Photonics laboratory
Physics 472
Spring 2024

Experiment#9 Fiber Optic Sensors

Proximity Sensor

Some fiber sensors make use of Lowe-technology fiber bundles. An example of a proximity sensor which uses a bifurcated (Y-branched) fiber bundle is shown in the figure. Optical power, which, in this case, can be from a white-light source, is launched in one arm of the fiber bundle. It is reflected from a surface at the output end of the fiber, and part of that reflected light is accepted by the second arm of the bundle and is transmitted to a detector. The amount of light returned to the detector depends on the distance between the end of the bundle and the surface being monitored.

Microbend Displacement Sensor

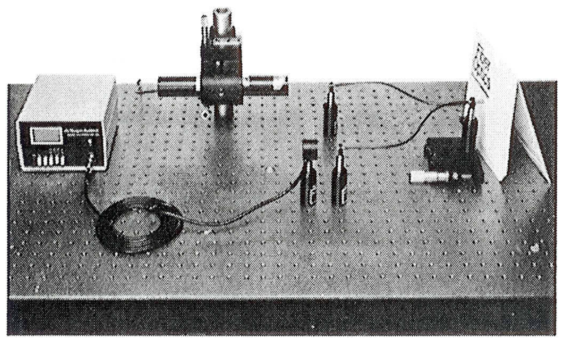
Internal effect sensors make use of modulation schemes which perturb the fiber itself, so that the fiber is both the transmission medium and the transducer. The modulation effects which may be used in these sensors includes the *microbending loss mechanism*, the "**fiberdyne**" modal intensity modulation effect, in which mode filtering is used to detect redistribution of the optical power due to mode coupling caused by mechanical deformation of the fiber, and internally generated thermal radiation.

As an example of the sensors which can be designed, is a ***displacement sensor*** which makes use of the *microbending phenomenon* as shown in the figure. Optical power is coupled from guided modes to the cladding when the fiber is bent. The displacement sensor has a fiber placed between two corrugated plates and the optical loss is measured as a function of the displacement of the two corrugated plates with respect to each other. The examples of multimode fiber optic intensity sensors which have been discussed here are, of course, only a small part of the large number of fiber optic sensors which have been investigated or developed.

EXPERMENTS

Task#1: Proximity Sensor

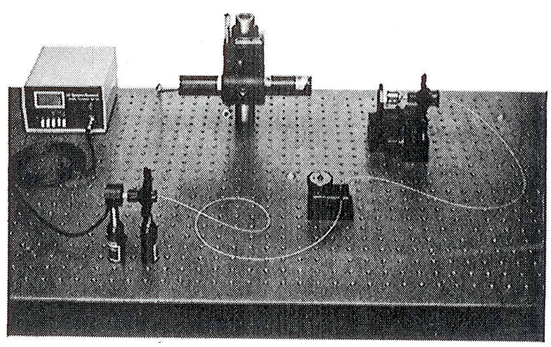
1. Fix the 777-1 dual fiber bundle into the collar as shown in the figure. Gently tighten each set screw. Do not over tighten.
2. Illuminate one end of the dual fiber bundle with a HeNe laser. This sensor can also be constructed using a white-light source if you have a high-power lamp which can be focused onto the end of the fiber bundle.



3. Place the post with the common end of the fiber bundle into this holder and fix it to translation stage and. Set up a card so that the HeNe output of the fiber bundle shines on the card or mount the translation stage so that the output shines on a wall. In either case, the fiber bundle needs to be mounted so that it is able to actually make contact with the surface to be measured.
4. Light reflected by the surface being monitored will be reflected back into the fiber bundle and will go to the second single end. Mount this end in a post holder and couple the output light onto the detector of the Power Meter.
5. Measure the reflected output as a function of distance, d, of the surface of the common end of the bifurcated fiber bundle from the monitored surface. Also plot this power as a function of $1/d^2$.
6. Find the point where a linear $1/d^2$ dependence begins. This is the distance at which the finite diameter of the fiber core is no longer significant in determining the amount of reflected light accepted by the fiber bundle. Why does the amount of reflected power accepted by the fiber bundle drop from a maximum as you get very close to the surface? (**Hint**: Draw the light cone from the fiber bundle incident on the surface being monitored and the cone of acceptance of the neighboring fiber which detects the light. Vary the distance between the fiber end faces and the reflecting surface.)
7. Estimate the positional resolution of this sensor.

Task#2: Microbend Displacement Sensor

1. We can use the mode scrambler as an example of a displacement sensor. Rotate the knob on the scrambler to fully separate the corrugated surfaces.
2. Launch light into a segment of Multimode fiber using the He-Ne laser and the F-916 coupler. The laboratory set-up for this sensor is shown in the figure.



3. Place the jacketed fiber in the slot between the corrugated surfaces the rotate the knob until the corrugated surfaces just contact the fiber. Note the knob position. *Each major graduation on the knob represents a 25-micron displacement; the smaller graduations mark 12.5-micron displacements*.
4. Record the output from the fiber as a function of displacement. The fiber has a soft buffer, so some period of stabilization may be needed after you set the displacement for the transmitted power to come to equilibrium. In an actual sensor system, the knob-controlled displacement would be replaced by having the corrugated surfaces attached to two surfaces whose relative position is to be measured.