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2026
Optics Communications
https://ir-library.kabianga.ac.ke/handle/123456789/1224
Nyarangi, W. K., Kipnoo, E. R., Wekesa, F. W., Jena, J., & Waswa, D. W. (2025). Simultaneous polarization-based fiber sensor and 10 Gbps data transmission over 75 km SMF for mining safety application. Optics Communications, 132693.

Optics Communications 600 (2026) 132693

Contents lists available at ScienceDirect

Optics Communications

journal homepage: www.elsevier.com/locate/optcom

Simultaneous polarization-based fiber sensor and 10 Gbps data transmission over 75 km SMF for mining safety application

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ABSTRACT

In this paper, we present a novel approach to enhancing safety and communication in mining environments by integrating a fiber optic sensor with high-speed data transmission capabilities. For the first time to our knowledge, we propose a fiber sensor design that also serves as communication hub to enhance safety in a mining environment. This design employed different light sources; WDM, MZM and DFB. Each of the light sources was modulated using a 10 Gbps Pseudorandom Binary Sequence (PRBS 2^9-1) signal onto a fiber for data transmission. Among them, the MZM source demonstrated superior performance, enabling transmission over 75 km of single-mode fiber (SMF) while maintaining signal integrity. WDM and DFB attained a maximum of 50 km. Concurrently, the system monitored both the signal's power and state of polarization (SOP). Mechanical disturbances were applied to the fiber by incrementally loading 2 kg masses at 10-s intervals, up to a total of 18 kg, to simulate real-world environmental stresses. This incremental mechanical loading of up to 18 kg caused a measurable power loss of 0.43 dB and an average SOP rotation of 613° over 120 s, corresponding to a strain sensitivity of 0.024 dB/kg and SOP speed of 5.108°/s. The system demonstrated high sensitivity to changes in the polarization state and power, allowing for real-time detection of mechanical faults or anomalies. This dual-purpose system not only ensure reliable communication but also provides real-time safety monitoring, showing significant potential for improving both operational efficiency and safety in mining applications. Additionally, the architecture supports bi-directional communication using distinct upstream (1310 nm) and downstream (1550 nm) optical windows, enabling two-way interaction between underground personnel and external monitoring systems.

1. Introduction

Mining operations, particularly those in remote or underground environments, present significant challenges to worker safety and operational efficiency [1,2]. Traditional safety measures often fall short in detecting early signs of hazardous conditions, such as structural weaknesses, temperature anomalies, or equipment malfunctions, which could lead to catastrophic failures [3]. In this regard, real-time monitoring systems that offer both early detection and communication capabilities are crucial to ensuring a safe working environment [3,4].

Fiber optic technology has emerged as a key player in addressing these challenges due to its ability to provide continuous, remote monitoring and high-speed data transmission over long distances [5–7]. Among various fiber sensing techniques, polarization-based fiber sensors have proven to be highly sensitive to changes in the physical environment, such as strain, temperature, or vibrations [8–11]. These sensors are particularly useful in harsh and dynamic environments like mines, where conventional sensors may struggle due to environmental conditions or interference [12–14].

Recent advances in integrated sensing and communication (ISAC) have explored the coexistence of data transmission with distributed sensing on the same fiber infrastructure, including φ-OTDR and Brillouin techniques. However, few implementations demonstrate polarization-based dual-functionality in the context of underground mining safety, especially over long distances [9,15]. Our work builds upon these efforts by designing and experimentally validating a polarization-sensitive system that achieves real-time mechanical sensing while maintaining a 10 Gbps transmission over 75 km of NZDSF fiber.

Compared to existing wireless-based mining safety systems, the proposed architecture offers significantly higher data rates (10 Gbps vs sub-Gbps), immunity to electromagnetic interference (EMI), and improved long-range performance (75 km vs tens of meters). Unlike traditional fiber-based systems that require separate links for sensing and communication, this dual-purpose system reduces infrastructure redundancy and enhances maintainability by sharing the same optical path for both functions. Furthermore, the polarization-based sensing approach avoids the complex filtering or signal separation required in Brillouin or φ-OTDR-based systems, offering a simpler yet robust solution for integrated monitoring in harsh underground environments.

In this paper, we propose a novel integrated system that combines a

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https://doi.org/10.1016/j.optcom.2025.132693
Received 13 September 2025; Received in revised form 24 October 2025; Accepted 18 November 2025
Available online 19 November 2025

fiber optic sensor with a high-speed communication hub, designed to enhance both the safety and operational capabilities of mining environments. To contextualize our system's performance, Table 1 presents a comparison with recent fiber-optic sensing and communication systems. While φ-OTDR and Brillouin systems provide high sensing sensitivity, they often operate at lower communication data rates or require complex multiplexing strategies. PolMUX-based high-speed links lack integrated sensing. In contrast, our proposed system balances moderate high-speed transmission (10 Gbps) with simultaneous polarization-based sensing over long distances using a shared signal path, offering a simpler and scalable architecture suitable for mining environments.

Recent advances in optical communication systems have demonstrated the potential of polarization multiplexing (Polmux) combined with advanced modulation schemes to enhance data throughput and signal robustness. For instance, the mitigation of nonlinear responses in Polmux-based long-haul optical systems has been effectively addressed using duo-binary modulation schemes, improving system performance and reach [16]. Furthermore, hybrid millimeter-wave-over-fiber (MMW-over-fiber) and orthogonal frequency-division multiplexing--free space optics (OFDM-FSO) transmission systems employing doublet lens schemes and Polmux techniques have been proposed to achieve high-capacity and resilient communication links [17]. These studies underscore the relevance of Polmux and Mach-Zehnder Modulators (MZMs) in pushing the boundaries of integrated sensing and communication systems.

This paper is arranged as follows; the introduction giving an overview of the research, materials and methods employed in the design, results and discussions on the findings, and finally the conclusion.

2. Materials and methods

Fig. 1 shows a schematic representation for investigating sensing capabilities and transmission performance over various fiber lengths and establishing sensitivities. The programmable pattern generator (PPG) was used to generate a pseudo-random bit stream (PBRS) pattern consisting of 0 and 1 bits. This is a typical representation of a digitized information/data. Light from a laser source was modulated with the generated pattern and then transmitted over a fiber under test (FUT). To simulate strain conditions similar to those of a potential mine collapse, incremental 2 kg masses (up to a total of 18 kg) were applied to the FUT. This is however not typical of a real mine collapse as this is gradual and for investigation purpose. While this loading may not fully replicate actual mining strain, it effectively demonstrated the strain sensitivity of optical fibers. 18 kg was used because of bare fibers under investigation. In a real environment, a fiber with a protective jacket is utilized, providing strength to additional forces. Regarding the loading test methodology, we acknowledge that actual mining environments experience sudden, complex stress variations including dynamic loads and vibrations. However, our controlled incremental loading in 2 kg steps was designed to establish baseline strain sensitivity and sensor linearity under gradual loading conditions. This approach provides a repeatable, quantifiable approximation of strain response which forms the foundation for future tests involving dynamic or non-linear loading scenarios. Furthermore, while real underground mechanical dynamics involve multi-axis stresses and temperature coupling, the present study focuses on demonstrating the principle feasibility and sensitivity of the polarization-based fiber sensor integrated with data transmission under laboratory conditions.

During the strain loading experiments, the fiber was securely clamped between fixed, smooth plastic plates to ensure uniform and controlled application of compressive force. The smooth surfaces minimized micro-bending effects caused by surface roughness, providing consistent strain conditions along the fiber. It is acknowledged that in real-world mining environments, fiber contact surfaces may be uneven or rough, potentially introducing localized micro-bending and affecting optical attenuation [18]. Future studies should investigate such effects to better replicate practical installation conditions and improve sensing accuracy.

In this configuration, the fiber functions both as a transmission medium and as a sensing element [15,19]. As part of an initial investigative study, three laser sources were considered: a Distributed Feedback (DFB) laser from Thorlabs (model LP1550 – SAD2), a Wavelength Division Multiplexing (WDM) source from Thorlabs (model TLS1550 - C), and a Mach-Zehnder Modulator (MZM) source from Photline (Modbox platform). These were evaluated to determine the most suitable option for long-range, strain-sensitive transmission.

A Variable Optical Attenuator (VOA) was included in the setup to vary the optical power levels. This allowed for systematic evaluation of the system's Bit Error Rate (BER) performance under different power conditions. After transmission through the fiber, the optical signal was split using a 90/10 coupler: 90 % of the signal was directed to a photodetector (PD) for optical-to-electrical conversion, while 10 % was reserved for signal monitoring. The electrical signal from the PD was fed into a Bit Error Rate Tester (BERT) from Photline, which measured the BER and evaluated the integrity of the received data. Simultaneously, a Digital Signal Oscilloscope (DSO) was used to visualize the eye diagram and inspect individual bits, providing insight into signal quality.

To further investigate the effects of strain and environmental disturbances on the fiber, a polarization analyzer was incorporated into the 90 % (main) path. The analyzer provided real-time measurements of the State of Polarization (SOP), including Stokes' parameters and Degree of Polarization (DOP). This allowed for the detection of dynamic changes in the SOP, which can be indicative of strain, bending, or external perturbations along the fiber. Through this approach, the system gained the capability to monitor both transmission performance and the physical state of the fiber, highlighting its dual use as a communication channel and a sensor.

All experiments were conducted in a controlled laboratory environment with the ambient temperature maintained at 22 ± 1 °C. No active thermal isolation or temperature compensation was applied, but environmental fluctuations were minimal. While polarization-based fiber sensors are generally sensitive to temperature variations, previous studies have shown that for short-duration measurements under small temperature excursions, the thermal influence on the state of polarization is negligible, and active compensation is often unnecessary [20,21].

Table 1
Comparison with related work in integrated optical fiber sensing & communication.

Ref	Modulation Type	Data Rate	Fiber Type	Length (km)	Sensing Type	Strain Sensitivity	Integration Method	Key Limitation
[6] φ-OTDR + Comms	NRZ-OOK	1 Gbps	SMF	50	φ-OTDR	~0.5 με	Time-division multiplexing	Lower comm. rate
[7] Brillouin + Comms	NRZ	2.5 Gbps	SMF	40	Brillouin	~0.03 nm/kg	Wavelength division	Complex filtering
[8] PolMUX	Duo-binary	40 Gbps	NZDSF	80	No sensing	–	Polarization division	No sensing
This work	NRZ	10 Gbps	NZDSF	75	Polarization-based	0.024 dB/kg	Shared signal path	Lab-only loading

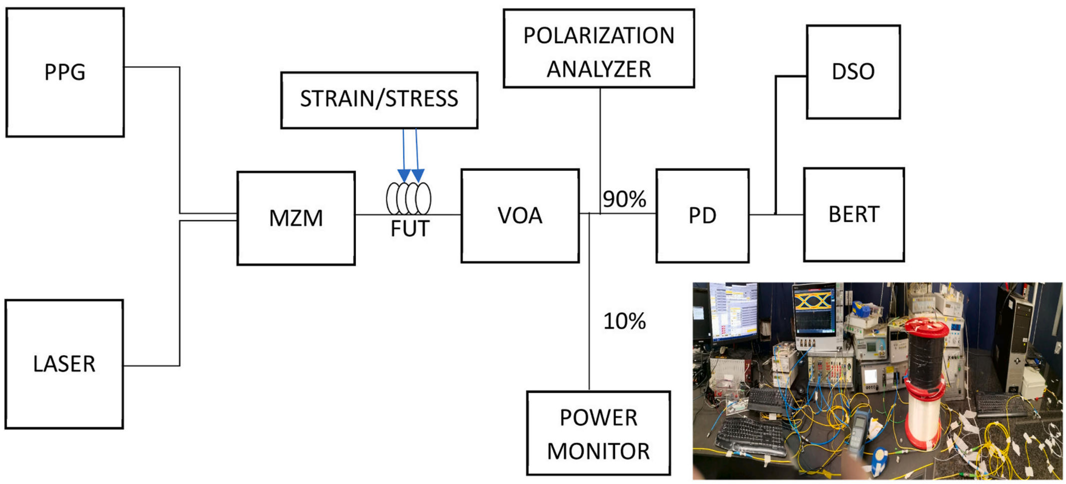

Fig. 1. Experimental setup for assessing transmission performance and strain sensitivity of an optical fiber using BER measurements and polarization monitoring under simulated loading conditions.

3. Results and discussions

3.1. Transmission performance

This section describes the transmission performance of the designed testbed. Light from each source was coupled into a Single Mode Fiber (SMF) of varying lengths, up to 75 km, to establish the Bit Error Rate (BER) performance of the transmitted signal. Fig. 2 (a), (b), (c), shows the corresponding measurements for each source.

Back-to-back (B2B) measurements were first performed to establish receiver sensitivity and to characterize the photodiode without fiber-induced degradation. Subsequent measurements with lengths of 25 km, 50 km, and 75 km non-zero dispersion shifted fibers (NZDSFs) were used to assess how fiber-induced effects—primarily dispersion and attenuation—impacted signal clarity and transmission integrity. NZDSF is ideal for long transmission because of low dispersion values and

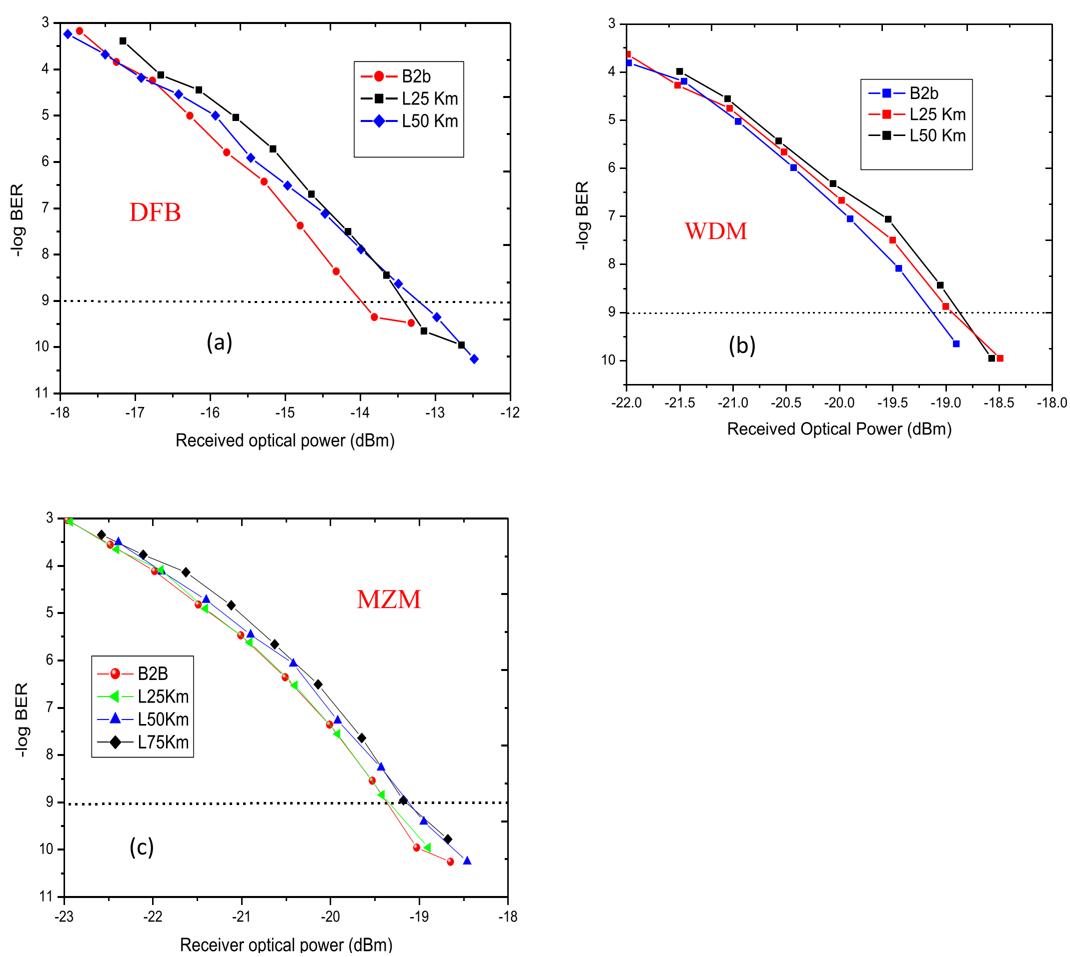

Fig. 2. Transmission performance of laser sources over various distances; (DFB, WDM, MZM).

attenuation at 1550 nm window. In this work, the fiber used was a Non-Zero Dispersion-Shifted Fiber (NZDSF, ITU-T G.655 standard). The fiber specifications were based on manufacturer datasheets, which report a dispersion of approximately 4.5 ps/(nm·km) at 1550 nm, an attenuation of about 0.22 dB/km, and a polarization mode dispersion (PMD) of less than 0.1 ps/$\sqrt{\text{km}}$. Direct OTDR or dispersion measurements were not conducted; however, these typical values are widely accepted for NZDSF fibers used in long-haul optical communication systems [22]. Future studies could include direct characterization to confirm these parameters under experimental conditions.

Of the three sources investigated, only the MZM source achieved error-free transmission over a 75 km fiber span. In contrast, both the DFB and WDM sources were limited to 50 km before BER degradation exceeded the acceptable telecommunication threshold of 10^{-9}. In this study, "error-free transmission" refers to Bit Error Rates (BER) below 10^{-9}, which is a commonly accepted threshold in optical communication systems prior to Forward Error Correction (FEC). No FEC was applied during the experiments, ensuring that the measured BER values reflect the intrinsic transmission quality of the system without compensation. This conservative approach enhances the reliability of the results and allows direct comparison with baseline telecommunication standards.

This clearly indicates that the MZM source supports a longer transmission reach compared to the DFB and WDM sources. Such an extended range implies that a fiber stretch of up to 75 km can be feasibly deployed in a mining environment, ensuring wide area coverage for both communication and sensing.

For the DFB source, the received optical power at the B2B configuration was −13.97 dBm. At 25 km and 50 km transmission distances, the BER threshold was met at received powers of −13.42 dBm and −13.16 dBm, resulting in power penalties of 0.55 dB and 0.81 dB, respectively. For the WDM source, the received optical powers were −19.13 dBm, −18.94 dBm, and −18.87 dBm for the B2B, 25 km, and 50 km transmissions, respectively. This translated to transmission penalties of 0.19 dB and 0.26 dB.

The MZM source demonstrated the most stable performance, with incident optical powers measured at −19.36 dBm (B2B), −19.33 dBm (25 km), −19.15 dBm (50 km), and −19.10 dBm (75 km). The resulting power penalties were 0.03 dB, 0.21 dB, and 0.26 dB for the 25 km, 50 km, and 75 km transmissions, respectively. These results reinforce the MZM's robustness and minimal signal degradation over distance.

The observed penalties across all sources are primarily attributed to cumulative dispersion effects and minor attenuation over the fiber length. As expected, transmission penalties increased with fiber length. However, the relatively small penalty increase observed with the MZM source underscores its suitability for long-distance transmission in environments such as underground mines, where both communication reliability and spatial coverage are critical.

While our study focused primarily on BER measurements as the key performance metric, we acknowledge that eye-diagram and Q-factor analyses could provide additional insights into signal quality. Due to equipment limitations, these measurements were not conducted in the current work. We recommend that future investigations include eye-diagram and Q-factor characterization to complement BER results and provide a more comprehensive performance evaluation.

Moreover, the system supports bi-directional communication across the mining infrastructure, enhancing its practicality for real-time operational scenarios. Similar to how upstream and downstream channels function in standard telecommunication networks (e.g., home internet or mobile data services), this optical system allows downstream communication (from external command centers to underground miners) and upstream communication (from miners or underground sensors to external monitoring stations). This duplex capability ensures a two-way data flow essential for coordination, emergency alerts, and status updates.

The deployment utilizes different optical windows to achieve this duplexing. Specifically, the 1310 nm wavelength window can be designated for upstream signals, while 1550 nm is used for downstream, or vice versa, depending on the system configuration. This wavelength division strategy minimizes crosstalk and enables simultaneous high-speed data exchange in both directions over the same fiber. The ability to integrate both data transmission directions into a single fiber infrastructure is a key enabler for real-time interaction and control within deep or remote mining operations.

The bi-directional transmission at 1310 nm and 1550 nm wavelengths was carefully configured to minimize nonlinear effects such as four-wave mixing (FWM) and cross-phase modulation (XPM). Given the wavelength separation and power levels used, the impact of nonlinearities was negligible in our system, as supported by the stable bit error rates observed during simultaneous transmission and sensing. Additionally, the choice of NZDSF fiber with optimized dispersion characteristics further reduces nonlinear impairments, ensuring reliable operation over the 75 km link.

3.2. Transmission performance under demonstrated strain loading

To evaluate the system's robustness under stress, additional transmission tests were conducted over a 75 km fiber span in which mechanical strain was intentionally applied to a section of the fiber. This strain application, although simplified, was designed to demonstrate the system's dual-functionality; simultaneously acting as a high-speed data transmission link and a sensing element. The Mach-Zehnder Modulator (MZM) source, previously shown to provide stable long-distance performance, was used. The received optical power at the back-to-back (B2B) configuration was –19.36 dBm, establishing the baseline as shown in Fig. 3. Over 75 km with no strain, the received power was –19.15 dBm, corresponding to a minimal power penalty of 0.21 dB.

To simulate mechanical perturbations, 10 kg and 18 kg weights were sequentially applied to a section of the fiber. Under a 10 kg load, the received power decreased to −19.63 dBm, resulting in a 0.73 dB penalty. Under 18 kg, the power dropped to −18.34 dBm, producing a 1.02 dB penalty.

This demonstration highlights the fiber's dual-purpose capability: even under mechanical stress sufficient to alter its optical properties, the fiber continued to support error-free 10 Gbps transmission. These results confirm the viability of using a single fiber link for both real-time environmental sensing and long-haul data communication, especially in infrastructure-critical scenarios such as underground mining environments.

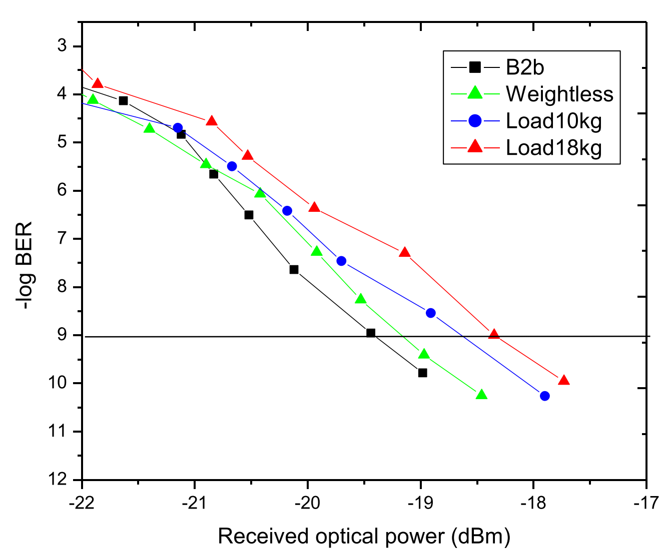

Fig. 3. Transmission Performance of MZM source under demonstrated mechanical loading (75 km Fiber).

3.3. Power and SOP fluctuation

Following preliminary investigations with multiple laser sources, the Mach-Zehnder Modulator (MZM) source was selected for further analysis due to its superior transmission reach and lower signal degradation over distance. This section presents the strain sensitivity performance of the MZM-based system when subjected to mechanical disturbances simulating real-world scenarios, such as a potential mine collapse.

Modulated light from the MZM source was injected into a standard G655 OFS single-mode fiber of 75 km. We selected G.655 non-zero dispersion-shifted fiber (NZDSF) for this study due to its lower dispersion slope and minimized nonlinear effects at the 1550 nm window, which is optimal for long-distance, high-speed transmission. Compared to G.652 (standard single-mode fiber), G.655 offers a more favorable balance between dispersion and nonlinearity management. This allows for extended reach and higher data rates with reduced inter-symbol interference and four-wave mixing — critical in maintaining signal quality over the 75 km test span. Key specifications of the G.655 OFS fiber used include; Dispersion: 4–6 ps/nm·km at 1550 nm, Attenuation: <0.22 dB/km and Polarization Mode Dispersion (PMD): $\leq$0.1 ps/$\sqrt{\text{km}}$. These properties make G.655 fibers highly suitable for both high-speed data transmission and sensing in scenarios where long reach and low distortion are essential — such as underground mine environments where fiber routing spans large areas and operates over extended durations without amplification.

To simulate strain conditions, incremental 2 kg weights were applied to the fiber at 10-s intervals, reaching a total of 18 kg. The input power from the MZM source was maintained at 0.49 dBm before applying any strain, as shown in Fig. 4. Upon reaching the full load, the output power dropped to 0.06 dBm, corresponding to a total power loss of 0.43 dB.

The strain sensitivity was calculated using Equation (1):

$$Sensitivity = \frac{\Delta Power}{Mass}\ (\text{dB / kg}) \qquad 1$$

Based on the measured power loss, the system exhibited a sensitivity of 0.024 dB/kg, indicating that the MZM-based configuration is capable of detecting subtle mechanical changes in the fiber with a high degree of resolution. This is particularly valuable in underground environments, where early detection of structural shifts is critical for safety and operational continuity.

In addition to power loss, State of Polarization (SOP) fluctuations were monitored using a polarization analyzer. Variations in the Stokes' parameters and Degree of Polarization (DOP) were recorded in real time during the loading process. These fluctuations correlated well with the applied mechanical strain, confirming the system's ability to respond to dynamic physical disturbances. The SOP analysis further reinforced the MZM source's suitability for dual-functionality: both high-fidelity data transmission and distributed strain sensing.

Fig. 5 illustrates the SOP fluctuation of the signal as it propagated through the G655 OFS fiber during the controlled application of strain. The SOP data was recorded throughout the mass-loading sequence and processed offline using MATLAB. Over a total sampling period of 120 s, the optical signal experienced an average SOP rotation of 613°, corresponding to an average SOP speed of 5.108°/s. This substantial and consistent shift in polarization state directly correlates with the applied strain, confirming the system's sensitivity to mechanical perturbations along the fiber path.

Also shown in Fig. 5 is the Poincaré sphere representation of the SOP evolution during the same strain/stress event. The trajectory of the polarization state on the sphere demonstrates a smooth and continuous shift as the mass was incrementally applied. This non-random polarization migration reflects the deterministic influence of mechanical strain/stress on fiber birefringence. The result confirms that SOP analysis offers a reliable means of detecting structural stress and complements power-based sensing by capturing additional dynamic behaviour of the optical signal.

While our laboratory setup primarily focused on mechanical strain, real-world mining environments present additional environmental factors such as electromagnetic interference (EMI), temperature gradients, humidity, dust, and ground vibrations, which may affect both the optical transmission and polarization stability.

Electromagnetic interference has minimal impact on the optical fiber itself, as fiber systems are inherently immune to EMI, giving them a significant advantage over copper-based communication lines in electrically noisy mining environments. However, extreme temperature gradients can alter the refractive index and birefringence of the fiber, resulting in SOP drift and minor power fluctuations. To address this, temperature-controlled enclosures or temperature compensation algorithms can be deployed alongside the polarization monitoring unit.

Humidity and dust may degrade connector interfaces or equipment housing over time but do not directly affect the optical signal within the fiber. Vibration, especially low-frequency seismic noise common in mines, can induce fast polarization variations. However, our system—through continuous SOP tracking on the Poincaré sphere—can detect such dynamic disturbances in real-time. This makes the configuration suitable for both communication and distributed sensing even under variable environmental stresses. Future deployment in live mining environments should include extended testing under coupled mechanical

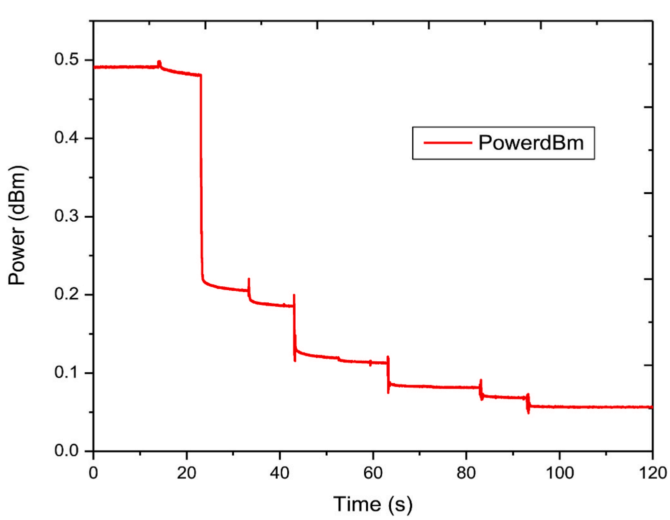

Fig. 4. Power fluctuation of light from an MZM source over a G655 OFS fiber.

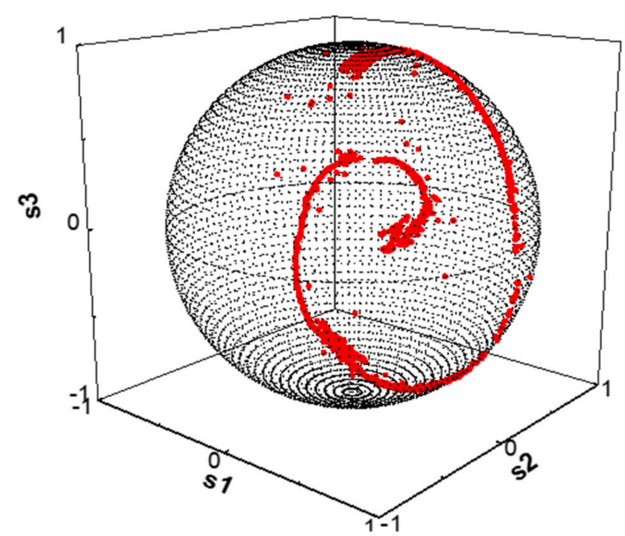

Fig. 5. Poincare' Sphere representation from a G655 OFS subjected to mass loading.

and thermal loads to fully characterize system resilience.

Together, these observations validate the dual-role capability of the MZM-based system: maintaining high-quality long-distance transmission while simultaneously acting as a strain-sensitive sensing platform. The pronounced SOP variation under controlled loading conditions reinforces the potential of this configuration for real-time structural health monitoring in environments such as deep mines, where early detection of mechanical shifts is critical for safety and operational continuity.

The results demonstrate that the MZM-based system delivers both extended communication reach and high sensitivity to strain-induced perturbations. Error-free transmission was achieved over 75 km with minimal power penalties, and mechanical loading produced detectable power loss and significant SOP rotation, with an average polarization change of 613° over 120 s. These findings underscore the system's practical utility for integrated data and safety monitoring in underground and industrial environments, offering a scalable, passive, and cost-efficient infrastructure solution.

This dual-purpose system offers the unique advantage of combining high-speed data communication with real-time monitoring of the fiber network's integrity, which is critical for detecting potential failures, structural issues, or safety hazards in mining environments. The proposed system represents a significant advancement in enhancing both communication reliability and safety assurance, thereby contributing to the overall efficiency and security of mining operations.

3.4. Modulation scaling and sensing accuracy

At present, our system was designed and tested using 10 Gbps NRZ modulation. Although advanced modulation formats such as 25 Gbps PAM4 can provide higher data throughput, they also impose increased bandwidth requirements and exhibit greater sensitivity to polarization-related noise, including state-of-polarization (SOP) fluctuations. Previous studies have shown that PAM4 modulation has a narrower signal-to-noise margin than NRZ, making it more susceptible to polarization mode dispersion (PMD) and SOP drift in long-haul links. As demonstrated in Ref. [23], PDM-PAM4 transmission over 80 km of standard single-mode fiber required adaptive equalization and polarization control to maintain acceptable BER performance, highlighting the increased complexity and sensitivity of PAM4 systems compared to NRZ. We anticipate that at higher data rates, maintaining both robust communication and accurate sensing will require additional signal processing or calibration to mitigate these effects. Exploratory tests showed that at higher data rates, the trade-off between communication performance and sensing sensitivity becomes more pronounced, indicating the need for further system optimization.

4. Conclusion

This work presents a novel dual-purpose fiber optic system capable of simultaneously supporting high-speed data transmission and real-time strain/stress sensing for mining safety applications. By employing a 1550 nm Mach-Zehnder Modulator (MZM) as the light source, the system successfully transmitted data at 10 Gbps over 75 km of single-mode fiber (SMF) while continuously monitoring both the power and state of polarization (SOP) of the optical signal. Among the tested sources, the MZM demonstrated superior transmission performance and reliability over extended distances, with minimal transmission penalties.

The system also exhibited high sensitivity to mechanical disturbances, making it suitable for detecting structural anomalies or potential failures in harsh mining environments. The integration of communication and sensing within a single optical infrastructure enhances both safety monitoring and operational efficiency, reducing the need for separate systems. These findings demonstrate the potential of polarization-based fiber sensing systems to significantly improve safety and connectivity in remote and underground industrial settings.

The inclusion of bi-directional capability via 1310 nm and 1550 nm channels further enhances the system's practical value, supporting full duplex data exchange essential for real-time monitoring, communication, and control in underground operations.

Future work may focus on integrating additional sensing modalities, automating anomaly detection, and deploying the system in live mining environments for comprehensive field validation.

CRediT authorship contribution statement

W.K. Nyarangi: Writing – original draft, Conceptualization. **E.K. Rotich Kipnoo:** Supervision, Conceptualization. **F.W. Wekesa:** Supervision, Conceptualization. **J. Jena:** Resources, Investigation, Funding acquisition. **D.W. Waswa:** Resources, Investigation, Funding acquisition.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We gratefully acknowledge the support of Nelson Mandela University (Centre for Broadband Communication) and the African Laser Centre (ALC), in collaboration with the University of Kabianga, for funding our research visit and facilitating the experimental work.

Data availability

Data will be made available on request.

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