# Customization Process for Polarization Maintaining Fiber Optic for Relay Protection G 654

## Overview

Polarization-maintaining fibers are specialty fibers with strong built-in birefringence, preserving the linear polarization of an input beam.

## Key Takeaways

The customization of G.654 polarization-maintaining fiber involves precise birefringence design, axis alignment, and coupling optimization to ensure stable polarization for high-precision relay protection systems.Core Principles of PM Fiber Customization

Birefringence Design: PM fibers achieve polarization stability by introducing strong birefringence through structural designs such as panda-type or bow-tie-type cores. This ensures that the propagation constants of the two orthogonal polarization states differ significantly, locking the polarization along a specific axis and minimizing polarization mode dispersion (PMD) caused by stress or temperature variations . For G.654 fibers, which are optimized for low attenuation and long-distance transmission, maintaining high birefringence is critical to preserve signal integrity over relay protection links. Mode Field Optimization: The mode field diameter (MFD) and numerical aperture (NA) are carefully selected to match the system requirements. For example, small mode field PM fibers can achieve splicing losses ≤0.22 dB, which is essential for high-sensitivity applications . The MFD must be compatible with the operating wavelength (typically around 1550 nm for G.654 fibers) to ensure single-mode propagation and minimal crosstalk.

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Axis Alignment and Coupling

Principal Axis Matching: During customization, the fast and slow axes of the PM fiber must be precisely aligned with the optical components or other fibers. Two common configurations are “principal axis parallel” or “principal axis cross,” depending on the system design . Misalignment can degrade polarization extinction ratio (PER) and reduce relay protection accuracy. Fused Coupler Integration: PM fused couplers are used to split or combine optical signals while preserving polarization. The coupling process relies on evanescent field interaction between fibers, and the high birefringence must be maintained to prevent random polarization rotation . This is particularly important in relay protection systems where phase-sensitive measurements are critical.

Environmental and System Considerations

Stress and Temperature Compensation: PM fibers are designed with anisotropic cores and stress elements to minimize the effects of external stress and temperature changes on polarization . For relay protection, this ensures that the optical signals remain stable under varying environmental conditions. Low PMD and High PER: G.654 PM fibers are customized to achieve PMD coefficients below 0.01 ps/√km and polarization extinction ratios above 30 dB, supporting ultra-long-distance transmission without signal degradation . This is essential for relay protection systems that require precise timing and phase information.

Testing and Validation

Splicing and Connectorization: Customized PM fibers undergo careful splicing and connectorization to maintain axis alignment. Losses are minimized through optimized waveguide structures and precise fusion techniques . Performance Verification: After assembly, the fiber is tested for PER, insertion loss, and PMD under simulated environmental conditions. This ensures that the fiber meets the stringent requirements of relay protection systems, including high-speed fault detection and signal integrity.

Summary

The customization process for G.654 polarization-maintaining fibers for relay protection involves:

• Designing strong birefringence structures to lock polarization.

• Optimizing mode field diameter and numerical aperture for low-loss single-mode propagation.

• Precisely aligning fast and slow axes during splicing and coupling.

• Integrating PM fused couplers while preserving polarization.

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• Compensating for environmental stress and temperature variations.

• Testing for PER, PMD, and insertion loss to ensure reliable relay protection performance. By following these steps, PM fibers can provide stable, high-precision optical signals essential for modern relay protection systems in power networks .

## Article Content

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