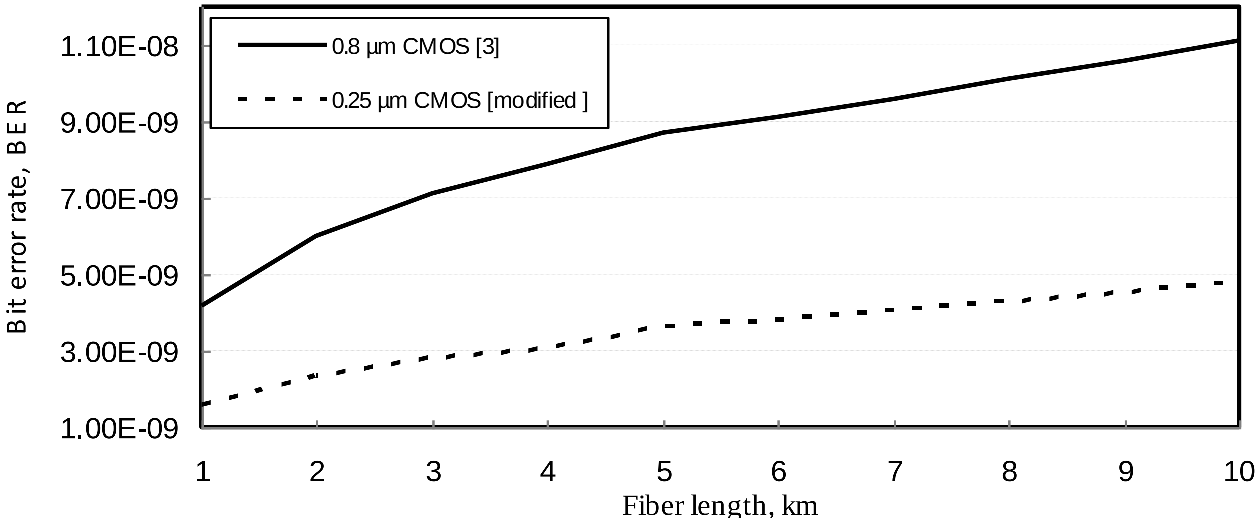


Fig. 13. Variations of BER against variations of fiber length for different CMOS technology size based on TIA in the case of local area applications.

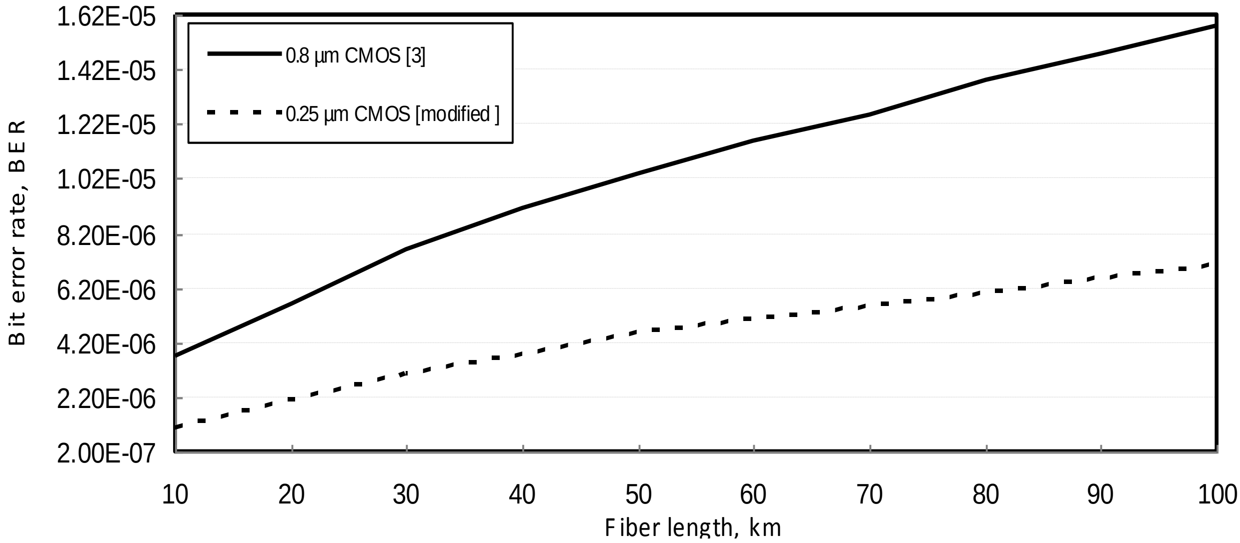


Fig. 14. Variations of BER against variations of fiber length for different CMOS technology size based on TIA in the case of long haul applications.

Figures (9-11), have assured that signal quality factor decreases with increasing fiber length for different CMOS technology size . As well as the signal quality factor has presented the highest values with indoor applications in compared with other applications. Moreover, our results with signal quality have been demonstrated better than the results in reference [3]. As well as the Figures (12-14), have assured that bit error rate increase with increasing fiber length for different CMOS technology size based on TIA .As well as the bit error rate has presented highest values with long haul applications in compared with other applications. Moreover, our results with bit error rate have been demonstrated better than the results in Ref. [3].

IV. Conclusions

Related to the standard parameters of transimpedance amplifiers in the two different technologies, by applying the optiwave system 7 simulation that the electrical power, output radio frequency (RF) spectrum and the amplitude range that are shown in Table 2.

Table 2: The output Results

Input/output	Electrical power (mW)	Output RF Spectrum (dBm)	Amplitude unit of TIA
Input power	6.85	-80 to 5	0 to 600 mA
0.8 µm CMOS [3]	15.4	30 to120	10 to100 KV
0.25 µm CMOS	68.5	80 to170	0 to 60 MV

Depending on the previous results, The 0.25 µm CMOS technology provides higher and better results in compared with the results of the 0.8 µm CMOS technology, as well as 0.25 µm CMOS technology provides the highest electrical power, amplitude unit range, and RF spectrum range compared to 0.8 µm CMOS technology.

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Dr. Ahmed Nabih Zaki Rashed was born in Menouf city, Menoufia State, Egypt country in 23 July, 1976. Received the B.Sc., M.Sc., and Ph.D. scientific degrees in the Electronics and Electrical Communications Engineering Department from Faculty of Electronic Engineering, Menoufia University in 1999, 2005, and 2010 respectively. Currently, his job carrier is a scientific lecturer in Electronics and Electrical Communications Engineering Department, Faculty of Electronic Engineering, Menoufia university, Menouf 32951.
His scientific master science thesis has focused on polymer fibers in optical access communication systems. Moreover his scientific Ph. D. thesis has focused on recent applications in linear or nonlinear passive or active in optical networks. His interesting research mainly focuses on transmission capacity, a data rate product and long transmission distances of passive and active optical communication networks, wireless communication, radio over fiber communication systems, and optical network security and management. He has published many high scientific research papers in high quality and technical international journals in the field of advanced communication systems, optoelectronic devices, and passive optical access communication networks. His areas of interest and experience in optical communication systems, advanced optical communication networks, wireless optical access networks, analog communication systems, optical filters and Sensors. As well as he is editorial board member in high academic scientific International research Journals. Moreover he is a reviewer member in high impact scientific research international journals in the field of electronics, electrical communication systems, optoelectronics, information technology and advanced optical communication systems and networks. His personal electronic mail ID (E-mail:ahmed_733@yahoo.com). He has supervised four PhD students and three MSc. students successfully and four Ph. D students and Seven MSc. students are currently pursuing their research under guidance. His published paper under the title **"High reliability optical interconnections for short range applications in high performance optical communication systems"** in Optics and Laser Technology, Elsevier Publisher has achieved most popular download articles in 2013.