Journal of
Communication Engineering & Systems
STM JOURNALS
https://journals.stmjournals.com/joces
ISSN: 2249-8613 (Online)
ISSN: 2321-5151 (Print)
Volume 16, Issue 1, 2026
January–April
DOI (Journal): 10.37591/JoCES
Review JoCES

Analysis of a Communication Link Performance Across Various Rayleigh Channels in Tropical Climates

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Abstract

Tropical regions are characterized by intense and persistent rainfall throughout most of the year, and this environmental condition significantly influences wireless communication performance. The continuous presence of heavy precipitation weakens, scatters, and disrupts radio frequency signals, causing noticeable attenuation during transmission from the source to the destination. As a result, reliable communication becomes challenging, particularly for modern high-speed systems such as 5G networks. To address this limitation and enhance communication quality in such climates, this research proposes a robust design for a 5G communication link specifically tailored for areas that experience frequent rainfall. In the proposed model, three independent frequency-selective Rayleigh fading channels are configured to realistically represent the propagation environment in tropical regions. To further improve the reliability and data throughput of these channels, convolutional coding schemes with code rates of 1/3 and 3/4 are incorporated. Additionally, multiple digital modulation techniques, namely 8PSK, 16PSK, 32PSK, 64PSK, and 16QAM, are implemented to analyze their influence on signal capacity, data security, and bandwidth efficiency. Comprehensive comparative evaluations of these modulation schemes across different code rates and Rayleigh channels are carried out to determine which combination yields the lowest bit error rate (BER). The results highlight the modulation approaches most capable of maintaining effective communication in heavy-rainfall environments, providing valuable insights for future 5G link designs optimized for tropical climates.

Keywords: Analysis of communication, bit error rate, convolution coding, Rayleigh channel, signal fading

INTRODUCTION

Radio communication signifies an expression that encompasses communication processes and the formation of communication concerning the use of radio communication technology and designs. The goal of 5G technology is to provide high-quality data at gigahertz per second with a small bit error rate (BER). The BER, which plays a significant role in determining the effectiveness of a transmission system, was shown [1]. The coding of regulating errors, which is one of the most effective ways to transmit information without errors to the receiver in the communication system, was displayed [2]. It is depicted that in telecommunication systems, modification is a variation of one or more waveform structures called 'carrier waves' with a modulating wave that contains information to be transmitted [3]. It is demonstrated that the carrier signal is a periodic signal with a constant rate of occurrence(amplitude)and rate of repetition (Hz), in which information can be added to the operator by changing its length, frequency, or category.

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Received Date: October 14, 2025
Accepted Date: December 19, 2025
Published Date: April 14, 2026

Citation: Amit Dey, Rudra Krishna Sharma, Alakesh Hazra, Trilochan Patra, Swarup Kumar Mitra, Gour Gopal Jana. Analysis of a Communication Link Performance Across Various Rayleigh Channels in Tropical Climates. Journal of Communication Engineering & Systems. 2026; 16(1): 6–12p.

In an investigation [4], it is exhibited that when a signal is sent via a wireless channel, there are some errors. To avoid these errors, various coding methods have been utilized, such as convolutional coding, block coding, cyclic coding, etc. In a study [5], it is expressed that in digital transmission, the number of bit errors is the number of bits received for streaming data over a channel that is altered by noise, interference, distortion, or slow synchronization errors. This phenomenon is a unitless measurement of performance, which is usually expressed in percent. This is a reliable mechanism for analyzing the effectiveness of various flexibility strategies. In a finding [6], it is depicted that the additive white Gaussian noise (AWGN) Channel is a fundamental channel model that is used for signal transmission when signals make passage along the channel and mimic the backdrop noise of the channel. The mathematical expression of the received signal V (t) through the AWGN channel has been expressed in the form of equation [1] stated below:

$$U(t) = V(t) + Z(t) \quad (1)$$

Where, V(t)implies the transferred signal and Z (t) indicates the backdrop noise. In an investigation [7], it was revealed that several studies have been conducted comparing the effectiveness of various flexibility strategies with the effectiveness of Eb/No vs. BER channel schemes.

Before performing the work in this study, a number of previous studies were examined to confirm whether any work executed in those previous studies was analogous to the work performed in this study. However, it was found that no work in those previous research papers is analogous to the work executed in this study [8].

Section 1 provides the introduction. Section 2 describes the proposed model. In Section 3, the measurement of system performance is presented. Section 4 describes the result analysis. Section 5 presents the conclusion. At the end of all sections, references are included [9].

PROPOSED MODEL

Block Diagram of the Proposed Model

A block diagram of the communication link model suggested in this study is shown in Figure 1.

Description of the Proposed Model

The proposed model is made of eight blocks, viz., input message, convolution encoding, modulation, designed Rayleigh channel, noise, demodulation, Viterbi decoding, and output message. The block diagram is classified into three categories: transmitter, channel, and receiver [10]. Transmitters contain an input message, convolution coding, and modulation. The channel includes a designed Rayleigh channel and noise. The receiver consists of demodulation, Viterbi decoding, and an output message. In the suggested communication link model, as depicted in Figure 2, the initial input message is encrypted, and thereafter, the encrypted message is processed by applying a digital variable method. Now the modified data passes along the Rayleigh dissipation channel. Then this message is extracted and decrypted after proceeding with the selected blurred Rayleigh channel. After that, the input message eventually reaches the desired destination. In this suggested model, three Rayleigh dissipation channels have been designed and two code rates, viz. 1/3 and 3/4 of the standard convolution code have been used as the convolution code renders a better outcome, the possible value of errors becomes higher, and channels are clamorous. Rayleigh dissipation channels have been applied because these dissipation channels are suitable for positions where an abundance of signal paths and mirroring remain present. This suggested communication link model aims to reduce BER by reducing signal fading and increasing the reliability of the system in tropical areas. The adaptive modulation technique, which is a significant portion of the adaptive waveform technique, has been adopted here to observe for which modulation technique the BER and rain attenuation caused by plenty of rainfall in the tropical areas reflect the minimum.

MEASUREMENT OF SYSTEM PERFORMANCE

Rayleigh channels are efficient devices in radio communication systems. These channels consist of multichannel distribution effects, a time distribution effect, and a Doppler Effect found in movements between the transmitter and receiver. Three types of frequency-selective Rayleigh dissipation channels were designed in this study, and their transfer functions are shown in Figure 2(a) and (b).

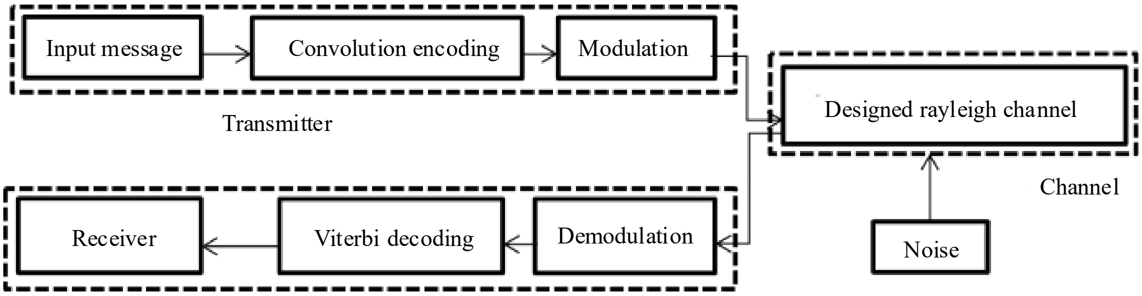

Figure 1. Block diagram of the proposed communication link model.

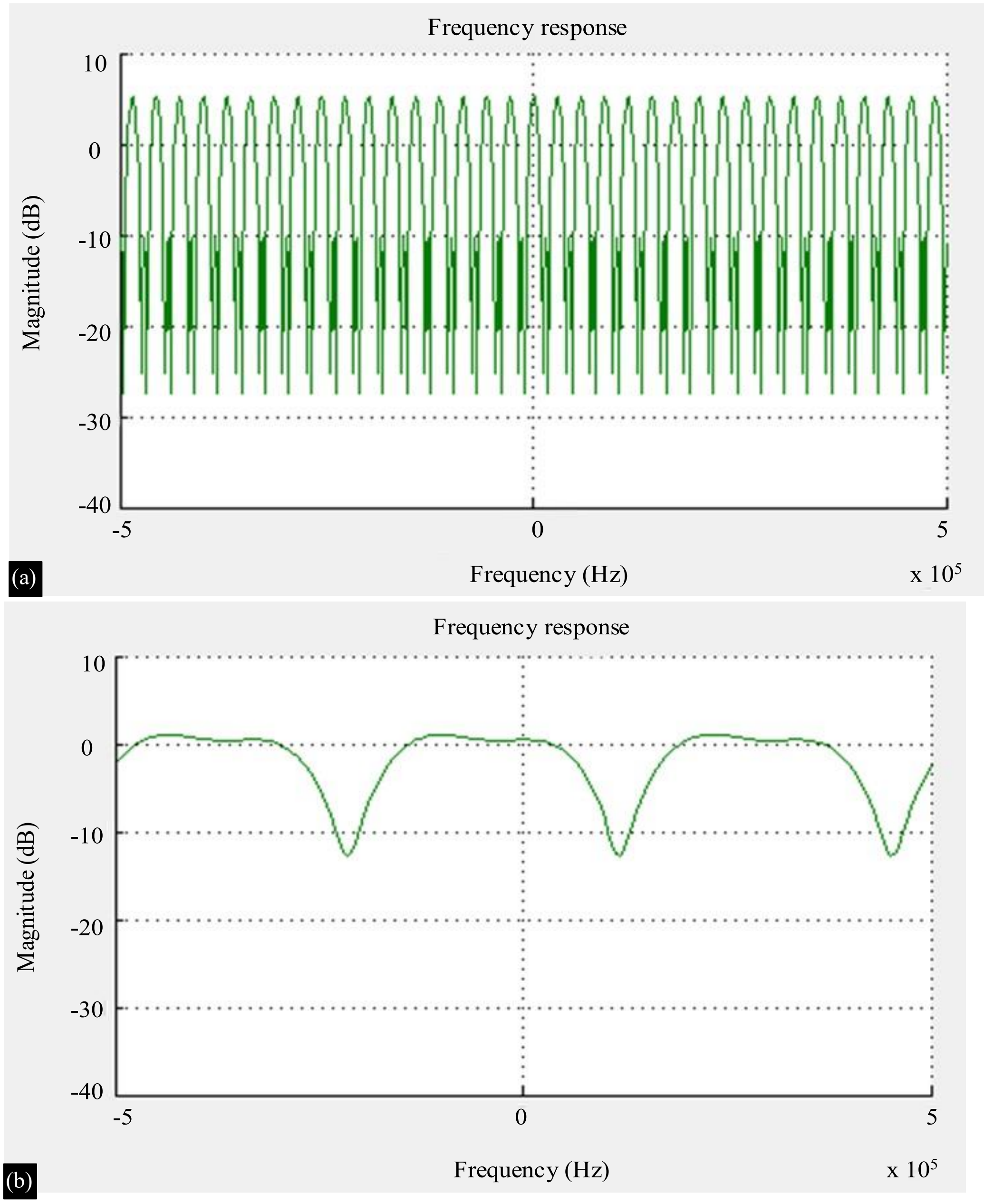

Figure 2. (a) to (b) Transfer function of the Rayleigh dissipation channel.

RESULT ANALYSIS

To design three frequency-selective Rayleigh dissipation channels, the Doppler frequency, channel delay, channel gain, and bit rate were altered. The transference performances for the three frequency-selective Rayleigh dissipation channels are presented in Section III. For the three designed Rayleigh dissipation channels, Doppler frequencies of 125 Hz, 250, and 375 Hz were selected to observe for which Doppler frequency a better outcome will be reflected. Using 1/3 and 3/4 code rates, the outcomes obtained from the three types of Rayleigh fading channels and different digital variation methods are displayed in Figures 3–8.

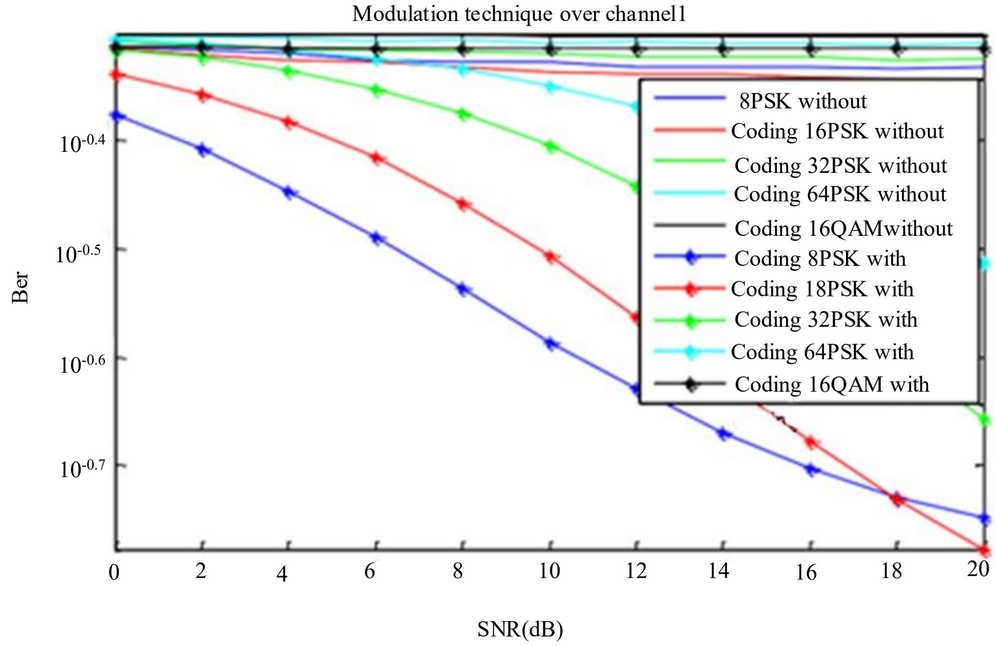

Figure 3. Comparative study of various digital variation methods for channel 1 with convolution coding of 1/3 code rate and without convolution coding of 1/3 code rate.

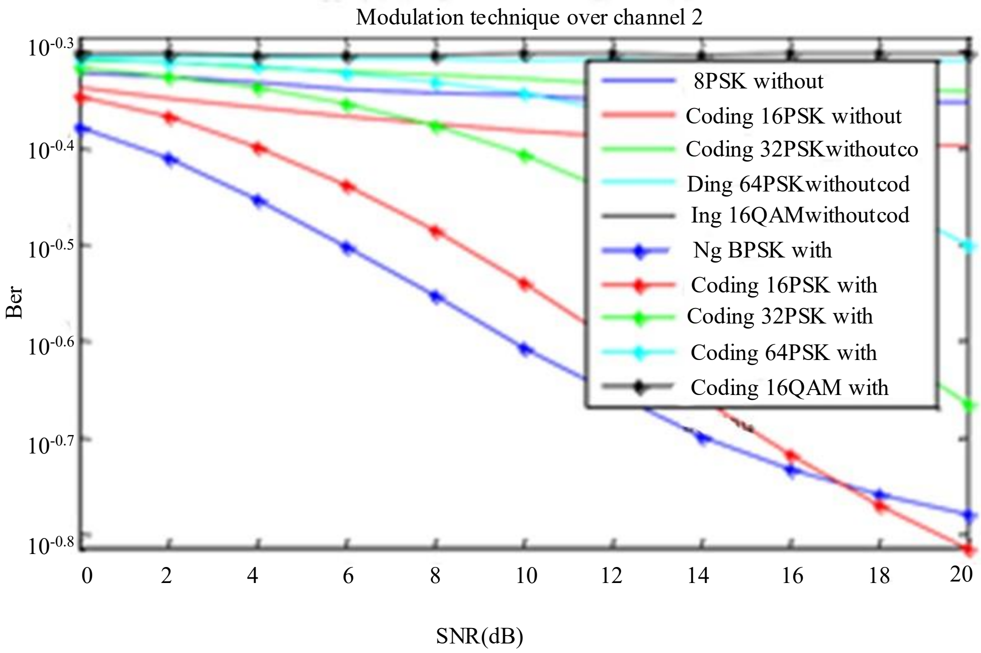

Figure 4. Comparative study of various digital variation methods for channel 2 with convolution coding of 1/3 code rate and without convolution coding of 1/3 code rate.

ISSN: 2249-8613 (Online), ISSN: 2321-5151 (Print)

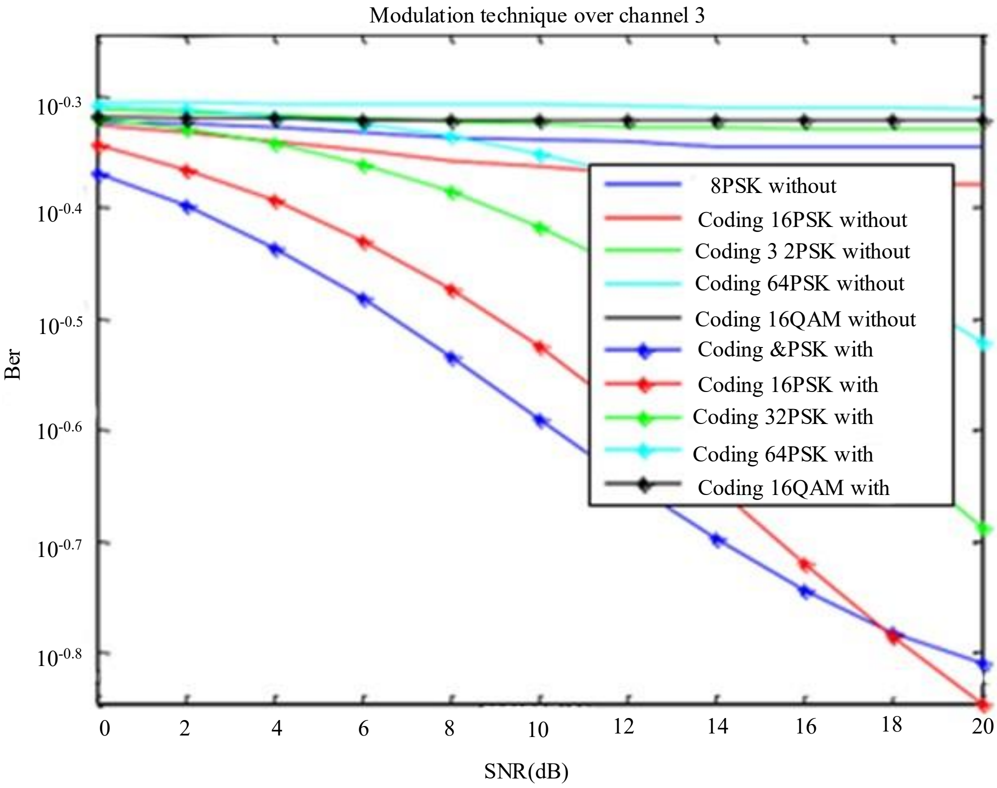

Figure 5. Comparative study of various digital variation methods for channel 3 with convolution coding of 1/3 code rate and without convolution coding of 1/3 code rate.

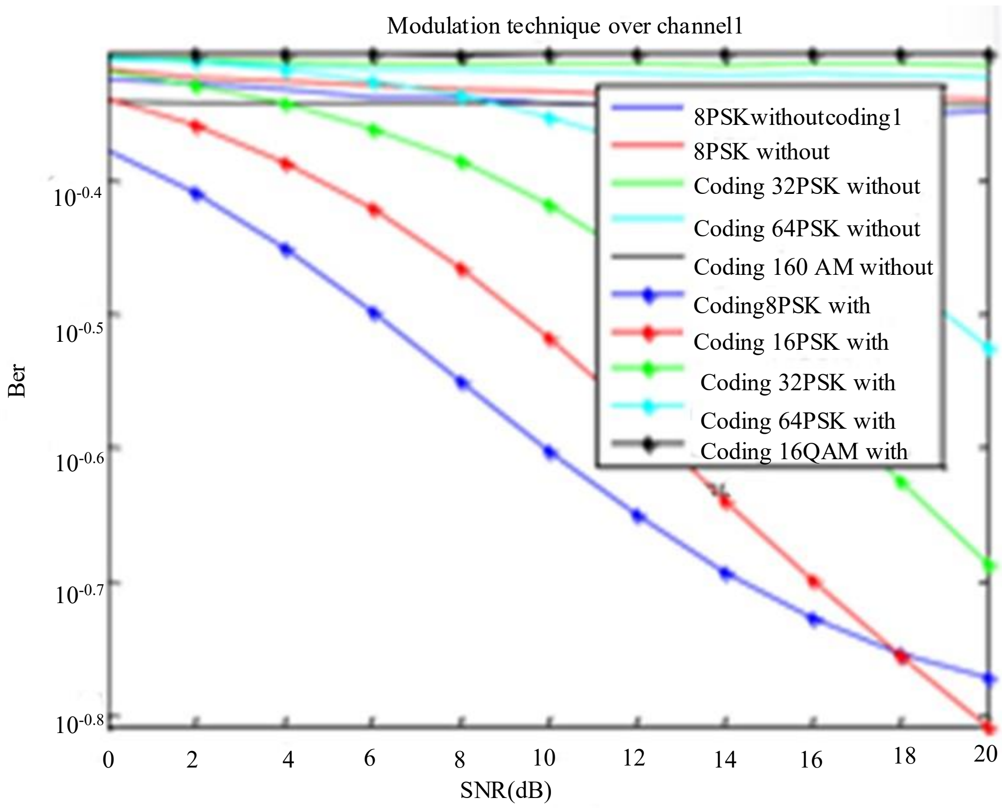

Figure 6. Comparative study of various digital variation methods for channel 1 with convolution coding of 3/4 code rate and without convolution coding of 3/4 code rate.

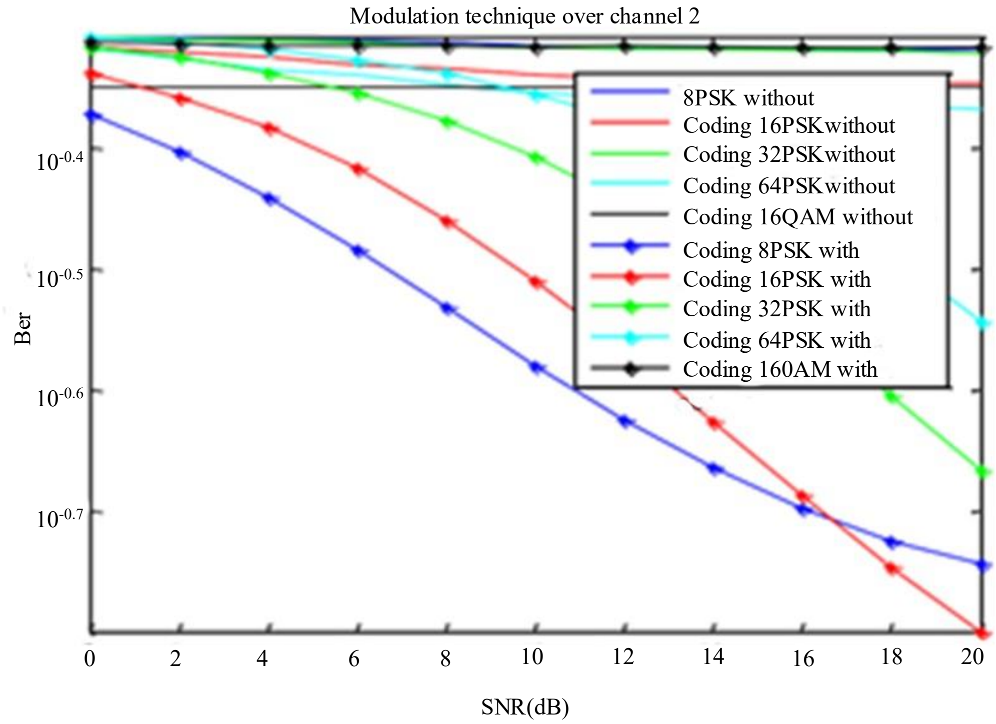

Figure 7. Comparative study of various digital Variation methods for channel 2 with convolution coding of 3/4 code rate and without convolution coding of 3/4 code rate.

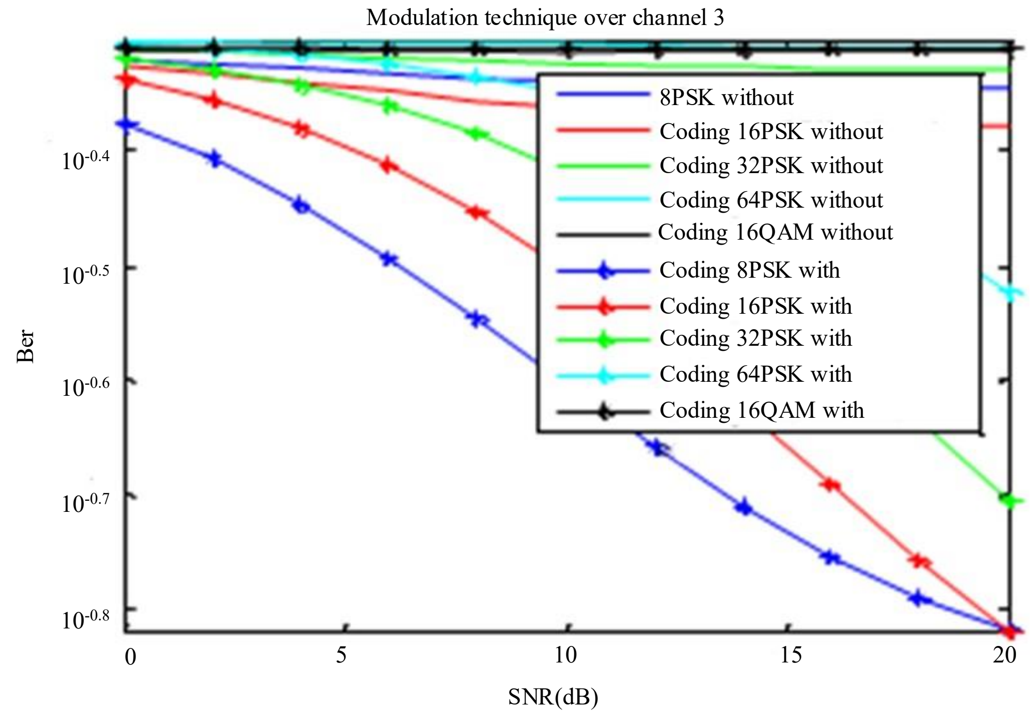

Figure 8. Comparative study of various digital variations methods for channel 3 with convolution coding of 3/4 code rate and without convolution coding of 3/4 code rate.

CONCLUSION

In this study, a comparative study of various digital variation methods was conducted by adopting three designed frequency-selective Rayleigh dissipation channels using convolution coding of code rates 1/3 and 3/4 to analyze the effectiveness of the suggested communication link model. From Figures 3 to 8, it is revealed that the 3/4 code rate produces a better result than that imparted by code rates of 1/3. Channel 2 yielded better results than channels 1 and 3. Therefore, from this study, it is deduced that the suggested communication link model provides a desired outcome for the 16PSK variation method, 3/4 code rate, and channel 2. Therefore, it is highly expected that this suggested communication link model can be the most efficient model to reduce signal fading to smooth the wireless communication system in tropical areas.

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