A NEW VERTICAL SEISMOMETER BASED ON THE MOIRE TECHNIQUE

Shamseddin ESMAEILI
Seismological Research Center, IIEES, Tehran, Iran
s.esmaeili@iiees.ac.ir

Anooshiravan ANSARI
Seismological Research Center, IIEES, Tehran, Iran
a.ansari@iiees.ac.ir

Hossein HAMZEHLOO
Seismological Research Center, IIEES, Tehran, Iran
hhamzehloo@iiees.ac.ir

Keywords: Seismometer, Moire Technique, Light Detector, Diode Laser

This paper describes a new optical seismic sensor for geophysical applications. Following the work done at Institute Advance studies in Basic sciences in Zanjan, we have built a new vertical short period seismometer based on the Moiré technique. This seismometer consisting of a spring-suspended mass whose position is monitored using the moiré technique. The Moiré technique has many applications in the measurement of very small displacements and light beam deflections. Moiré technique is based on the interference obtained when two transparent plates such as tow gratings are covered with equally period. If one of the plates is held over one another, they can be aligned so that no light will pass through or so that all light will pass through. Now, if one of the plates is placed over the other, and their lines have a small angle together, appear a new periodic structure that called Moiré pattern (Figure 1a). The dark and bright regions are called fringes. The period of Moiré fringes (d_m) is larger than the period of gratings (d). Therefore the use of Moiré technique magnifies the small displacements.

However, we used the springs of a commercial geophone (SE-10) to build our oscillation system that has a natural frequency of 8 Hz. Also, to make Moiré pattern we use a pair of similar gratings that one of them is fixed to the suspended mass and another one is fixed to the seismometer frame. The gratings are installed near together without any physical contact, which the planes of the gratings are parallel together and the lines of gratings have small angle (less than 6^o) respect together.

Due to a typical impulse, the gratings displace respect to each other, and as a result the Moiré fringes are moved with a magnification of more than ten times. To detect and record of fringes movements or finally seismic pulses we used a diode laser (5 mW) was placed in front of one of the gratings, and a light-detector faced the laser source from the opposite side. Also, a narrow vertical slit was placed in front of the detector to narrow the light beam. The diode, the detector, and the slit were all fixed to the instrument frame. The diode laser beam passes through the Moiré pattern then the narrow slit and finally detect by the light sensor.

Due to a seismic pulse received by our sensor, the moiré fringes pass through the laser light and the intensity of the light on detector varies as a result. The detector records these variations as a time series. The output of the light detector is electric voltage, with amplitude proportional to the amplitude of ground motion. As we know, the damping in seismometer is very important to detect seismic pulses. Our damping system is based on viscose oil. The damping factor is 0.65. Also, a 12 bit A/D device is used to digit the analog responses of optical seismometer. Our seismometer is shown in Figure 1b.

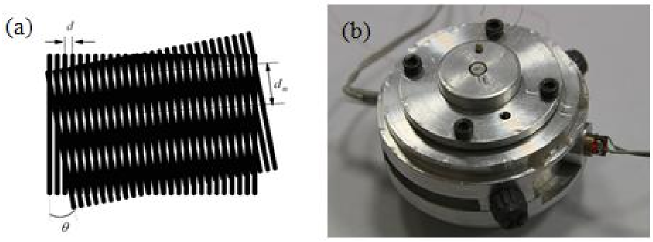

Figure 1. a) Moir é pattern obtained by superposition two gratings. b) Optical short period seismometer

We carried out an experiment to investigate the performance of our optical seismometer. We subjected our seismometer (8 Hz) and a calibrated commercial seismometer (6TD Guralp, 0.1 Hz) to identical impulses and comparison their responses. Figure 2 shows the both response of optical and 6TD seismometer to some impulses in a real and similar condition. As we can see, our sensor response has a good agreement with 6TD response. Also, the power spectrum of both responses is shown in Figure 3.

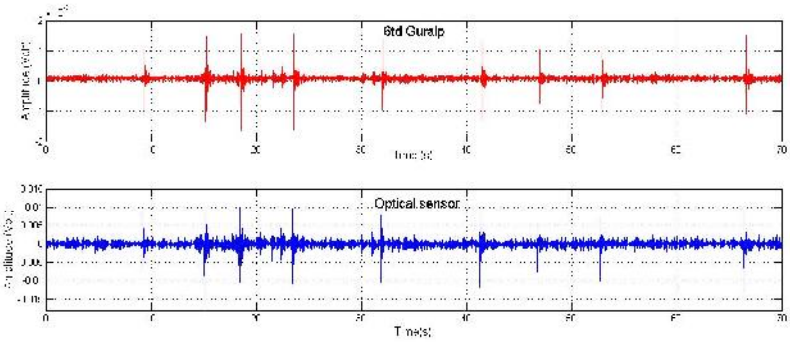

Figure 2. The output of optical seismometer (8 Hz) and 6TD Guralp (0.1 Hz) in similar conditions

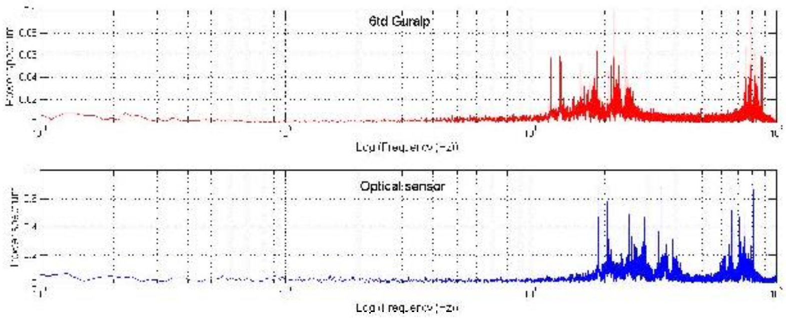

Figure 3. The power spectrum of optical and 6TD seismometers

Comparisons with conventional seismometers show that, in terms of both noise and signal fidelity, the optical approach is quite viable. Also, our sensor has some additional advantages. Optical sensor free of EM noise, the output can be easily regulated by altering the period and the angle of the gratings or the intensity of the light source. Our instrument is easier to install, and insensitive to environmental conditions such as temperature fluctuations. Also, in the moiré detecting system, we can vary the sensitivity to detect the displacement by varying the gratings period, the angle between the rulings of the gratings. We can also, enhance the output of detector by enhancing the power of light source and enhancing the proportion of signal to noise.

REFERENCES

Amidror I (2000) The Theory of moiré phenomenon, *Kluwer Academic Publishers*, Netherlands

Esmaeili S, Rasouli S, Sobouti F and Esmaeili S (2012) Moiré micro strain gauge (MMSG), *Optics Communications*, 16804: No of Pages 3

Patorski K (1993) Handbook of the Moiré fringe technique, *Elsevier*, Amsterdam