International Journal of Computer Science, Communication & Information Technology (CSCIT)
Vol.7 pp. 55-60

Modeling and Analyzing the BER and SER Performances of MIMO System using Multi Level - DPSK Modulation Technique Under Rayleigh Fading Channel

Nsreen Hawisa [1] and Amer R. Zerek[2]

[1, 2]Zawia University, Faculty of Engineering, Electrical and Electronic Eng. Department
Zawia, Libya
[1]E-mail hawisansreen@gmail.com
[2]E-mail anas_az94@yahoo.co.uk

Abstract—**Nowadays wireless communication system is improving for the new generation of data communication technology, since it has to facilitates the user to communicate and share information or data through different wirelessly connected equipment. These techniques improve and examine the existing technologies to make technology easier for the subscribers in order to provide several features.**

One of most important M-ary carrier digital modulation schemes is M- ary Differential Phase Shift Keying (MDPSK) which is very important part of the implementation of modern wireless communications systems .

In this paper investigation and simulation of the multi-level (M-ary) DPSK modulation using Matlab with Simulink 2017 for M=16, 32, 64 and 128,so that theproposed system implements multi antenna diversity of 2x4 ,where the number of transmitter antennas is 2 and the receiver antennas is 4. This investigationanalysis and compares the BER and SER performanceover Rayleigh channel. The obtained results showed that as the level of modulation increases the BER and SER increases at the same E_o/N_o value. This means the lower the M value the better the performance.

Keywords— wireless communication, M-aryDPSK, BER , SER and MIMO

I. INTRODUCATION

Modulation plays an important role in transmission of signals from transmitter to receiver in all communication systems and the performance of digital modulation systems is the most important key factor to achieve the best results without interference, for example; mobility, better productivity, low cost, easy installation facility and scalability, modulation to increase efficiency of radiation.....etc.

The digital modulation is categorized into two main schemes such as pulse digital modulation and carrier digital modulation. Carrier digital modulation can be classified into two main types that are binary carrier digital modulation and multi-level or M-ary carrier digital modulation . In both types of carrier digital modulation techniques there are three main parameters of a sinusoidal signal that are modulated,which are amplitude, phase, and frequency. According to this concept of these types of parameters binary and multi-level (M-ary) . A binary carrier digital modulation include Binary Amplitude Shift Keying (BASK) , Binary Phase Shift Keying (BPSK) and Binary Frequency Shift Keying (BFSK) . Also an M-ary or multi-levelcarrier digital modulation includes three main types: M-ary FSK, M-ary PSK and M-ary ASK. The M-ary ASK called Quadrature Amplitude Modulation (QAM)) .For an M-ary PSK where M=4 this type of modulation is calledquadrature phase shift keying (QPSK). When that scheme of modulation uses differential encoding is usually called DQPSK which can be extended to an M-ary DPSK. In M-ary DPSK modulations $\log_2 M$ (= L) bits per symbol transmission is achieved providing powerand bandwidth-efficient communication. [1].

This paper will investigate and analyzes the BER and SER performances of MIMO system using multi-Level DPSK modulation technique Rayleigh fading channel.

II. MIMO SYSTEM

Multi input multi output (MIMO) system uses n_T antennas at transmitter and $n_R$at receiver i.e ($n_{Tx}n_R$) and there is a communication channel between each of the transmit and receive antennas . Figure 1 illustrated the MIMO system with transmit and receive n antennas. This MIMO system is used to improve overall throughput of the wireless link.In addition to that MIMO channels offer a several benefits over conventional single input single output (SISO), single input multi output (SIMO), and multi input single output (MISO), communication channels such as the array gain, the diversity gain, and the multiplexing gain. While the array and diversity gains are not exclusive of MIMO channels and also exist in single-input multiple-output (SIMO) and multiple-input single-output (MISO) channels, the multiplexing gain is a unique characteristic of MIMO channels.

MIMO system is significantly used in a number of wireless technologies like Wireless Fidelity(Wi-Fi) , 4G, Long Term Evolution (LTE) and Worldwide Interoperability for Microwave Access (WiMAX), IEEE 802.16e to name some few important ones.[2, 3, 4].

In this work a MIMO system along with two transmit antennas and four receive antennas (2x4) is considered as shown in figure (1)

ISSN 1737-930X

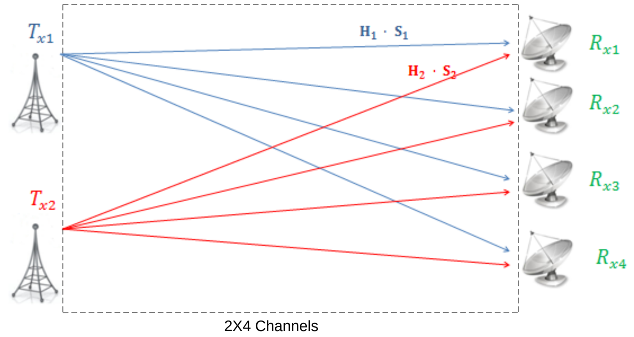

Figure 1.2x4 MIMO System

The received signal on the first receive antenna is

$$R_1 = H_{11}S_1 + H_{12}S_2 + N_1 \qquad (1)$$

The received signal on the second receive antenna is

$$R_2 = H_{21}S_1 + H_{22}S_2 + N_2 \qquad (2)$$

The received signal on the third receive antenna is

$$R_3 = H_{31}S_1 + H_{32}S_2 + N_3 \qquad (3)$$

The received signal on the fourth receive antenna is

$$R_4 = H_{41}S_1 + H_{42}S_2 + N_4 \qquad (4)$$

Where

$R_1, R_2, R_3 and R_4$ are the received symbol on the first , second, third and fourth antennas respectively .

H_{11} is the channel from 1^{st} transmit antenna to 1^{st} receive antenna

H_{12} is the channel from 2^{nd} transmit antenna to 1^{st} receive antenna

H_{21} is the channel from 1^{st} transmit antenna to 2^{nd} receive antenna

H_{22} is the channel from 2^{st} transmit antenna to 2^{nd} receive antenna

H_{31} is the channel from 1^{st} transmit antenna to 3^{rd} receive antenna

H_{32} is the channel from 2^{nd} transmit antenna to 3^{rd} receive antenna

H_{41} is the channel from 1^{st} transmit antenna to 4^{td} receive antenna

H_{42} is the channel from 2^{nd} transmit antenna to 4^{td} receive antenna

S_1 *and* S_2 are the transmitted symbols and N_1,N_2, N_3 and N_4 is the noise on the 1^{st},2^{nd},3^{rd} and 4^{th} receive antennas respectively.

Equation 1 to 4 can be illustrated in matrix form as follows:

$$\begin{bmatrix} R_1 \\ R_2 \\ R_3 \\ R_4 \end{bmatrix} = \begin{bmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \\ H_{31} & H_{32} \\ H_{41} & H_{42} \end{bmatrix} \cdot \begin{bmatrix} S_1 \\ S_2 \end{bmatrix} + \begin{bmatrix} N_1 \\ N_2 \\ N_3 \\ N_4 \end{bmatrix} \qquad (5)$$

Hence

Received signal vector = $\begin{bmatrix} R_1 \\ R_2 \\ R_3 \\ R_4 \end{bmatrix}$

Channel matrix = $\begin{bmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \\ H_{31} & H_{32} \\ H_{41} & H_{42} \end{bmatrix}$

Transmitted signal vector = $\begin{bmatrix} S_1 \\ S_2 \end{bmatrix}$

Noise signal vector = $\begin{bmatrix} N_1 \\ N_2 \\ N_3 \\ N_4 \end{bmatrix}$

Then received vector can be expressed as

$$R = H.S + N \qquad (6)$$

III FADING

One of the more intriguing features of wireless communication channels is fading. Different path-loss or shadowing, which are large-scale attenuation effects owing to distance or obstacles.Fading is caused by the reception of multiple versions of the same signal. The multiple received versions are caused by reflections that are referred to as multipath. The reflections may arrive nearly simultaneously, for example, if there is local scattering around the receiver or at relatively longer intervals,owing to multiple paths between the transmitter and the receiver. [5].

When some of the reflections arrive at nearly the same time, their combined effect is depending on the phase difference between the arriving signals, the interference can be either constructive or destructive, which causes a very large observed difference in the amplitude of the received signal even over very short distances. In other words, moving the transmitter or the receiver even a very short distance can have a dramatic effect on the received amplitude, even though the path-loss and shadowing effects may not have changed at all.

The time-varying tapped-delay-line communication channel model of Equation 3. This channel h(t) response can be thought of as having two dimensions: a delay dimension τ and a time-dimension t, as illustrated in Figure 2. Since the channel changes over distance and hence time, the values of h_0, h_1, h_2 .....h_n, may be totally different at time *t* versus time $t + \Delta t$ Because the channel is highly variant in both the τ and *t* dimensions, it must use statistical methods to discuss what the channel response is. [6].

$$h(k,t) = h_0\,\delta(k,t) + h_1\delta(k-1,t) + \ldots + h_n(k-n,t) \qquad (3)$$

ISSN 1737-930X

The use of an overall model describing the channel in discrete time is a simple Tap-Delay-Line (TDL). Here, the discrete-time channel is time varying so it changes with respect to and has non-negligible values over a span of *n+1* channel taps.

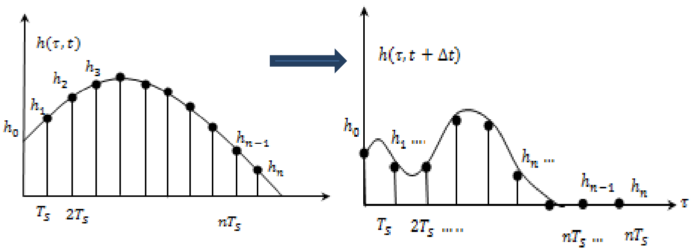

Figure 2 Channel h(t) Response Delay τ and Time t

A good way to understand wireless fading channel, is by considering its key physical parameters and modeling issues, the characteristic of wireless channel is the variation of the channel strength over time and frequency, the variations can be roughly divided into two types:the first type is fast fading whichrefers to changes in signal strength between a transmitter and receiver as the distance between the two changes by a small distance of about one-half a wavelength. The second type is a slow fading which refers to changes in signal strength between a transmitter and receiver as the distance between the two changes by a larger distance, well in excess of a wavelength.

The fading also can be classified intoflat fading or nonselective and selective fading.The flat fading, is that type of fading in which all frequencycomponents of the received signal fluctuate in the same proportions simultaneously. While the selective fading affects unequally the different spectral components of a radio signal.

IV RAYLEIGH FADING

The path between the transmitter and receiver can vary from simple line-of-sight to one that is severely obstructed by buildings, mountains, and foliage, non- line-of-sight. Unlike wire channels that are stationary and predictable, fading channels are extremely random and do not offer easy analysis. There are two main types of fading channels models such as Rican and Rayleigh. The Rayleigh fading channel model will be used in this work.

The Rayleigh channel is also known as a non-line of sight (NLOS) channel; , generally in wireless communications, the envelope of the carrier signal is Rayleigh distributed; and that distribution is caused by multipath with or without the Doppler effect. In the multipath case, when the main signal becomes weaker, such as in the NLOS case, the received signal is the sum of several components that are reflected from the adjacent obstacles building, … etc . In this scheme of channel , there are many other paths by which the signal may reach the receiver. When the signals reach the receiver, the overall signal is acombination of all the signals that have reached the receiver via the multitude of different paths that are available.

In that Rayleigh channel combines line of sight (LOS) and NLOS transmission components and because of that some of reflections that happens to the signal could have a positive factor and improves performance of the communication system. [7].

V MULTI-LEVEL DPSK MODULATION TECHNIQUE

Differential Phase Shift Keying (DPSK) is a common form of phase shift keying modulation in which there is no reference phase signal required , the transmitted signal itself can be used as a reference signal. The DPSK is used in analog modems, does not needcomplex demodulation circuitry and is less susceptible to random phase changes in the transmitted signal . In this scheme of modulation the phase of the DPSK modulated signal is shifted relative to the previous signal element. No reference signal is deemed here. The phase of the modulated signal follows the 1 or 0 state of the previous element. This DPSK technique doesn't need a reference signal oscillator.[8]

The DPSK modulation technique has several advantages over the binary phase shift keying such as It has a better performance, it needs smaller bandwidth and does not need coherent detection,DPSK receiver is very simple to implement also carrier recovery circuitry is not required i.e. has a non-coherent demodulation. While PSK typically does not support this function. [9, 10].

M-ary- DPSK modulation is widely used in satellites and space telemetry. A more efficient use of bandwidth is achieved when eachsignaling element represents more than one bit. Although DPSK can be extended to an M-ary DPSK modulation which achieve the transmission of n= $\log_2 M$ or $M=2^n$ bits per symbol, In this paper bit error rate (BER) for DPSK modulation schemes has been analyzed for different values of M= 16, 32 , 64 and 128 over Rayleigh fading channel.

VI PERFORMANCE ANALYSIS OF MULTI LEVEL DPSK USING MATLAB SIMULINK

Simulink is an extension to MATLAB, It is a software package for modeling, simulating and analyzing dynamic and embedded system It gives a graphical environment and a set of block libraries that let researcher design, implement , simulate, and test a variety of linear and non-linear systems, including a variety of fields e.g. communication, control, digital signal processing, networks, image processing … etc. The baseband simulation models of 16, 32, 64 and 128 DPSK under Rayleigh fading channel is illustrated in figure (3).The simulation of multi-level DPSK model consists of three main parts;the transmitter, Rayleigh fading channel and the receiver. These parts include the following elements.

A) Transmitter Side

- The *Random Integer Generator block* generates uniformly distributed random integers in the range [0, *M*-1], where *M* is the **Set size** defined in the dialog box.

ISSN 1737-930X

- The *Integer to Bit Converter* block maps each integer (or fixed-point value) in the input vector to a group of bits in the output vector.
- The *M-DPSK Modulator Baseband block* modulates using the M-ary differential phase shift keying method. The output is a baseband representation of the modulated signal. The **M-ary number** parameter, M, is the number of possible output symbols that can immediately follow a given output symbol.
- The *Goto block* passes its input to its corresponding From blocks. The input can be a real- or complex-valued signal or vector of any data type. From and Goto blocks allow you to pass a signal from one block to another without actually connecting them.
- The Constellation Diagram block plots constellation diagrams, signal trajectory, and provides the ability to perform EVM and MER measurements. The symbols that the Constellation Diagram scope displays are always the most recently available symbols from the time buffer.

B) Communication Channel

- The *OSTBC Encoder block(Alamouti)* encodes an input symbol sequence using orthogonal space-time block code (OSTBC). The block maps the input symbols block-wise and concatenates the output codeword matrices in the time domain..
- Themulti-input/multi-output(*MIMO)*Rayleigh *Fading Channel block* filters an input signal using a MIMO multipath fading channel. This block model Rayleigh and employs the Kronecker model for modeling the spatial correlation between the links.
- The *Squeeze block* removes singleton dimensions from its multidimensional input signal. A singleton dimension is any dimension whose size is one. The Squeeze block operates only on signals whose number of dimensions is greater than two.
- The *OSTBC Combiner block* (Almaouti Code 4R_x) combines the input signal (from all of the receive antennas) and the channel estimate signal to extract the soft information of the symbols that were encoded using an OSTBC. The input channel estimate may not be constant during each codeword block transmission and the combining algorithm uses only the estimate for the first symbol period per codeword block. A symbol demodulator or decoder would follow the Combiner block in a MIMO communications system.

C) Receiver Side

- The *M-DPSK demodulator baseband block* demodulates a signal that was modulated using the multi-level DPSK method. The input is a baseband representation of the modulated signal. The input and output for this block are discrete-time signals. This block accepts a scalar-valued or column vector input signal.
- The *Bit to Integer Converter block* maps groups of bits in the input vector to integers in the output vector. *M* defines how many bits are mapped for each output integer.
- The ***Error Rate Calculation block*** compares input data from a transmitter with input data from a receiver. It calculates the error rate as a running statistic, by dividing the total number of unequal pairs of data elements by the total number of input data elements from one source.
- The ***To Workspace block*** inputs a signal and writes the signal data to a workspace. During the simulation, the block writes data to an internal buffer. When the simulation is completed or paused, that data is written to the workspace. Data is not available until the simulation is stopped or paused.

Display

- The Spectrum Analyzer block, referred to here as the scope, displays the frequency spectra of signals.

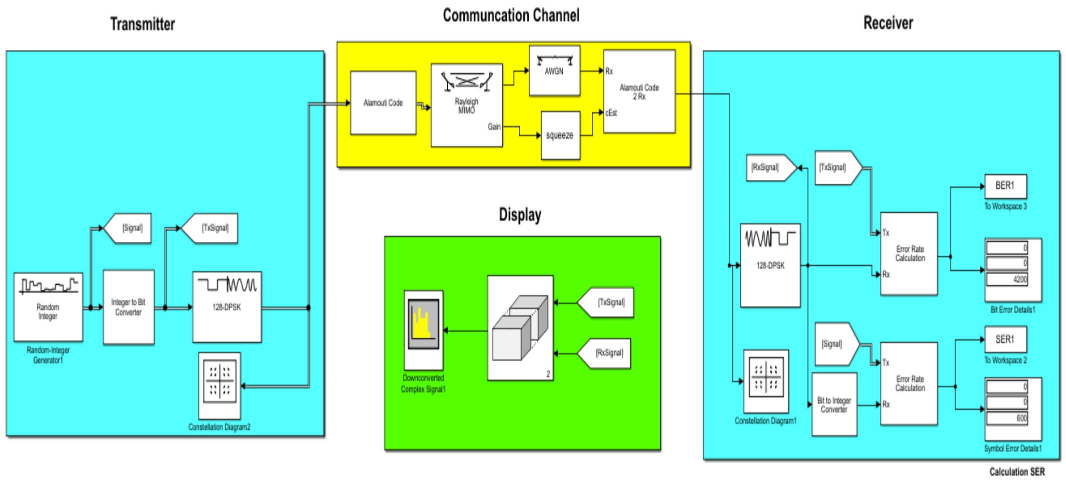

Figure . 3 .*Simulation model for Multi-Level DPSK*

Copyright IPCO-2019
ISSN 1737-930X

VII PERFORMANCE ANALYSIS OF MULTI LEVEL DPSK USING MATLAB SIMULINK

The results of bit error rate (BER) and symbol error rate (SER) performances of multi-level (M-ary) differential phase shift keying for M=16, 32, 64 and 128 obtained using Matlab Simulink communication toolbox are shown in figures4 and 5.

The comparative analysis of simulated results for BER vs E_b/N_o and for SER vs E_b/N_o for 16, 32, 64 and 128 DPSK overRayleigh fading channels are summarized in the tables 1 and 2 respectively.

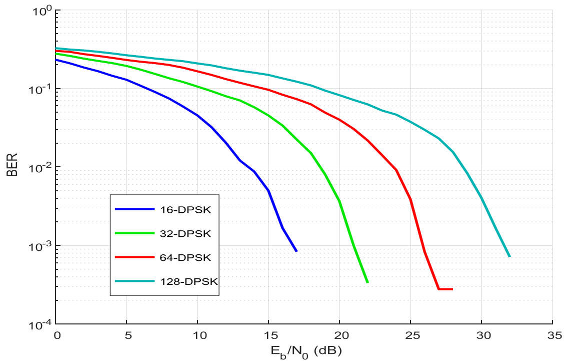

Figure 4. Bit Error Rate vs. E_b/N_o Performance of 16-32-64-128 DPSK Over Rayleigh Channel

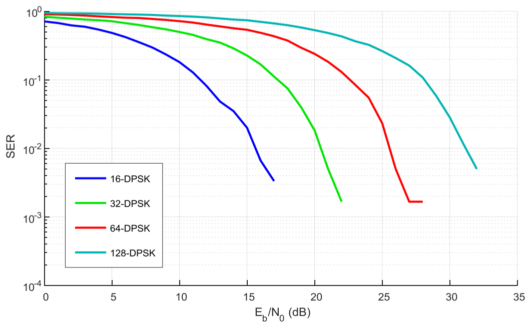

Figure 5. Symbol Error Rate vs. E_b/N_o Performance of 16-32-64-128DPSK Over Rayleigh Channel

Table 1 Bit Error Rate vs. Eb/No Comparison of Rayleigh Channel for 16-32-64 and 128 DPSK

Channel	16-DPSK		32-DPSK		64-DPSK		128-DPSK	
	E_b/N_0	BER	E_b/N_0	BER	E_b/N_0	BER	E_b/N_0	BER
Rayleigh	17	0.0008333	22	0.0003333	27	0.0002778	32	0.0007143

Table 2 Symbol Error Rate vs. Eb/No Comparison ofRayleigh Channel for 16-32-64 and 128 DPSK.

Channel	16-DPSK		32-DPSK		64-DPSK		128-DPSK	
	E_b/N_0	SER	E_b/N_0	SER	E_b/N_0	SER	E_b/N_0	SER
Rayleigh	17	0.003333	22	0.001667	27	0.001667	32	0.005

Examining the plots in figures (4) and (5) for BER and SER performances under various levels of DPSK modulation i.e. 16, 32, 64 and 128 DPSK , when considering the fading model Rayleigh channel the following can be noted:

- It is quite clear that as the level increases the BER and SER increases i.e. a more signal energy is needed to get a better BER and SER.
- It can be noted also theRayleigh model has improved the performance in terms of BER and SER and that can be explained in that Rayleigh model combines line of sight and non-line of sight transmission components and because of that some of reflections that happens to the signal could have a positive factor and enhances performance. .

VIII CONCLUSION

In this paper the simulations using Matlab Simulink shows that the bit error rate (BER) and symbol error rate (SER) for the multi-level DPSK modulation techniques decrease monotonically with increasing values of E_b/N_0 for MIMO (2x4) under Rayleigh channel. Also it is conclude that the using Rayleigh model has enhanced the performance in terms of both BER and SER and that can be clarified in that Rayleigh model combines line of sight (LOS) and non-line of sight (NLOS) transmission components and hence some of reflections that happens to the signal could have a positive impact and improves performance.

Simulation of multi-level DPSK using Matlab Simulink gives the better results. This scientific tool also simplifies the process of passing from simulation to implementation, without the necessity of being a specialized hardware engineer.

REFERNCES

[1] P. H. Hwei , "Analog and Digital Communications-Schaum`s Outlines", McGraw-Hill, 2003..

[2] S. Kumari and R. Bera, Sourav Dhar, "Modeling and Analyzing the BER Performance of MIMO System using Different Modulation Technique", International Journal of Engineering Research & Technology (IJERT) , Vol. 4 Issue 05, May-2015

[3] A.J.Paulraj, D.A.Gore, R.U.Nabar, H.Bölcskei, An overview of MIMO communications- A key to gigabit wireless, IEEE proceedings, vol.92, pp 198-218, Feb.2004

[4] M. Assaad, D. Zeghlache, Comparison between MIMO techniques in UMTS-HSDPA system, IEEE Conferences, 2004, Page(s): 874-878.

[5] A. Sudhir Babu and Dr. K.V Sambasiva Rao," Evaluation of BER for AWGN, Rayleigh and Rician Fading Channels underVarious Modulation Schemes", International Journal ofComputer Applications (0975 – 8887) Volume 26– No.9, July2011

[6] A. Sudhir Babu and Dr. K.V Sambasiva Rao," Evaluation of BER for AWGN, Rayleigh and Rician Fading Channels under Various Modulation Schemes", International Journal of Computer Applications (0975 – 8887) Volume 26– No.9, July2011.

[7] T. Tokle, M. Serbay, Y. Geng, J. B. Jensen, W. Rosenkranz, and P. Jeppesen, "Penalty-free transmission of multilevel 240 Gbit/s RZ-DQPSK-ASK using only 40 Gbit/s equipment," in Proc. Eur. Conf. Opt. Commun., Gasglow, U.K., 2005, Paper Th.4.1.6..

[8] M. Riaz Ahmed, Md.Rumen Ahmed , Md.Ruhul Amin Robin, Md. Asaduzzaman, Md. Mahbub Hossain, Md. Abdul Awal, "Performance Analysis of Different M-Ary Modulation Techniques in Fading

Channels using Different Diversity", Journal of Theoretical and Applied Information Technology, Vol. 15. No.1, pp 23-28, May 2010..

[9] T. Tokle, M. Serbay, Y. Geng, J. B. Jensen, W. Rosenkranz, and P. Jeppesen, "Penalty-free transmission of multilevel 240 Gbit/s RZ-DQPSK-ASK using only 40 Gbit/s equipment," in Proc. Eur. Conf. Opt. Commun., Gasglow, U.K., 2005.

[10] C. Behrens, R. I. Killey, S. J. Savory, M. Chen, and P. Bayvel, "Nonlinear distortion in transmission of higher order modulation formats,"IEEE Photon. Technol. Lett., vol. 22, no. 15, pp. 1111–1113, 2010.

.

ISSN 1737-930X