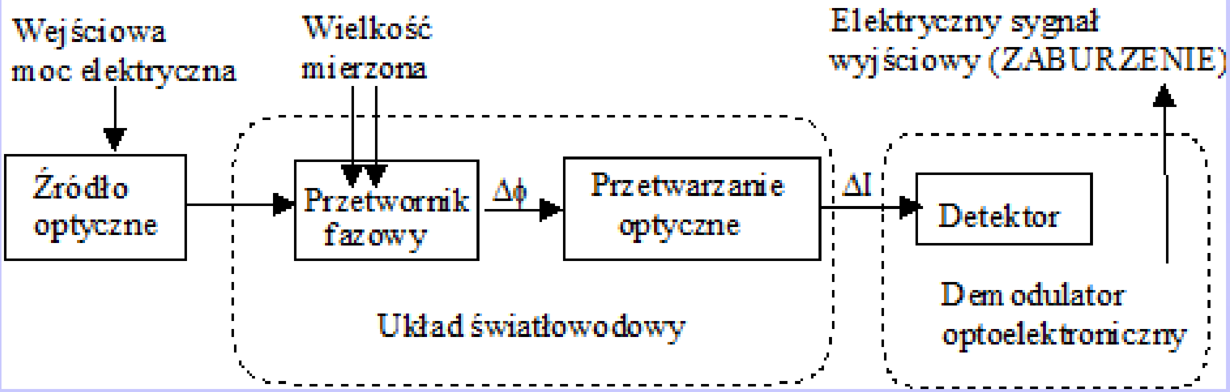
Optical fiber interferometry

- Signal processing
    - electronic considerations

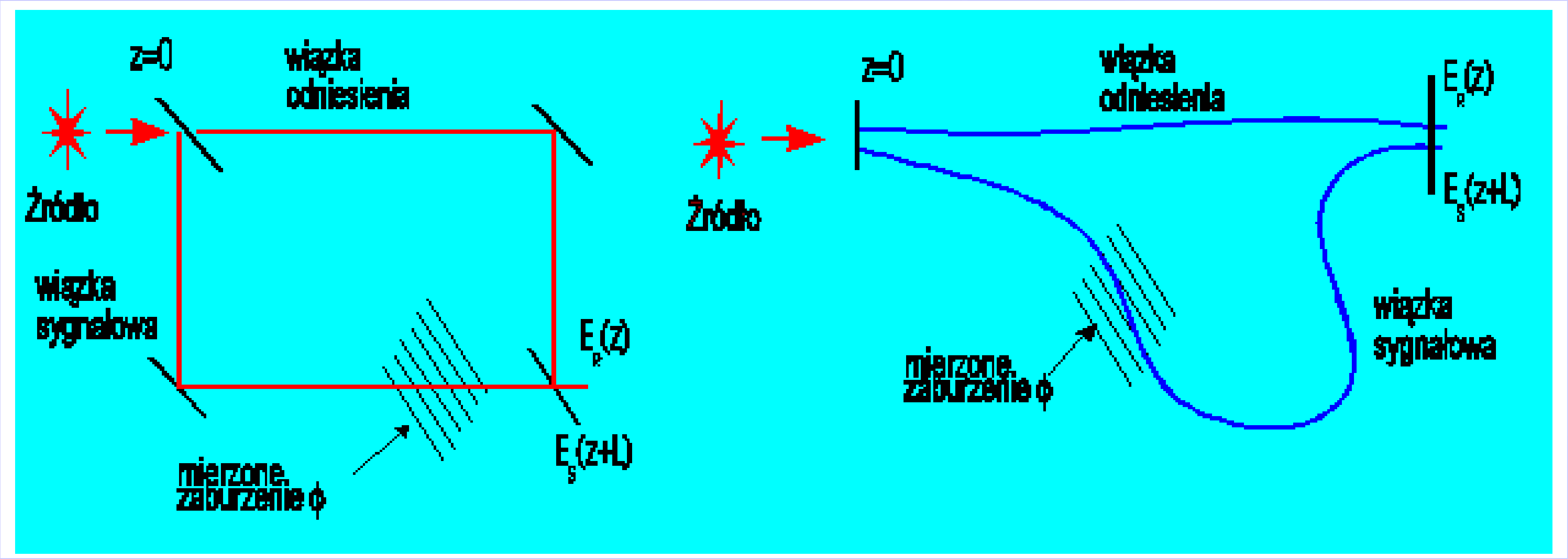
Introduction

They are a new sensor class, where general principle of operation based on chenges by measurand the optical way or polarization properties of optical fiber. Such sensors are named *intrinsic* or *phase* sensors.



For optical fiber, optical processing technique which process phase information on intensity information (ΔI), is called *optical-fber intereferometer*. It is a simple fiber-optic device allows observation of a interference between two or more optical beams.

Fiber optic interfereometers are equivalents all well-known optical bulk interfereometers, where light is closed in structure of single-mode or polarization preserving optical fiber.



Transfer function:

$$I = I'\{1 + V(\gamma)\cos[\phi - \alpha(\gamma)]\}$$

bulk system

$$I = I'\{1 + V(\gamma, SOP)\cos[\phi - \alpha(\gamma, SOP)]\}$$

fiber-optic system

Electronic considerations

Transfer function:

$$I_1 = I_0 \left[1 - V\cos(\phi_a - \phi_b)\right]$$

Thus interferometer measures only relative phase delay between two arms instead of absolute phase delay.

The general problem of signal processing is recognize that part of phase changes which is correlated with measurand when exist different noise sources.

It is convenient to separate the measurand phase into a total contribution from noise sources (ϕ_d) and from a signal ($\phi_s \sin\omega_s t$).

$$\phi_a - \phi_b = \phi_d + \phi_s \sin\omega_s t$$

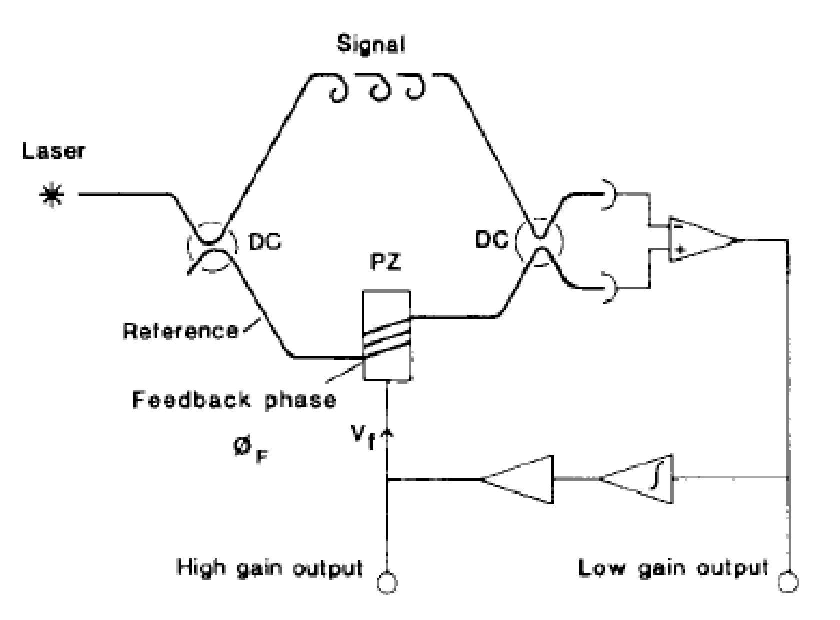
The photocurrent:

$$I_D = I_{OD}\left[1 + V\cos(\phi_d + \phi_s \sin\omega_s t)\right]$$

The frequency spectrum of the signal:

$$\cos(\phi_d + \phi_s \sin\omega_s t) = \cos\phi_d\left\{J_0(\phi_s) + 2\sum_{i=1}^{\infty} J_{2i}(\phi_s)\cos(2i\omega_s t)\right\} - \sin\phi_d\left\{2\sum_{i=0}^{\infty} J_{2i+1}(\phi_s)\sin[(2i+1)\omega_s t]\right\}$$

Because sensitivity depends from noise term ϕ_d the more sophisticated recovery technique must be applied for produce a useful signal.



Active homodyne technique

This scheme uses servo-element for taking interferometer in constant point of work i.e. (ϕ_d) = const. np. $\pi/2$ (work in quadrature)

Pasive homodyne technique

This scheme needs configuration with two output where exist constat phase difference – the best equal to $2\pi/3$ radian. For example system with 3x3 output coupler or polarymetr with quaterwave plate:

$$I_{D1} \propto \cos[\phi_d + \phi_s \sin\omega_s t] \qquad I_{D2} \propto \sin[\phi_d + \phi_s \sin\omega_s t]$$

After applaying low-band filter

$$I_{D1} \propto \sin\phi_d J_1(\phi_s)\sin\omega_s t \qquad I_{D2} \propto \cos\phi_d J_1(\phi_s)\sin\omega_s t$$

After multiple and suming;

$$S \propto J_1(\phi_s)\sin\omega_s t \propto \phi_s \sin\omega_s t \qquad (\phi_s \ll 1)$$

Heterodyne techniques

Heterodyne processing protecs linear system response with infinite tracking range. *Heterodyne* means that the optical frequencies in the interferometer arms are unequal, and this is conventionally achieved using a frequency modulator such as a Bragg cell. Output takes the form

$$I_D \propto \cos(\omega_0 t + \phi_d + \phi_s \sin\omega_s t)$$

The output is thus a phase-modulated heterodyne carrier. The demdulation of such a siganl is a familiar electronic problem, and a number of techniques are established for its solution.