Investigation the Effect of Nonlinear Distortion for Radio over Fiber Link

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ABSTRACT
This paper consist a simulation study of nonlinear distortion (NLD) for radio over fiber *(RoF)* link. The simulation is performing on OptiSystem platform. The investigation of the nonlinear effect in done by electrical cancellation point, output power, oscilloscope visualizer, types of modulation and laser power etc.

General Terms
Optical Power, QAM, Simulation.

Keywords
Nonlinear Distortion, OptiSystem, Radio over Fiber.

1. INTRODUCTION
A Radio over Fiber (RoF) is one of the most preferable In the early 1980s, the US introduced the integration of wireless and optical fiber to accommodate military requirements such system is widely known the RoF *(Radio over Fiber)* system, where Cooper initially adopted RoF into cordless and mobile communications [1].

The integration of wireless and optical networks is a potential solution for increasing mobility as well as decreasing costs in the access network, by RoF [2]. The RoF technology holds numerous recompense compared to the wireless technology such like as Low Attenuation Loss; Low Power Consumption; Full control of the range of radio wave (No trouble of the radio signals of neighbors, health and hacking concerns); Reduced the cost of system; Invulnerability to Radio Frequency Interference; Extension of existing radio coverage; Fewer multipath fading effects; Increased channel capacity and efficiency; Enhanced quality of signals; High Bandwidth and data transfer rate; Support for future generation networks.[3].

In the era of new generation the requirements for networks:
Everywhere broadband internet services with simplicity in accessing devices, and services irrespective of network technologies. The users are also looking for long time between re-charging and new and ever-present mechanisms for charging of devices.[4-5]

The integration will make the networks more transparent, dynamic, faster and greener. The existing technology face the problem like: Low speed of data transmission No coverage in "Dead Zone" area. The radio-over-fiber (RoF) system portion of the system usually has adequate bandwidth to support wide-band and high capacity services. Once completion of RoF techniques there are some significant issues arise those are parallel investigated for RoF system, especially in a multi-user environment, nonlinear distortion (NLD) of the RoF link, due mainly to the laser diode, becomes the biggest concern. The performance of the RoF link is limited by NLD[6-7].

Thus in this paper we are investigated the effect of NLD on RoF link. There are different methods carrying out research in the field of optical systems, like experiments and simulations. To minimize time and cost requirements also to broaden the investigation, this study focuses on simulation experiments based on software in order to investigate the performance of signal transmission for different comprehensive setups.

2. SIMULATION TOOL
The study of NLD on RoF can be analyses on OptiSystemTM (Optical Communication System and Amplifier Design Software). This tool is a versatile design suite for Fiber optic telecommunication network, FTTH applications, CATV design, PON, SONET/SDH ring design and optical amplifier design Optical communication systems are increasing in complexity on an almost daily basis. The design and analysis of these systems, which normally include nonlinear devices and non- Gaussian noise sources, are highly complex and extremely time-intensive. A comprehensive Graphical User Interface (GUI) controls the optical component layout and net list, component models, and presentation graphics. The extensive library of active and passive components includes realistic, wavelength dependent parameters. OptiSystem satisfies the demand of the booming photonics market for a powerful and easy-to-use optical system design tool [8].

3. EXPERIMENT SETUP
The proposed setup for simulation is given in figure 1. The experiment work is performed on OptiSystem software. RoF link is consist of the direct modulation technique in which we used using directly modulated laser at ~1550 nm wavelength with ~0 to 25 dBm power; ~25 to 80mA bias current & 25MHz line width. Two amplifiers of 45 dB & 31 dB gains are used & signal mode fiber of 1km length with 0.2 dB/km attenuation. At the receiving side PIN photodiode use in optical detector *(Reponsivity 1A/W & Dark Current 1nA*). The input signal is m-QAM signal (i.e. QAM, 16 QAM, 32 QAM & 64 QAM). The QAM transmitter signal is generated by M-array pulse generator & QAM modulator & QAM sequence generator. The QAM modulated signal will be transmitted through radio over fiber. The QAM demodulator is used for detection. Analyzing tools oscilloscope visualize, electrical cancellation, optical power meter, electrical power meter etc are used for observation.

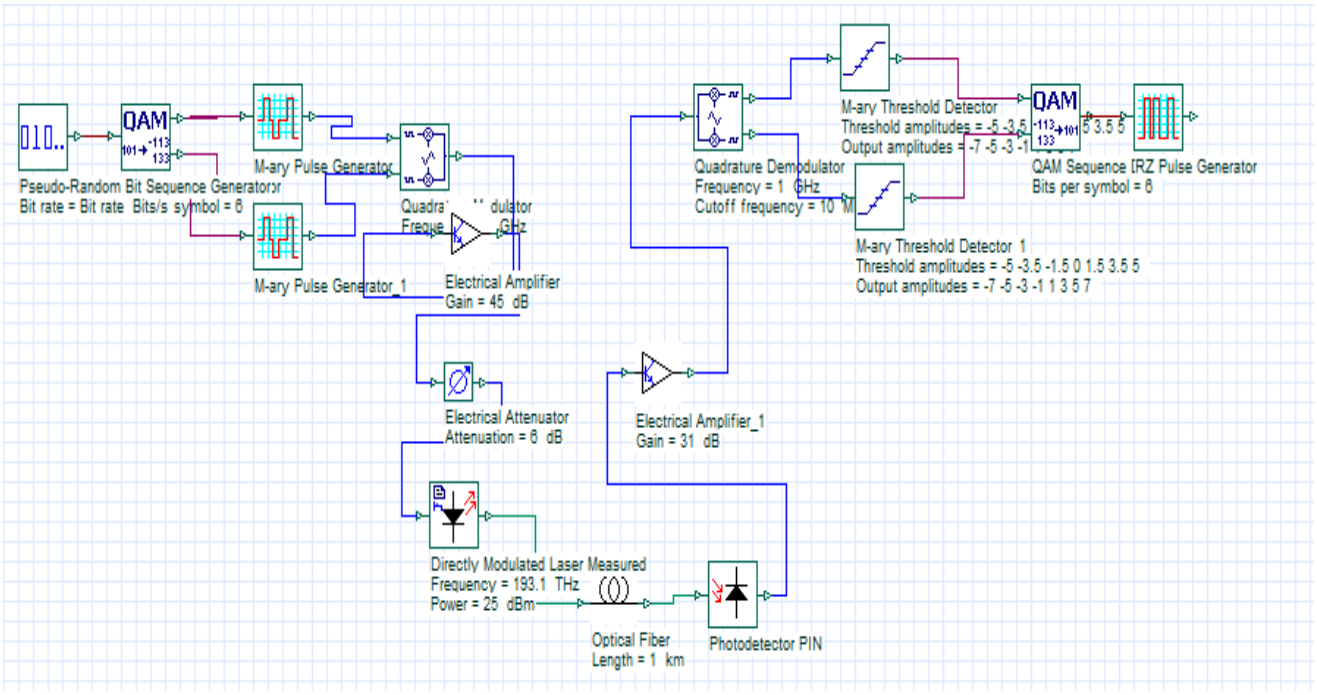
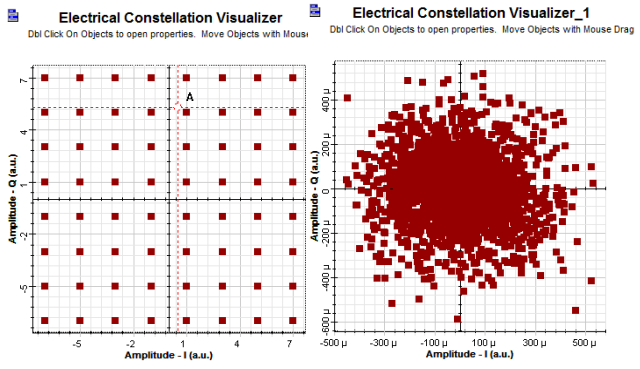


Figure 1: Experiment Setup for Radio over Fiber Link

4. SIMULATION RESULT

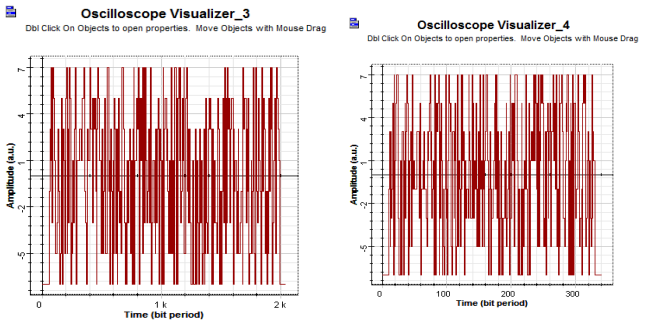
The simulation result of experiment setup is given in figure 2 (a) and (b) for Constellations of transmitted & received signal respectively. The pseudo random bit sequence generator with 64 QAM modulated input signal at 1 GHz frequency of amplitude of (~7.7 a.u.) is transmitted through radio over fiber & received signal has amplitude of (~0.18 a.u.).The reduction in amplitude of received signal is ~97% due the nonlinear distortion.



(a) **(b)**

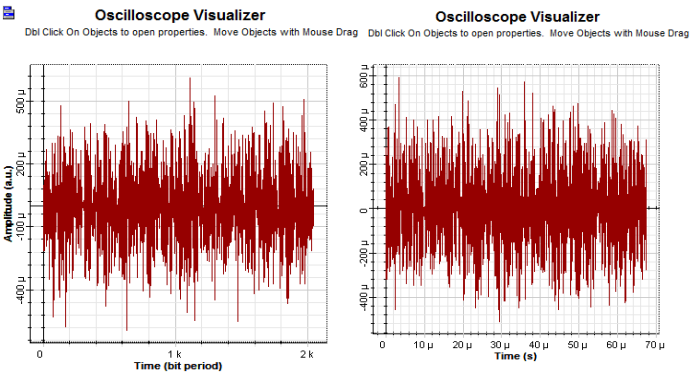
Figure 2: Constellations of the (a) Transmitted Signal (b) Received Signal

The result of experiment setup is given in figure 3 (a) and (b) for oscillation of transmitted M-ary I & Q respectively. The 64 QAM modulated input signal amplitude of (~7.0 a.u.) with ~ 0 dBm noise power & received oscillation are observed on visualize 1 & 2 as shown in figure 4 (a) & (b) for I & Q M-ary has amplitude of (~0.2 a.u.). The reduction in amplitude ~ 96 % because of NLD.



(a) **(b)**

Figure 3: Oscillation of Input Signal (a) I –Mary (b) Q-Mary



(a) **(b)**

Figure 4: Oscillation of Ouput Signal (a) I –Mary (b) Q-Mary

In also increase thus the effect of nonlinear distortion can be reduce by increase the order of modulation *(i.e. QAM to 64 QAM).*

Table 1 Effect of Modulation on Output Power

Types of Modulation	Output Power (Electrical Domain)
QAM	-31.115 dBm
16 QAM	-31.719 dBm
32 QAM	-31.736 dBm
64 QAM	-31.932 dBm

The laser power provides the significant role for performance of RoF link. It is observed that power of received signal is increase by increasing the laser power. In table 2 the effect of laser power on output power show that when the laser power in vary from 0 dBm to 25 dBm and then output power is contrast form ~ -31.932 dBm to ~ 18.067 dBm. Consequently the effect of NLD can be decrease by laser power.

Table 2 Effect of Laser Power on Output Power

Laser Power (dBm)	Output Power
0	-31.932 dBm
10	-11.933 dBm
15	-1.933 dBm
20	8.067 dBm
25	18.067 dBm

5. CONCLUSION

We investigated the effect of nonlinear distortion on RoF link. We are also analyzed the parameter which has importance role to mitigate the effect of NLD on RoF link .The amplitude of the output signal is reduced by ~ 97 % due the NLD effect & output power can be increase ~76% by increasing the laser power. The modulation order has also significant reduce the nonlinear distortion effect. The future work for this research is to develop the predistorter to reduce the effect of this nonlinearity for radio over fiber applications at higher frequencies.

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7. REFERENCES

[1] Cooper. 1990. Fibre/radio' for the provision of cordless/mobile telephony services in the access network. Electronics Letters. 26: 2054-2056.

[2] C.H. Cox et.al. 1997. What Do We Need to get Great Link Performance. International Topical Meeting on Microwave Photonics. 1 (1):215 – 218.

[3] Ajay Kumar Vyas, Dr. Navneet Agrawal, , Radio over Fiber: Future Technology of Communication, International Journal of Emerging Trends & Technology in Computer Science, Volume 1, Issue 2, July – August 2012, pp 233-237.

[4] Technical Report. 2010. RoF System for Dual WCDMA & LTE System. NTT DOCOMO Journal. 12(4):24-29.

[5] Strategic Research Agenda. 2012. Innovation in future Network in Europe. eMobility Networld. 0.1: 1-168.

[6] Thavamaran Kanesan. 2013. Impact of Optical Modulators in LTE RoF System with Nonlinear Compensator for Enhanced Power Budget. Technical Digest, Optical Society of America.

[7] Philippos Assimakopoulos et al. 2013. Statistical Distribution of EVM Measurements for Direct-Modulation Radio-Over-Fiber Links Transporting OFDM Signals. IEEE tran. on Microwave Theory & Techniques . 61(4):1709-1717.

[8] Url.www.optiwave.com