Republic of Iraq

Ministry of Higher Education and Scientific Research

University of Technology

Laser and Optoelectronic Engineering Department

Improving nonlinearity tolerance in optical transmission systems that employ multidimensional modulation formats

A Thesis

Submitted to the Department of Laser and Optoelectronics Engineering of the University of Technology in Partial Fulfillment of the requirement for the Degree Master in Science in Optoelectronics Engineering

By

Abbas Sattar Abdulzahrah

B.Sc. in Optoelectronics Engineering (2017)

Supervised by

Prof .Dr.Jassim Kadim Hmood

2022 **1444**

ABSTRACT

In this thesis, a new combination between pulse position modulation (PPM) and return to zero (RZ) - m-ary quadrature amplitude modulation (mQAM) is proposed to increase the spectral efficiency and mitigate the nonlinear fiber impairments. This hybrid modulation combination is utilized to modulate the information optically in single channel and ultra-dense wavelength division multiplexing (UWDM) communication systems. The performance of proposed systems are analytically modulated and numerically investigated. The PPM-RZ-mQAM UWDM transmission scheme has a four-dimensional optical signal space with amplitude, phase, time, and wavelength dimensions. In proposed systems, firstly, each channel is optically modulated by mQAM modulator and subsequently coded with RZ and PPM formats. The envelope of resulting pulses has a sinc-like shape. The performance of the PPM-RZ-mQAM UDWDM system is numerically investigated and compared to the performance of the mQAM UDWDM scheme. Results show that the transmission capacity of single channel system is duplicated as well as a nonlinear phase noise (NPN), when PPM-4QAM and PPM-16QAM are used, the effect of fiber nonlinearity is significantly reduced. The transmission reach of PPM-4QAM is increased by about 33%, in comparison to 4QAM system. In addition, the required optical signal-to-noise ratios (OSNRs) are decreased by 4.7 dB and 7.5 dB for the PPM-4QAM and PPM-16QAM schemes, respectively. In UWDM system, the results indicate that both spectral efficiency and signal quality are elevated for PPM-RZ-4QAM and PPM-RZ-16QAM UDWDM systems in comparing with 4QAM and 16QAM UWDM. The propagation distance for PPM-RZ-4QAM is lengthened by 55% and OSNR is lowered by 2.6 dB in opposition to conventional system.