# ACCURATE DETERMINATION OF BRILLOUIN FREQUENCY IN BRILLOUIN DISTRIBUTED FIBER SENSORS USING CROSS RECURRENCE PLOT ANALYSIS

## IITM Technology Available for Licensing

### Problem Statement

- Conventional distributed Brillouin sensors face accuracy limitations due to very low signal-to-noise ratios (SNR), especially at the farther end of the sensing fiber.
- Standard methods like quadratic fitting are error-prone with low SNR signals, leading to inaccuracies in Brillouin frequency shift (BFS) estimation.
- Existing techniques need enhancement to accurately measure BFS over long distances with low SNR, with cross-correlation methods showing promise for improving measurement accuracy.

### Intellectual Property

- IITM IDF Ref. **1545**
- **IN 379844 - Patent Granted**

### TRL (Technology Readiness Level)

**TRL - 5: Technology validated in relevant environment.**

### Technology Category/ Market

**Category - Fiber Optic Sensing**
**Applications** - Structural Health Monitoring, Power Grid & Geotechnical Monitoring
**Industry- Telecommunications, Energy and Utilities, structural monitoring**

**Market -** Global Fiber Optic Sensors Market to Reach $605.4 Million by 2032 with a **CAGR of 6.2%**

### Research Lab

**Prof. Balaji Srinivasan,**
Dept. of Electrical Engineering, IITM

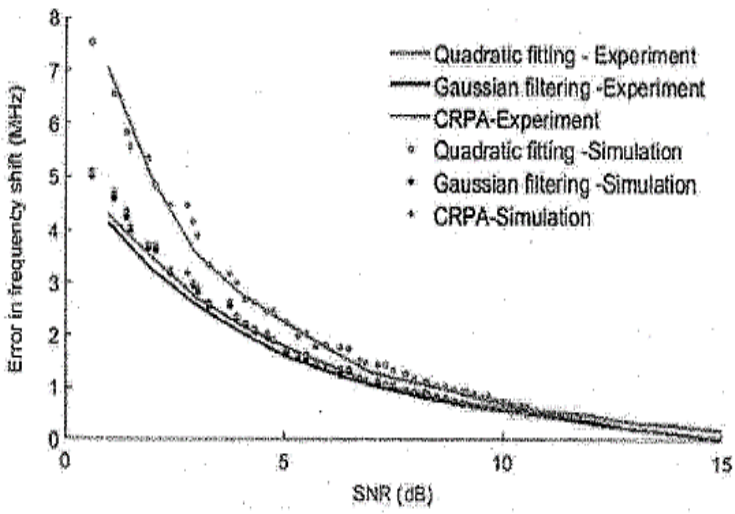


**FIG. 1. illustrates the error in Brillouin frequency estimation as a function of SNR.**

### Technology

1. **Brillouin Scattering and Frequency Shift Measurement**: The process involves initiating Brillouin scattering in an optical fiber by propagating an intense optical signal, generating backscattered light with a frequency shift indicative of local acoustic velocity.
2. **Cross Recurrence Plot Analysis (CRPA)**: The method uses CRPA to compute the Brillouin frequency at various locations along the sensing fiber by comparing a reference spectrum (Lorentzian, Gaussian, or Voigt lineshape) with the measured spectrum. This technique enhances the accuracy of frequency measurement even with low signal-to-noise ratios (SNR <10 dB).
3. **Enhanced Measurement Accuracy**: The process is designed to work effectively with distorted Brillouin gain spectra and uses frequency steps greater than 1 MHz.

**CONTACT US**
**Dr. Dara Ajay, Head TTO**
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

**IITM TTO Website**:
https://ipm.icsr.in/ipm/

**Email**: smipm-icsr@icsrpis.iitm.ac.in
sm-marketing@imail.iitm.ac.in
**Phone**: +91-44-2257 9756/ 9719

## Key Features / Value Proposition

### 1. Enhanced Accuracy

- Utilizes Cross Recurrence Plot Analysis (CRPA) to accurately measure Brillouin frequency shifts, improving precision even in low signal-to-noise ratio conditions.

### 2. High Sensitivity

- Capable of detecting small changes in temperature and strain with high sensitivity by analyzing the Brillouin gain spectrum.

### 3. Robust Performance

- Effective in environments with distorted Brillouin gain spectra, maintaining reliable measurements under challenging conditions.

### 4. Flexible Spectrum Analysis

- Supports various reference spectrum types (Lorentzian, Gaussian, Voigt), providing versatility in different sensing applications.

### 5. Large-Scale Monitoring:

- Suitable for distributed sensing along extensive optical fiber lengths, enabling comprehensive monitoring of large infrastructures.

### 6. Advanced Data Processing

- Employs advanced signal processing techniques to handle low SNR measurements, enhancing the overall performance and accuracy of Brillouin distributed sensors.

**CONTACT US**
**Dr. Dara Ajay, Head TTO**
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

**IITM TTO Website**:
https://ipm.icsr.in/ipm/

**Email**: smipm-icsr@icsrpis.iitm.ac.in
sm-marketing@imail.iitm.ac.in
**Phone**: +91-44-2257 9756/ 9719