FIBER OPTIC SENSOR SYSTEM FOR INTRUSION LOCATION DETECTION BASED ON SAGNAC INTERFEROMETER

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ABSTRACT: In this paper, a simple novel sensor system based on a Sagnac interferometer is presented. The system consists of a dual Sagnac interferometer, where the larger interferometer is longer for the fiber delay line (L_D). A low coherence source (SLD) is modulated using pulse modulation. By exerting pressure on the fiber at a specific location, a small phase shift occurs. By observing the ratio of the electrical signals obtained by subtraction of the currents of photodetectors PD1 and PD2 the precise location of intrusion can be determined.

MEASURMENT SETUP

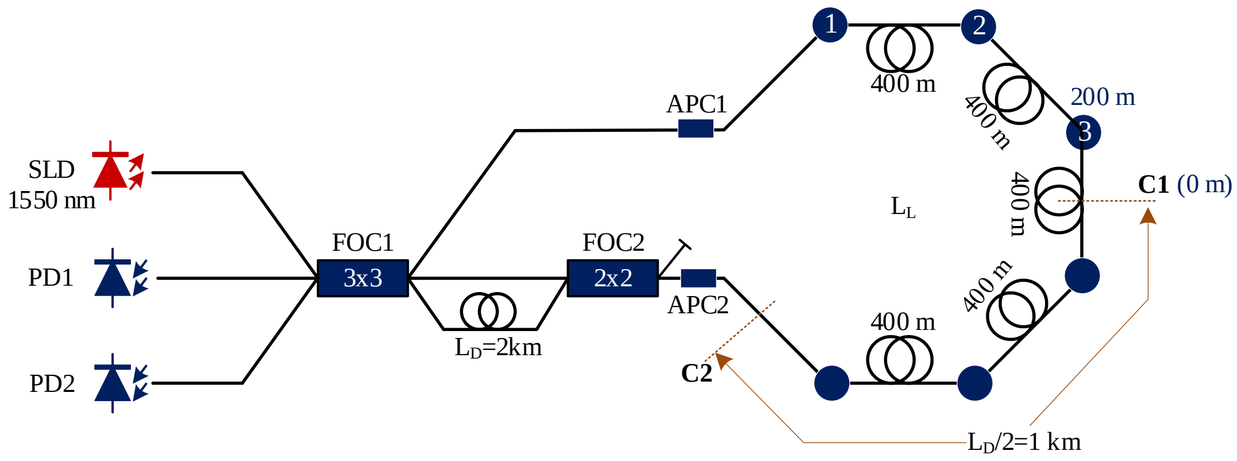

Fig.1. Experimental setup of a double Sanjak interferometer

- SLD (1550 nm) is pulse modulated using signal generator
- Metal plates with vibrating motors are placed at the measuring points
- Vibrating motors are switched on sequentially and the system response is recorded
- Signals from the photodiodes are further processed in the LabVIEW software package

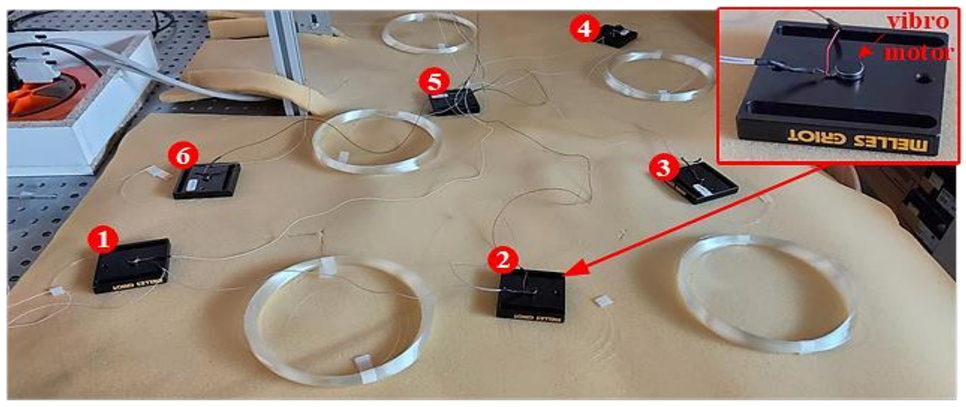

Fig.2. Experimental setup in the laboratory

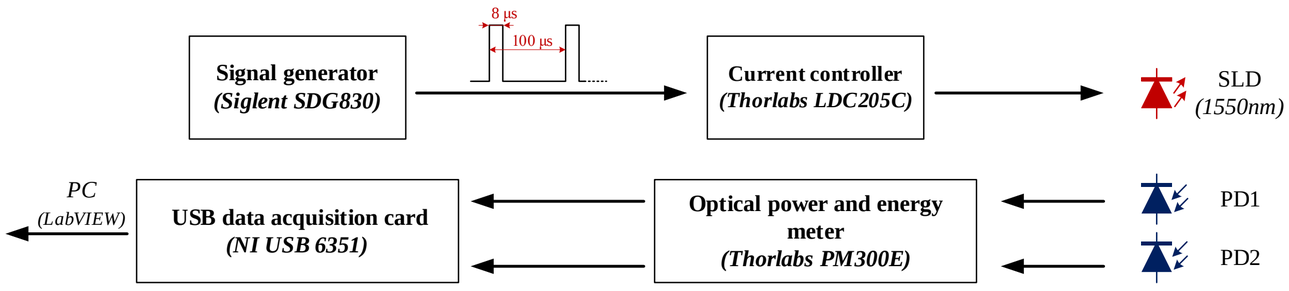

Fig.3. The method of modulation of an SLD and data acquisition from photodiodes

ANALYSIS

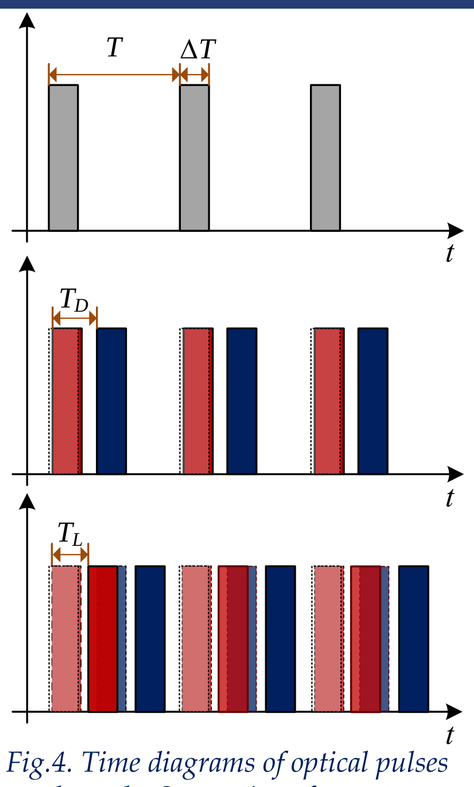

Fig.4. Time diagrams of optical pulses along the Sagnac interferometer

- In Fig.4. pulses that propagate through the shorter branch (SLP) between FOC1 and FOC2 are marked in red, while the pulses that propagate through the longer branch (LLP) (with length L_D) are marked in blue
- The first diagram (Fig.4.) represents the time diagram of optical pulses emitted by SLD, the second diagram shows light pulses at the output of FOC2, while in the third pulses at the input of FOC1 are shown
- The condition for implementing time multiplexing is $\Delta T < T_D$

$$T_L = \frac{nL_L}{c} \qquad T_D = \frac{nL_D}{c}$$

$$s_1(t) = i_{PD1}(t) - i_{PD2}(t)$$

$$s_2(t) = i_{PD1}(t + T_D) - i_{PD2}(t + T_D)$$

$$S = \frac{s_1(t)}{s_2(t)} \approx K \frac{z}{z + \frac{L_D}{2}}$$

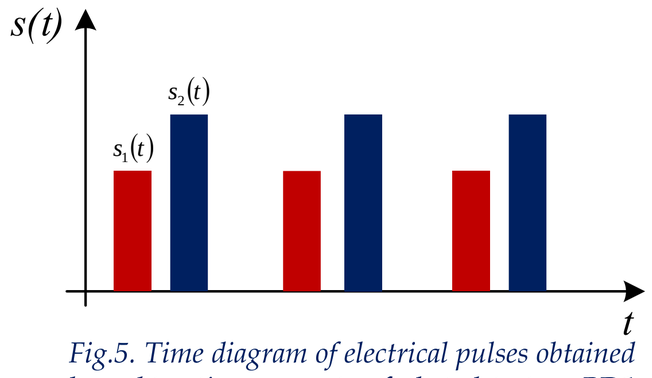

Fig.5. Time diagram of electrical pulses obtained by subtracting currents of photodetectors PD1 and PD2

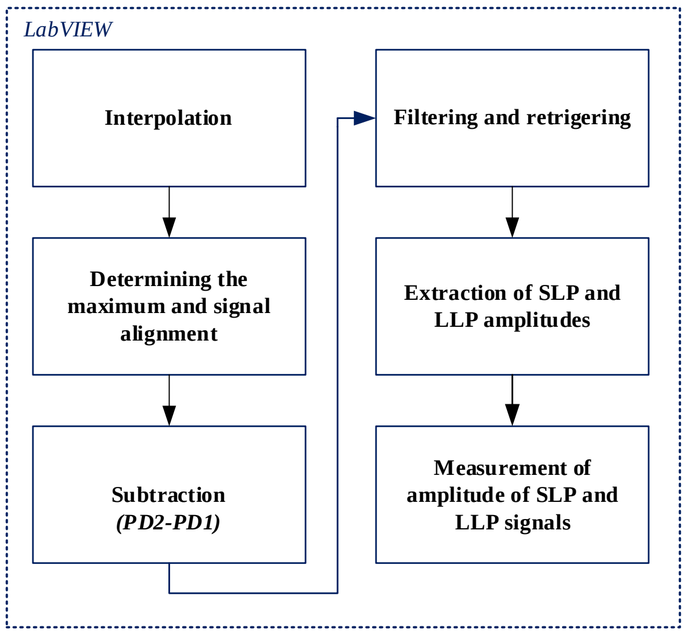

Fig.6. Computer signal processing algorithm (LabVIEW)

MEASURMENT RESULTS

- Vibrational motors are used for testing, frequency 200-250Hz
- Dependance of the system response on the frequency of intrusion (motor vibration) is not significant (except at very low frequencies when due to small amplitudes, signals can not be measured reliably)
- System responce is highly dependent on optical fiber orientation, bending and load
- The results show excellent match with the expected results derrived by theoretical analysis

Meas. point	z[m]	SLP		LLP		A_{SLP}/A_{LLP}
		F[Hz]	A[mV]	F[Hz]	A[mV]	
1	1000	229.9	200.5	229.9	297.7	0.673364
2	600	233.3	119.7	233.3	233.2	0.513112
3	200	203.1	37.6	203.1	137.5	0.273097

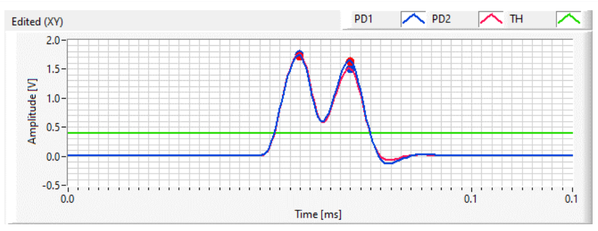

Fig.6. The shape of the raw signals of the photodiodes

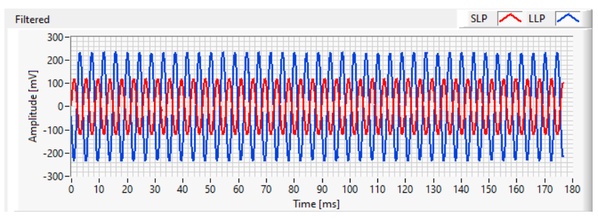

Fig.7. Signals after filtration and processing

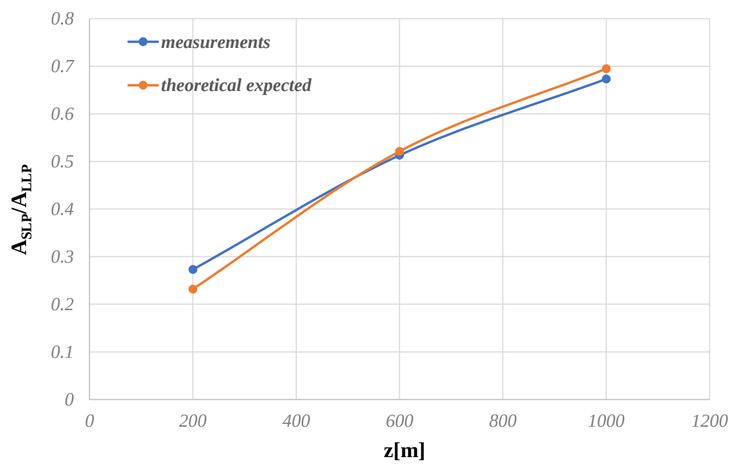

Fig.8. Measurment results for three measurement points

CONCLUSION: A simple novel sensor system based on a Sagnac interferometer is tested. The ratio of the electrical signals obtained by subtraction of the currents of photodetectors PD1 and PD2 was observed. The results obtained by measurement did not deviate significantly from the expected, derived by the theoretical analysis. During the measurements dependence of the output signals on bending, twisting and moving of the fiber was observed. The twisting and bending of the fiber influence the polarization, which may disturb the operation of the Sagnac interferometer. In further research dependence of the measurement on the polarisation of the light and elimination of the polarisation will be examined.

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