1987

Fiber-optic interferometric geophone with hydrophone applications

Gardner, D.L.

OSA/OFC

OFC./IDOT '87
http://hdl.handle.net/10945/47214

TUI5 Fiber-optic interferometric geophone with hydrophone applications

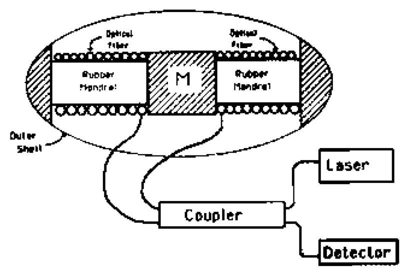
D. L. GARDNER, R. K. YARBER, E. F. CAROME, S. L. GARRETT, Naval Postgraduate School, Physics Department, Monterey, CA 93943.

A fiber-optic interferometric geophone has been developed which consists of a seismic mass (520 g) supported by two rubber mandrels wound with a single layer of single-mode optical fiber. The mandrels act as the springs as shown schematically in Fig. 1. The two mandrel-wound lengths of optical fiber, each 6.5 m long, with reflecting ends are attached to a coupler to form the two legs in a Michelson interferometer. When the case of the sensor is displaced at frequencies above the mass-spring resonance frequency (i.e., in the mass controlled frequency regime), the mass remains approximately at rest, while the fiber around one mandrel is compressed and the other is expanded. This geometry has the advantage of not requiring a reference leg and providing 4 times the sensitivity of a single sensor by its push-pull operation and the fact that the light traverses each leg twice due to reflection. Sensitivities of 7500 rad/μm have been measured at frequencies above the mass-spring resonance.

When the geophone is enclosed in a neutrally buoyant case, the sensor motion is the same as the acoustically induced oscillations of the fluid medium in which it is immersed creating a fiber-optic bidirectional hydrophone similar to a pressure-gradient hydrophone.[1] In addition to increased sensitivity, the neutrally buoyant geophone configuration has several advantages over previous fiber-optic pressure gradient/accelerometer configurations.[2,3] The pressure-gradient hydrophone has a sensitivity which increases linearly with increasing frequency (i.e., +6 dB/oct). This leads to aliasing problems if the hydrophone is part of an array which is sampled in time and, of course, reduces the effectiveness in detecting low-frequency sources. The geophone has a sensitivity which increases linearly with decreasing frequency, since, for fixed pressure or velocity amplitude, the fluid particle displacement must increase with decreasing frequency. Additionally, if the demodulator measures fringe rate, the geophone output is proportional to velocity so it can be summed directly with an omnidirectional pressure hydrophone to produce a cardioid beam pattern.

Data accumulated to date with a prototype sensor indicate a sensitivity of 7500 rad/μm above resonance. This corresponds to a displacement amplification factor (optical lever) of ~2100. As the geophone design parameters become better understood, further increases in sensitivity are expected along with lower operating frequencies. **(12 min)**

1. G. B. Mills, S. L. Garrett, and E. F. Carome, "Fiber Optic Gradient Hydrophone," Proc. Soc. Photo-Opt. Instrum. Eng. **478**, 98 (1984).
2. C. M. Davis, "Fiber Optic Sensors: an Overview," Opt. Eng. **24**, 347 (1985).'
3. G. E. MacDonald, "Fiber Optic Gradient Hydrophone Construction and Calibration for Sea Trial," Master's Thesis, Naval Postgraduate School, Monterey, CA. (1984) (DTIC Report AD A 156 469).



TUI5 Fig. 1. Schematic diagram of Michelson interferometric fiber-optic geophone in a neutrally buoyant case for hydrophone application.

NOTES