様式８

論　文　内　容　要　旨

報告番号	甲　先　第　402　号	氏　名	TUMENDEMBEREL SURENKHOROL
学位論文題目	Study on Waveguide-Type Optical Circuits for Recognition of Optical 8QAM Coded Labels (直交振幅変調8QAM光ラベルの光導波路回路による識別に関する研究)		

内容要旨

In last years, internet traffic is increasing rapidly due to the advancement of information technologies and its varied applications. As a result of it, capacity of current transmission technologies are reaching its limits and potential. Therefore, the more the internet traffic increases, transmission network needs to be evolved concurrently. One of the main faced issue in current transmission technologies is an existence of electrical signal processing in network nodes which causes delay and high power consumption. Therefore, this research work discuses and focuses on this problem area.

A photonic label router, which is one of the main network node, performs several functions including label extraction, label recognition, optical matrix switching, optical buffering, control signal generation and label rewriting. Among them, this research aims to find possible candidate solution to implement label recognition function in optical domain.

For this purpose, in this work, waveguide-type recognition circuit for optical eight quadrature amplitude modulation (8QAM) coded label is proposed. Its operation principle is based on self-routing and passive interference effect between 8QAM coded signal and reference signal along with waveguide circuit. As a result of it, there are unique output intensities found for each input code combinations.

A proposed 8QAM recognition circuit (8QAM-RC) is based on former quadrature-phase shift keying recognition circuit (QPRC) which consists of 3-dB directional coupler, two Y-junction couplers, and an asymmetric X-junction coupler. Likewise, 8QAM-RC consists of two Y-junction couplers, an attenuator, phase shifter and two QPRCs. A reference and 8QAM signal pulses are fed into inputs of 8QAM-RC to interfere along the circuit.

Firstly, by combining the characteristics of each waveguide element in recognition circuit, output pulses are calculated theoretically. As a result, outputs with unique null intensity are found for each input code combinations. Therefore, 8QAM coded label can be recognized by minimum output ports. For the recognition by maximum output, it is required to discriminate two identical maximum output ports. Therefore, thresholding devices with logical circuit is applied as post processing in this case.

To prove the calculated results, finite difference beam propagation methods (FD-BPM) is used. The null intensities are clearly identified by this numerical simulation.

In practical application, required number of labels are enormous. Therefore, to check the scalability of our proposed method, we design recognition circuit for two symbol 8QAM code as a detection by minimum output. The scaled circuit is built by two-stage connection of 8QAM recognition circuit, where each symbol is recognized at corresponding stage, respectively. With the scaled two symbol 8QAM-RC, different null intensities are found for each input code.

Noise tolerance as a function of bit-error rate (BER) against optical signal-to-noise ratio (OSNR) is clarified for our proposed method. Simulation models are built on OptiSystem software for 1- and 2-symbol minimum recognition circuit and 1-symbol maximum recognition circuit. The OSNR values to achieve BER less than 1.0×10^{-3} are 7.8 dB, 10.8 dB and 13.9 dB at 2.5-, 5- and 10-Gbaud symbol rates, respectively for the minimum recognition. For the maximum recognition circuit, it has found to be 11.6 dB, 14.6 dB and 17.7 dB which is around 4 dB higher than the minimum recognition method due to the complexity of the post processing with logical circuits. As the result shows, recognition by the minimum output can be the optimal architecture for the 8QAM coded label. Therefore, we investigated the noise tolerance for the extended two symbol minimum recognition circuit as well. OSNR at BER of 1.0×10^{-3} was found as 20.8 dB at 2.5-Gbaud symbol rate. As compared with the 1-symbol minimum recognition result, it was around 13-dB higher.

In future work, scalability for more than 3-symbol label and experimental investigation is expected.