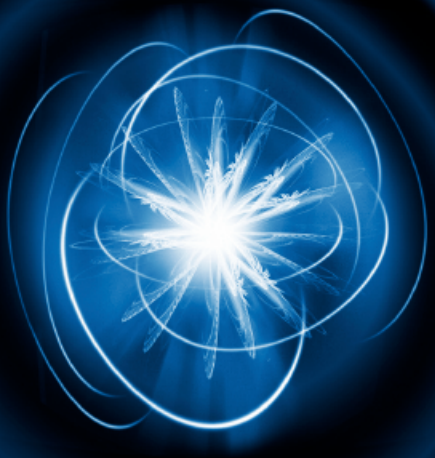
Conference Information and Agenda of Sessions

FiO LS

Frontiers in Optics + Laser Science



Technical Conference:
27 September – 01 October 2026

Science + Industry Showcase:
29 – 30 September 2026

Joseph A. Floreano Rochester Riverside Convention Center
Rochester, New York, USA

Sponsored By:
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Wi-Fi

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Official program - schedule excerpt

Tuesday, September 29, 2026 | Eastern Time (US and Canada)

Technical conference | Rochester, New York, USA

SESSION FTu1B | FiO 7: Information Acquisition, Processing and Display

Optical Computing II

Location: Highland Room AK

08:30 - 08:45 FTu1B.2

Per-Ring-Calibrated 31-Level RAMZM for Coherent Optical Systems

Red outline emphasizes the scheduled talk in the official online program.

Source: official FiO LS 2026 schedule, session FTu1B / presentation FTu1B.2

frontiersinoptics.com/schedule#/Tuesday/544976/4569032

FRONTIERS IN OPTICS + LASER SCIENCE 2026

Official program - abstract excerpt

Tuesday, September 29, 2026 | FTu1B.2 | 08:30 - 08:45

Per-Ring-Calibrated 31-Level RAMZM for Coherent Optical Systems

Presenter Minkyu Cho, Yonsei University

Authors Minkyu Cho and Woo-Young Choi, Yonsei University

Abstract

We propose and experimentally demonstrate a method for calibrating a ring-assisted Mach-Zehnder modulator by mapping microring drop-port power to corresponding through-port field trajectory, achieving 31 RAMZM output levels in a fabricated photonic integrated circuit.

Abstract and author details transcribed from the official FiO LS 2026 program entry.

frontiersinoptics.com/schedule#/Tuesday/544976/4569032

Red underlines identify Minkyu Cho and Professor Woo-Young Choi.

Per-Ring-Calibrated 31-Level RAMZM for Coherent Optical Systems

Minkyu Cho and Woo-Young Choi*
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Abstract: We propose and experimentally demonstrate a method for calibrating a ring-assisted Mach–Zehnder modulator by mapping microring drop-port power to corresponding through-port field trajectory, achieving 31 RAMZM output levels in a fabricated photonic integrated circuit.

1 Introduction

Ring-assisted Mach–Zehnder modulators (RAMZMs) provide low-frequency chirp operation and are useful for coherent optical systems, including optical interconnects and homodyne photonic processors [1–3]. RAMZMs use a microring-assisted phase response that enables a compact footprint, making them attractive for large-scale photonic integrated circuits. However, RAMZM calibration is challenging because two microrings are expected to be detuned by equal magnitudes in opposite directions.

Figure 1(a) illustrates push–pull driving of a microring, which is typically employed in conventional RAMZM calibration with two microrings [1, 2]. This method assumes that applying symmetric voltage changes produces balanced blue- and red-shifted phase shifts, but process-induced variation and nonlinear voltage-to-effective-index characteristics can break this balance, as illustrated in Figure 1(b). Here, we instead calibrate the two microrings individually by monitoring their drop-port powers and building a look-up table (LUT) for each ring. This per-ring calibration avoids the balanced-response assumption of push–pull operation and enables 31-level RAMZM field generation.

2 Principle

The proposed calibration uses the drop port of each microring as a proxy for its through-port field trajectory. As shown in Figure 1(c), the drop-port field trajectory is parameterized by an angular coordinate θ. The measured drop-port power can then be converted to this coordinate and to the corresponding through-port

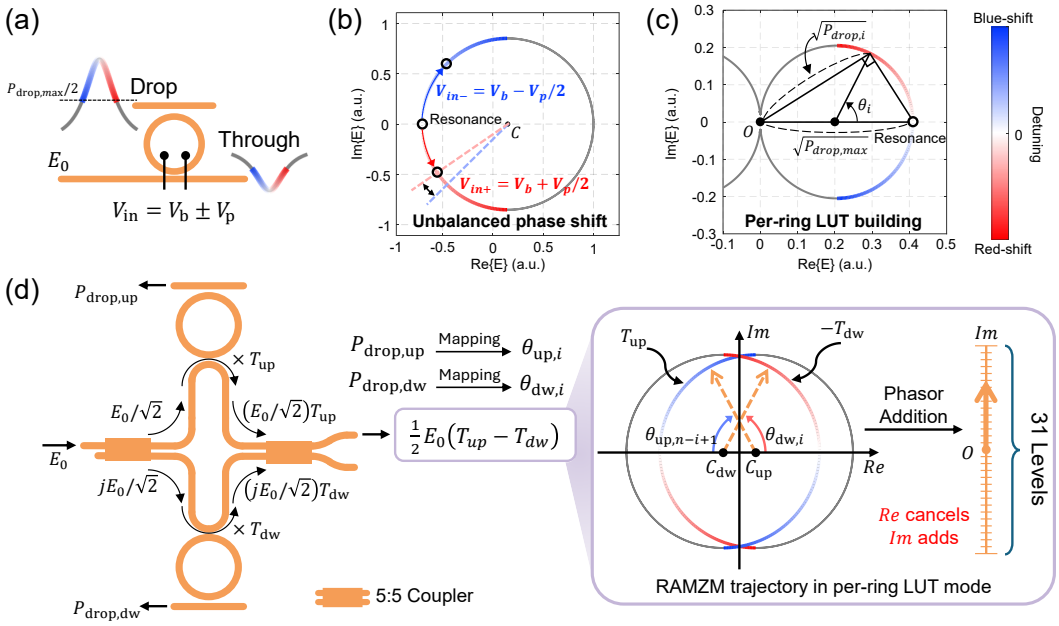


Figure 1: (a) Schematic of a microring driven in push–pull mode. (b) Through-port field trajectory of the microring in push–pull mode, showing unbalanced phase shifts between the push and pull states. (c) Drop-port field trajectory of the microring used to extract the angular coordinate θ and build a per-ring LUT. (d) RAMZM schematic and output field trajectory with independently calibrated upper and lower microrings.

field projection onto the imaginary axis as

$$P_{\text{drop}} \xrightarrow{\text{mapping}} \sin\theta = \pm 2\sqrt{\frac{P_{\text{drop}}}{P_{\text{drop,max}}}}\sqrt{1-\frac{P_{\text{drop}}}{P_{\text{drop,max}}}} \propto \text{Im}\{E_{\text{through}}\}. \tag{1}$$

By sweeping each microring and recording its drop-port power, a per-ring LUT can be built between the imaginary-axis field projection and the required drive voltage.

Figure 1(d) shows the RAMZM calibration concept. The upper and lower microrings are calibrated independently, and their through-port fields, T_{up} and T_{dw}, are combined at the signal port as $E_0(T_{\text{up}}-T_{\text{dw}})/2$. Selecting the LUT entries for opposite detunings makes the real components cancel while the imaginary components add, producing a calibrated output-field trajectory. This per-ring calibration enables 31-level RAMZM field generation with low-frequency chirp, without relying on balanced push–pull voltage responses.

3 Experimental Results

Figure 2(a) shows the experimental setup. A continuous-wave laser was coupled to a fabricated RAMZM. A multi-channel power supply drove the heaters, and the RAMZM output, upper-drop, and lower-drop ports were measured by photodiodes, transimpedance amplifiers, data acquisition, and PC-based processing. Because the device was thermally tuned, the heater drive conditions were generated using a thermal-crosstalk model to compensate inter-heater coupling.

During calibration, each microring heater was swept and the drop-port response recorded. Figure 2(b) shows the drop-port power of a microring and the corresponding 31 imaginary-axis field values extracted using Eq. (1). Figure 2(c) shows the RAMZM output obtained with the two microrings oppositely detuned as in Figure 1(d), matching the expected 31-level imaginary-axis response. Figure 2(d) shows the RAMZM output-error histogram measured while randomly sweeping the LUT levels with the two microrings oppositely detuned; the 31-level spacing over the normalized range is approximately $2/30 = 0.067$, larger than the measured standard deviation of $\sigma \sim 0.027$, indicating distinguishable multi-level encoding. These results demonstrate per-ring-calibrated LUT programming of a RAMZM; remaining errors are attributed to heater resolution, residual thermal crosstalk, and measurement noise.

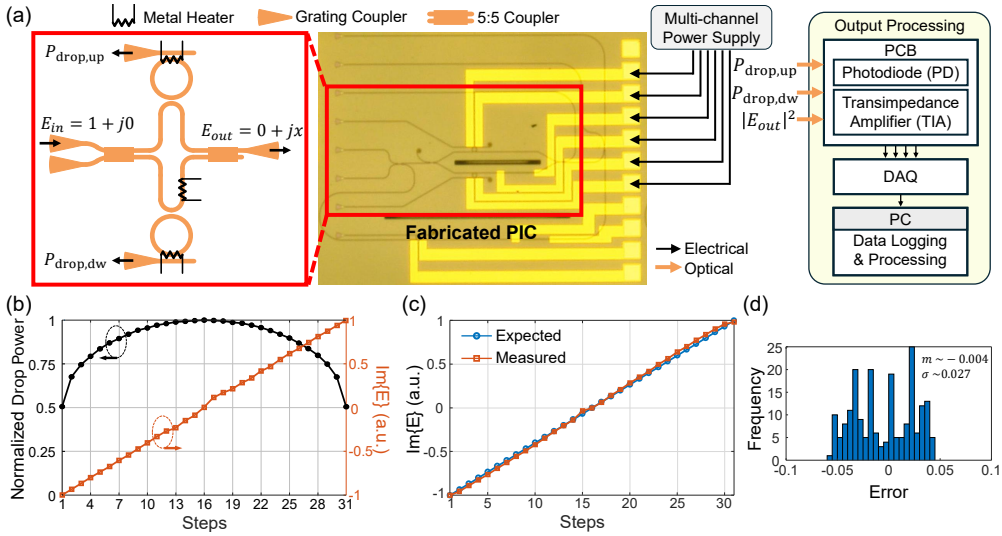


Figure 2: Experimental demonstration of 31-level RAMZM field encoding. (a) Measurement setup. (b) Drop-port power and extracted imaginary-axis field values of a microring. (c) Expected and measured RAMZM output. (d) Error distribution of RAMZM output from 300 random trials.

References

[1] A. Geravand et al., "Ultrafast coherent dynamics of microring modulators," Nature Photonics, 2025.

[2] F. G. Vanani et al., "A Scalable Silicon Photonic Tensor Accelerator," CLEO, 2025.

[3] N. Youngblood, "Coherent Photonic Crossbar Arrays for Large-Scale Matrix-Matrix Multiplication," IEEE JSTQE, 2023.

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. RS-2024-00455038).