Comparison of Low Noise and Latency Performance of Optical Circulators



Overview

A 6-port optical circulator using silicon photonic crystals has been designed and proposed in this paper as an essential component of an optical communication system.

Key Takeaways

All-fiber acousto-optic circulators offer lower insertion loss and broader bandwidth than traditional Faraday circulators, potentially reducing noise and latency in optical networks.

Faraday Circulators

Faraday circulators are magneto-optic devices that rely on the Faraday effect to achieve non-reciprocal light propagation. Key characteristics include: Insertion Loss: Typically around 1 dB at telecom wavelengths, which can increase at near-infrared or visible wavelengths. Higher insertion loss contributes to signal attenuation and can increase noise in sensitive systems.

Isolation and Extinction Ratio: High isolation prevents back-reflections, but the extinction ratio is generally lower than in advanced acousto-optic designs. Latency: Latency is minimal, primarily determined by the optical path length, but integration into compact photonic circuits is challenging due to the need for magnetic fields. Polarization Sensitivity: Some Faraday circulators are polarization-dependent, which can introduce additional noise if the input polarization fluctuates.

© 2026 ENSAA OPTICAL NETWORKS - All rights reserved

Faraday circulators are widely used in conventional optical networks and high-power applications due to their stability and reliability.

All-

Fiber Acousto-

Optic CirculatorsAll-fiber acousto-optic circulators use Mach-Zehnder interferometers with fiber null-couplers, where acoustic waves control the splitting ratio. Their performance advantages include: Low Insertion Loss: Experimental devices achieve as low as 0. 81 dB, significantly reducing signal degradation and noise compared to traditional Faraday circulators.

High Extinction Ratio: Up to 27 dB, which improves isolation and minimizes crosstalk, enhancing signal fidelity. Broad Bandwidth: At least 50 GHz, allowing high-speed signal transmission with minimal latency impact. Integration and Flexibility: Fabricated from standard single-mode fibers and electrically actuated, these circulators can be seamlessly integrated into existing fiber networks, including quantum communication systems, without requiring magnetic fields.

Latency Considerations: The Mach-Zehnder configuration introduces negligible additional latency, and the broad bandwidth supports high-speed optical routing. Comparative SummaryFeatureFaraday CirculatorAll-Fiber Acousto-Optic CirculatorInsertion Loss~1 dB (higher at visible/NIR)0. 81 dBExtinction RatioModerateUp to 27 dBBandwidthLimited≥50 GHzNoise PerformanceHigher due to insertion loss and polarization sensitivityLower due to low loss and high isolationLatencyMinimal, but integration can be bulkyMinimal, easily integrated into fiber networksIntegrationRequires magnetic fields, challenging for photonic circuitsElectrically actuated, compatible with standard fibersConclusionFor applications requiring low noise and minimal latency, such as quantum networks or high-speed optical routing, all-fiber acousto-optic circulators provide superior performance due to their low insertion loss, high extinction ratio, and broad bandwidth.

Faraday circulators remain reliable for conventional systems but may introduce higher noise and integration challenges in advanced optical setups.

© 2026 ENSAA OPTICAL NETWORKS - All rights reserved

Article Content

Optical Circulator

An optical circulator is defined as a nonreciprocal device that transmits light between ports in a predefined sequence, utilizing the Faraday effect to change the polarization of optical signals,

Low-loss and broadband all-fiber acousto-optic circulator

Here, we present a solution to this issue by realizing low-loss (0.81 dB), broadband (at least 50-GHz bandwidth), and high-extinction (up to 27 dB) circulators, based on Mach-Zehnder

A low loss hexagonal six-port optical circulator using ...

A 6-port optical circulator using silicon photonic crystals has been designed and proposed in this paper as an essential component of an optical communication system.

Optical Isolators & Circulators: Selection & Applications | YesWeHave

This guide provides a detailed overview of their principles, device structures, performance considerations, and application scenarios, helping engineers build efficient and high-performance

(PDF) Arrayed High Performance Optical Circulators

This review is focused on works using optical-fibre technology, employing diverse optical fibres, sensing techniques, and configurations applied in several medical fields.

Compact, low-loss and broadband photonic crystal circulator based

We propose and investigate a compact, low-loss and broadband circulator based on a star-type ferrite rod in two-dimensional square-lattice photonic crystals. Only one ferrite rod is

Fiber Optic Circulators Explained: Powering Directional Light Control ...

As global data demand continues to grow, optical communication networks must deliver higher bandwidth, lower latency, and greater reliability. At the heart of these advanced networks are

Faraday Circulators

These performance figures depend on the optical wavelength; circulators work well only within a limited optical bandwidth. One may specify lower limits of the mentioned performance factors within the

© 2026 ENSAA OPTICAL NETWORKS - All rights reserved

Performance analysis of optical interconnects'' architectures for data ...

Electrical interconnects in Data Center Networks (DCNs) suffer from various problems which include high energy consumption, high latency, fixed throughput of links and limited

Fiber Optic Circulators: Enabling Smarter, Directional Light

Conclusion Fiber optic circulators may be small in size, but their impact on optical systems is monumental. As networks evolve to support AI, quantum technologies, and global

Optical Circulators: A Comprehensive Guide

Discover the world of optical circulators, their working principles, and their significance in modern optics and photonics applications.

Latency reduction in optical interconnects using short optical pulses ...

Abstract— We present a new method of latency reduction in optical interconnects: using very low duty cycle return-to-zero encoding (i.e., subpicosecond pulses). An analytical comparison of three

Active quasi circulator: Comprehensive review and performance ...

Numerous designs of active-quasi circulators were implemented over the course of time. Therefore, to address this research gap, it becomes essential to have a comprehensive overview and comparison

Fibre Optics and 5G: The Future of High Speed Networks

The rest of this article shows you how these technologies work together, what innovations are driving performance, and how this shapes the future of high speed internet connectivity. What Is

A low loss hexagonal six-port optical circulator using ...

Optical circulators are used to route signals in optical sensors that measure stress, strain, temperature, and pressure. Because of the high isolation between input and reflected power,

Relative intensity noise comparison of fiber laser and amplified ...

Abstract The performance of Raman fiber laser and amplifier largely depends on the temporal stability of the pump sources. Here the relative intensity noise of three different sources are

Integrated TE and TM optical circulators on ultra-low-loss silicon ...

© 2026 ENSAA OPTICAL NETWORKS - All rights reserved

In this work, we have presented the design of two four-port integrated optical circulators for TE and TM modes, which combine the advantages of new low-loss silicon nitride waveguides with the non

Active quasi circulator: Comprehensive review and performance comparison

A comparative performance analysis of active-quasi circulators available in existing literature is shown in Table 2. In provides the technology information and performance data (return loss, insertion loss,

Contact Us

Continue your research online:

Website: https://ensaa.es
Technical inquiry: https://ensaa.es/contact.html

This document is for preliminary research. Verify specifications against current standards, product documentation and project requirements.

© 2026 ENSAA OPTICAL NETWORKS - All rights reserved