Noise Tolerance in Integrated-Optic Recognition Circuit for Optical 16QAM Codes

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In photonic label routers, various optical signal processing functions are required, which include optical label extraction, recognition of the label, optical switching and buffering controlled by signals based on the label information and network routing tables, and label rewriting. Among these functions, we focus on photonic label recognition. We have proposed two kinds of optical waveguide circuits to recognize 16 quadrature amplitude modulation (QAM) codes.

We consider recognition of the 16QAM code by cascaded connection of two circuits for QPSK code recognition. Fig.1 shows a waveguide circuit for QPSK phase recognition circuit (QPRC) followed by phase adjustment waveguides [1]. The circuit consists of a 3-dB directional coupler, two Y-branches, and an asymmetric X-junction coupler. First, we consider a proposed circuit for recognition from the minimum-output port. Using two-stage connection of this QPRC, a proposed circuit for recognition of 16QAM codes from the minimum-output port is formed as shown in Fig.2 [2]. The 16QAM coded signal is incident in the upper port $E_{\rm in}$, whereas a reference signal is incident in the lower port $E_{\rm ref}$. The circuit consists of five QPRCs and an attenuator, a 1:2 divider, and a 1:4 divider. Only one output port corresponding to the incident QAM code has minimum output intensity. Thus, the incident code can be determined from the minimum-output port. To increase the contrast ratio at the ports, thresholders are required as post processing.

Next, we consider another circuit as shown in Fig.3(a) [3]. The incident 16QAM code is recognized from the maximum-output port. This circuit consists of an input signal part and a reference signal part. The input signal part consists of three Y-branches and an attenuator. The reference signal part consists of three Y-branches, attenuators, and a 3-dB directional coupler. By feeding the output fields to the four QPRCs, sixteen outputs are obtained. Three kinds of threshold devices are connected at the output ports of QPRCs 1 and 2, QPRC 3, and QPRC 4, respectively. After the thresholders, a logic circuit shown in (b) is required as post processing.

We consider a communication system in 16QAM format to evaluate noise tolerance of the proposed recognition circuits. To simulate the communication system, we employed a

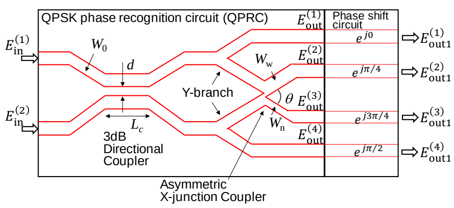


Fig.1 Optical waveguide circuit (QPRC) for recognition of a QPSK phase.

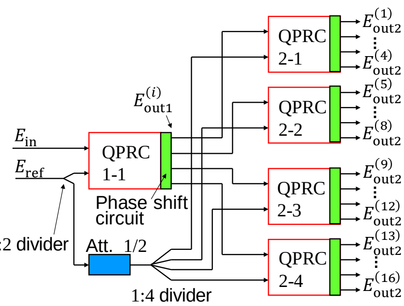
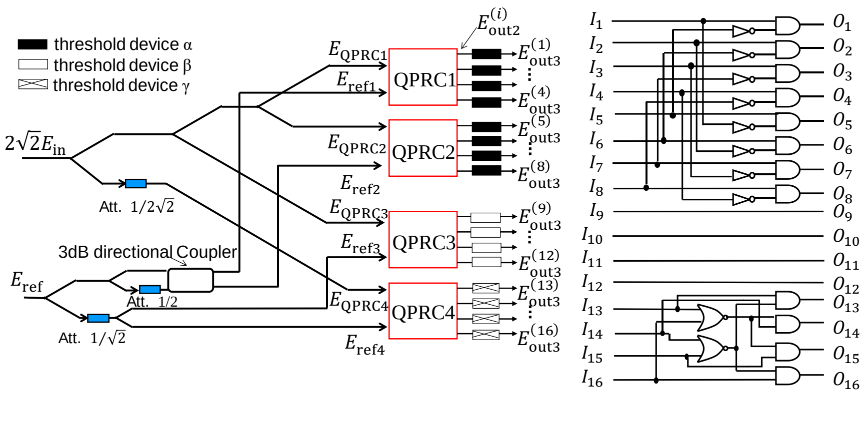


Fig.2 Recognition circuit for 16 QAM codes by detecting minimum output.



(a) (b)

Fig.3. Recognition circuit for 16QAM codes by detecting maximum output.

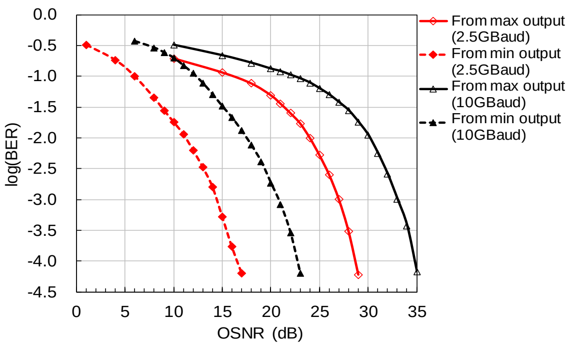


Fig.4. Simulated BER performance as a function of OSNR.

simulation software, OptiSystem (Optiwave Systems Inc.). An optical 16 QAM pulse sequence at bit rate of R_0 = 10 Gb/s and 40 Gb/s corresponding to symbol rate of $R_0/4$ = 2.5 GBaud and 10 GBaud is generated by pseudo-random bit sequence (PRBS) of 2^{15} -1.

Fig.4 shows the calculated bit error rate (BER) as a function of optical signal to noise ratio (OSNR) of the input 16QAM signal by the minimum-output and maximum-output configuration of the 16QAM recognition circuits. Resulted OSNRs for required BER at $1.0\text{x}10^{-3}$ are around 14.5 dB and 27.0 dB for the minimum-output and maximum-output configurations, respectively, at 2.5GBaud. The required OSNR for recognition by the maximum-output configuration is larger by 12.5 dB than that for recognition by the minimum-output configuration. Thus, it is concluded that the recognition from the minimum output port is much practical.

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References

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