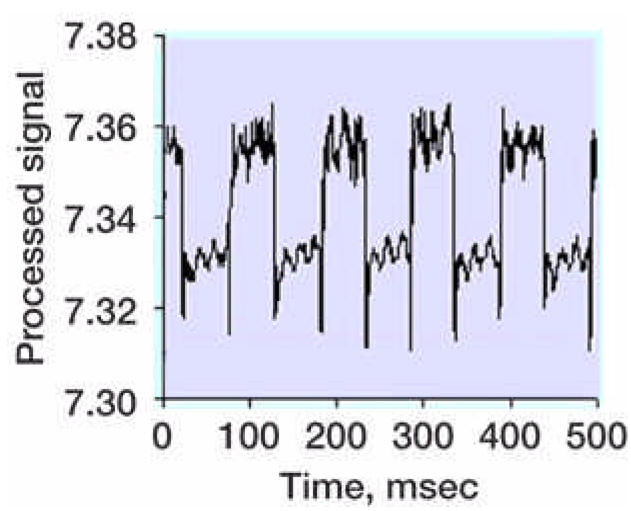
Fiber-Optic Pressure Sensor With Dynamic Demodulation Developed

Researchers at the NASA Glenn Research Center developed in-house a method to detect pressure fluctuations using a fiber-optic sensor and dynamic signal processing. This work was in support of the Intelligent Systems Controls and Operations project under NASA's Information Technology Base Research Program.

We constructed an optical pressure sensor by attaching a fiber-optic Bragg grating to a flexible membrane and then adhering the membrane to one end of a small cylinder. The other end of the cylinder was left open and exposed to pressure variations from a pulsed air jet. These pressure variations flexed the membrane, inducing a strain in the fiber-optic grating. This strain was read out optically with a dynamic spectrometer to record changes in the wavelength of light reflected from the grating.

The dynamic spectrometer was built in-house to detect very small wavelength shifts induced by the pressure fluctuations. The spectrometer is an unbalanced interferometer specifically designed for maximum sensitivity to wavelength shifts. An optimum path-length difference, which was determined empirically, resulted in a 14-percent sensitivity improvement over theoretically predicted path-length differences. This difference is suspected to be from uncertainty about the spectral power difference of the signal reflected from the Bragg grating.

The figure shows the output of the dynamic spectrometer as the sensor was exposed to a nominally 2-kPa peak-to-peak square-wave pressure fluctuation. Good tracking, sensitivity, and signal-to-noise ratios are evident even though the sensor was constructed as a proof-of-concept and was not optimized in any way. Therefore the fiber-optic Bragg grating, which is normally considered a good candidate as a strain or temperature sensor, also has been shown to be a good candidate for a dynamic pressure sensor.



Fiber-optic Bragg grating responds well to pressure fluctuations.

Long description Strip chart recording of the output of the Bragg sensor shows a square-wave signal that varies from about 7.32 to 7.36 in arbitrary units along the vertical axis. About 5 cycles are shown along the 500 milliseconds-long horizontal axis.

This optical pressure sensor has been examined for aerospace applications because of the advantages of using fiber optics over traditional cabling. The replacement of copper cabling by optical fibers can reduce weight, both because glass weighs less than copper and because optical signals can be more highly multiplexed than electrical signals. Also, because they operate using light rather than electrical signals, they are not susceptible to electromagnetic interference and do not pose a sparking hazard.

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