Recognition of 8QAM Coded Label by Maximum Output of Optical Waveguide Circuits

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ABSTRACT

This research work aims to implement a label recognition function of photonic router in optical domain. A waveguide type circuit has been proposed to recognize label which is considered to be an optical coded signal. The label can be identified as an unique output ports which have minimum or maximum intensity values.

In our previous work, an 8QAM (eight quadrature amplitude modulation) coded label recognition has been analyzed with the minimum output intensities of the circuit. In this paper, the 8QAM coded label recognition is investigated with the maximum output intensities. It is theoretically analyzed and noise tolerance simulation is run.

Keywords: optical 8QAM code, label recognition, optical waveguide circuit, noise tolerance

1 INTRODUCTION

The rapid development of Internet based technologies and its popularization require broadband network to have more capacities and higher transmission rate. To fulfill it, numerous kinds of research works have been investigated. Among them, transmitting information signal through network nodes in only optical form without electrical conversion is expected to accelerate processing speed of nodes [1].

Our research focuses on an optical processing of label recognition which is one of the most important functions of a photonic router. So far, number of recognition schemes have been studied for differently coded optical labels such as binary phase-shift-keying (BPSK) [2], quadrature PSK (QPSK) [3], and 16QAM [4]-[6].

We target on 8QAM coded label and for this purpose, we have been proposed passive waveguide-type label identification circuit which is expected to have low power consumption. In this work, by adjusting previously proposed minimum intensity detection circuit [7] with thresholding devices and logical post-processing circuits, 8QAM code detection is investigated by maximum output results. To review the efficiency of this method, noise tolerance simulation is run by OptiSystem software (Optiwave Systems Inc.).

2 PROPOSED RECOGNITION METHOD FOR 8QAM CODED LABEL

A constellation of our target 8QAM signal is shown in Fig. 1. It can be dealt with as two QPSK signals with different phase and amplitude values. Therefore, we propose a method based on former QPSK code recognition circuit (QPRC) [3] as shown in Fig. 2 and its input and output relations are expressed by Eq.(1).

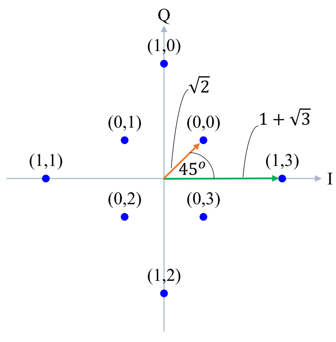


Figure 1. A constellation of 8QAM signal.

Our proposed 8QAM recognition circuit consists of two Y-couplers, an attenuator, a phase shifter, two QPRCs and threshold devices as illustrated in Fig.3(a). The thresholding values are set to be $\alpha = 1.4E_0^2$ and $\beta = 0.375E_0^2$. After the threshold devices make the output zero for inputs lower than these values, maximum intensities are discriminated by using post processing logic circuits as shown in Fig.3(b).

$$\begin{pmatrix} E_{out}^{(1)} \\ E_{out}^{(2)} \\ E_{out}^{(3)} \\ E_{out}^{(4)} \end{pmatrix} = \frac{1}{2} \begin{pmatrix} 1 & e^{j3\pi/2} \\ e^{j7\pi/4} & e^{j7\pi/4} \\ e^{j5\pi/4} & e^{j\pi/4} \\ e^{j3\pi/2} & 1 \end{pmatrix} \begin{pmatrix} E_{in}^{(1)} \\ E_{in}^{(2)} \end{pmatrix} \tag{1}$$

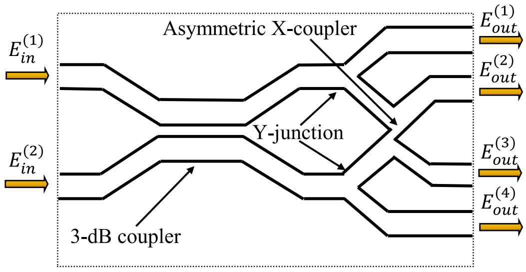
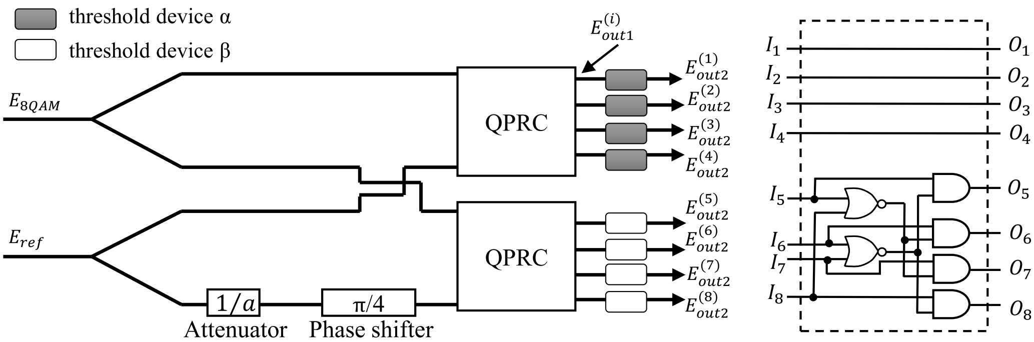


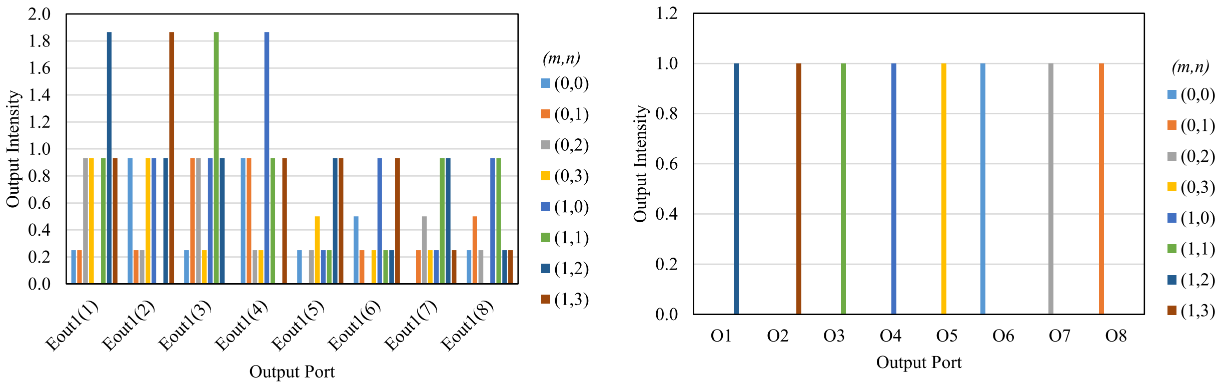
Figure 2. QPSK code recognition circuit.



(a) (b)

Figure 3. (a) Proposed 8QAM recognition circuit by the maximum output, (b) Post-processing logic circuit.

At the inputs of the recognition circuit, 8QAM and a reference signals are given and they can be written as $E_{8QAM} = a^m E_0 e^{j\pi/4} e^{jn\pi/2} e^{jm\pi/4}$ and $E_{ref} = aE_0$, respectively. Here, m=0, 1, n=0, 1, 2, 3, and $a = (1+\sqrt{3})/\sqrt{2}$. The reference signal is assumed to be transmitted with the 8QAM label as time-series pulses. Output intensities before thresholder and after post processing logic circuits are plotted in Fig. 4 (a) and (b), respectively. As the result shows, different outputs are found for each input code combinations.



(a) (b)

Figure 4. Output intensities (a) before thresholder and (b) after post processing logical circuit.

3 EVALUATION OF NOISE TOLERANCE

A simulation model for evaluation of noise tolerance is shown in Fig. 5. We design waveguide type recognition circuit by using discrete optical devices. The signal source is given from a continuous wave (CW) laser at wavelength of 1550 nm. The optical 8QAM pulse sequence is generated by pseudo random bit sequence (PRBS) of $2^{15}-1$. The amplified spontaneous emission (ASE) noise is considered to be added to both of the 8QAM and reference signals for evaluating noise tolerance.

Fig. 6 shows the calculated bit-error rate (BER) against optical signal-to-noise ratio (OSNR) at different bit rates of R_0= 7.5, 15.0, and 30.0 Gb/s which correspond to the symbol rates of $R_0/3$= 2.5, 5.0, and 10.0 Gbaud. The required OSNRs at log(BER)=-3 are found to be 11.5, 14.5, and 17.8 dB, respectively. At 2.5 Gbaud symbol rate, the OSNR is around 5dB higher than the back-to-back (B2B) value. In comparison, the required OSNRs at log(BER)=-3 at 2.5 Gbaud were 10 dB for 8QAM minimum-detection circuit [7] and 27 dB for 16QAM maximum-detection circuit [6].

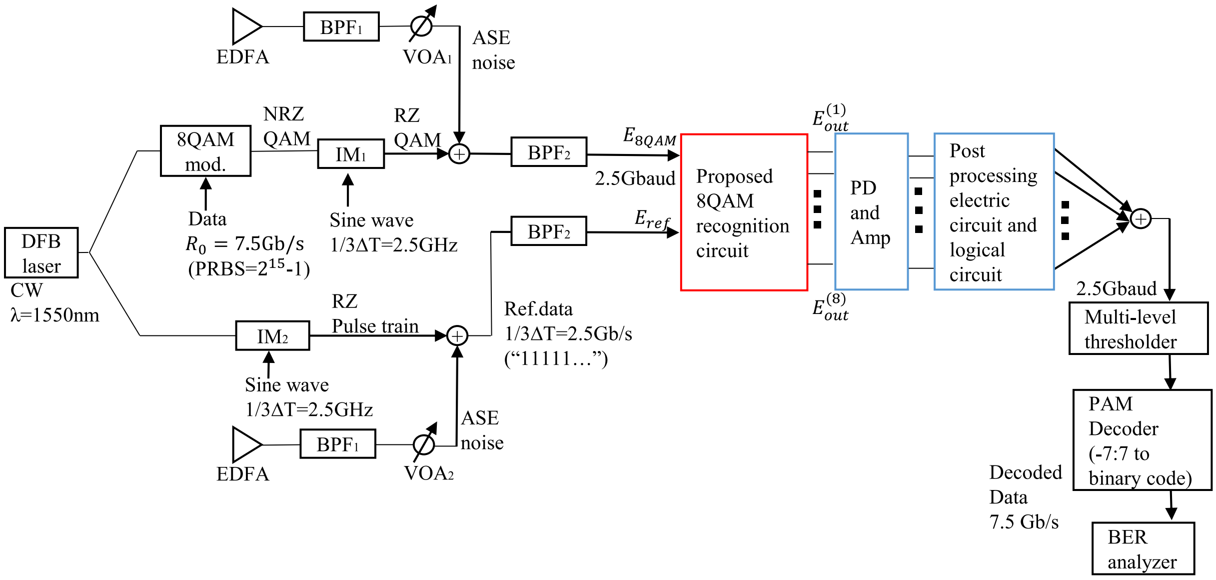


Figure 5. A simulation set-up for noise tolerance.

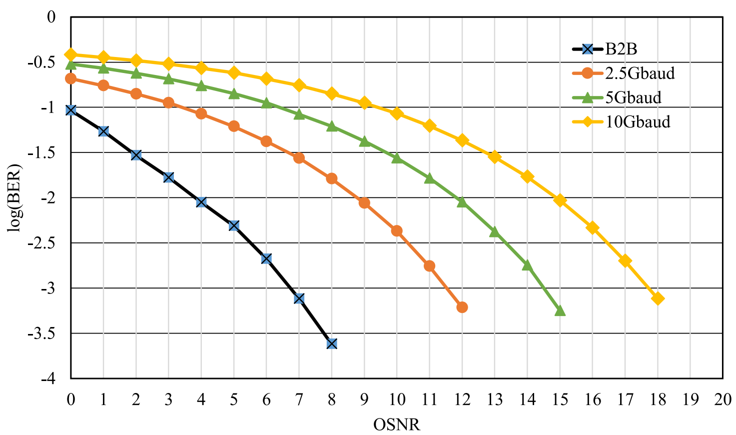


Figure 6. A simulated BER performance as a function of OSNR.

4 CONCLUSION

In this work, an operation of integrated-optic 8QAM label recognition circuit was investigated by maximum outputs. By using threshold devices and a post processing logical circuit, recognition was successfully achieved. The noise tolerance evaluation was examined as BER as a function of OSNR.

In our future work, we will work on scalability and improving noise tolerance.

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