# Geophone element testing

Malcolm B. Bertram and Eric V. Gallant


## ABSTRACT

A new system incorporating a laser interferometer for measuring geophone element characteristics is being developed. The purpose is to determine absolute measurements of linearity, distortion and phase for elements of different frequency, manufacture and orientation. This apparatus will also be used to measure the coupling of the elements in the auto-orienting sensor now in the process of being patented.


## INTRODUCTION

With the advance in resolution of seismic acquisition instrumentation in the last few years, there has been a demand for geophone improvement to complement the 24 bit systems. To meet this requirement, all the geophone manufacturers have brought out new products designed for 24 bit compatibility. In some cases, this has been accomplished by tighter tolerance in the manufacturing process, and in other cases there has been a complete redesign of the element - for example using rare earth magnets. The purpose of this paper is to present a new method of testing these geophones to determine whether they do in fact meet the expected specifications.

## TESTING METHODS

Currently geophone manufacturers use a current pulse applied to the coil to test elements for frequency and freedom of motion. This is followed by the application of a very low distortion sinusoidal current which drives the element over a known displacement. The voltage across the coil is sampled and used to calculate the distortion parameters. With careful design and application this method can indeed provide good quality information on the element under test. The use of a shaker table for element testing has been relegated to coarse measurements only, and as a quality control system for strings of geophones. Because of the extremely high resolution required to test "24 bit" geophones it is not possible to drive a mechanical shaker table with sufficient linearity to produce the necessary accuracy.

The method of testing geophones presented here does in fact use a shaker table, but the drive applied to the table does not require particularly high fidelity. Instead the actual movement of the element case is tracked by a laser interferometer which provides a positional accuracy of 84 nanometers. This output is compared with the electrical output from the element under test, which will be captured using a 24 bit Analog to Digital converter as is common in the seismic industry. For the first pass however, the signal will be acquired using a digital oscilloscope. The actual distortion, linearity and phase can then be measured for a range of different input displacements and frequencies. The table drive can also superimpose a high frequency low amplitude signal on a low frequency high amplitude signal to test the coil response at different physical displacements, simulating the signal-under-groundroll problem.

Measurements will be made on a representative sample of elements in a new condition, then after "aging" to represent field use. Testing will include consistency between elements, and changes in measured parameters after several stages of aging.

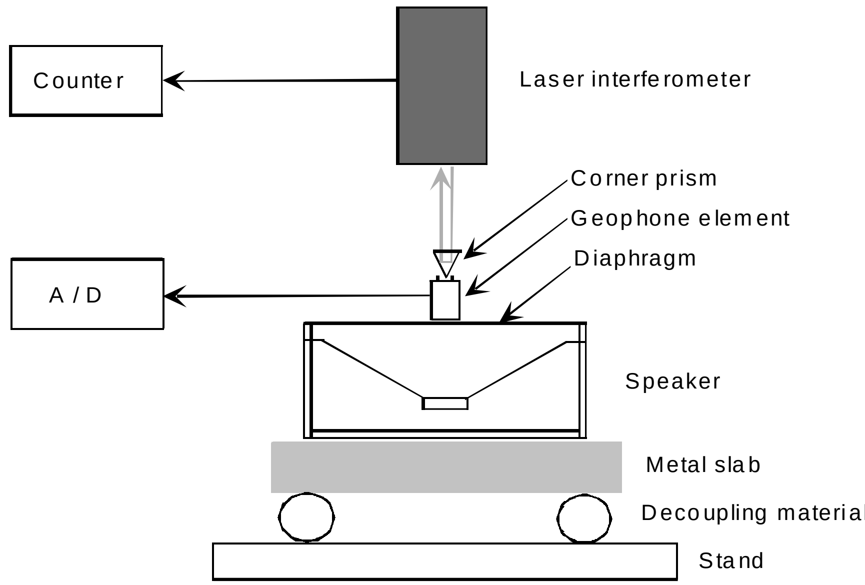


Fig 1. Diagram of the testing equipment setup

## SYSTEM DESIGN

The main element of the shaker table is a 15 inch speaker which will provide drive down to frequencies well below 1 Hz. This is driven by a 50 watt power amplifier fed from a signal source. The signal source is either a signal generator or a PC card which can provide a synthetic waveform of any desired shape. The speaker is mounted in a solid box with a thin diaphragm suspended about 1 cm above the outer frame of the speaker. The space between the speaker cone and the diaphragm is sealed to provide pneumatic coupling to the diaphragm, while removing the weight of the parts being tested from the speaker cone itself. (Figure 1)

The laser interferometer is mounted above the centre of the diaphragm by means of a frame which decouples the interferometer from ambient vibration. This means that the interferometer output will include this ambient motion, which will produce some output from the element under test in combination with the speaker drive. Without this decoupling the signal generated by the element as a result of the ambient noise would effect the measurement of distortion and linearity.

To reduce this ambient noise as much as possible, the whole system is mounted on a solid inertial plate decoupled from the supporting table.

## LASER INTERFEROMETER

The laser interferometer is a commercial product used for very high accuracy positioning and measuring purposes. A 672 nanometer (red) laser beam is passed through a beam splitter, then one of the outputs is transmitted through a transparent window to an external corner prism which returns the beam to the interferometer via a second window. This input is combined with the second output from the beam splitter to produce a detectable fringe pattern. There are two detectors operating in quadrature to provide an easily decoded signal for input to an up / down counter. Using a simple decoding scheme, there are 4 changes of state for each wavelength change of external beam path length, corresponding to a half wavelength movement by the prism. Thus there is a counter pulse every 84 nanometers.

For measuring geophone element characteristics, the corner prism is attached directly to the case of the element, ensuring accurate tracking.

The laser interferometer used for this particular apparatus is a LARS/200 manufactured by Gradient Lens Corporation.

## AUTO-ORIENTING GEOPHONE

The parameter of most concern for the auto-orienting geophone is the coupling between the outer case and the inner sphere. This is measured by attaching a second element, identical to the internal one being tested, to the outside of the case, so that the element output is a direct measure of the outer case motion. This output is then compared to the output from the internal element to provide a measure of coupling. The laser interferometer will also be utilised to provide constraints on the experiment such as maximum amplitude of motion.

The apparatus is designed for both vertical and horizontal operation, allowing both element orientations to be tested. As well, tilting at different angles will supply information on allowable limits in geophone planting.

## OTHER APPLICATIONS

Because of its small size and easy portability the laser interferometer can be used in the field to measure the actual ground motion on a seismic spread at various offsets. By capturing this signal, the experimental apparatus can then be used to re-create the motion experienced by a geophone in the field, thus providing a unique way of comparing different elements under field conditions.

## CONCLUSION

The test equipment is still being assembled, and many modifications are expected before the true testing to high accuracy can be started. The first pass will indicate whether this is indeed a viable method of testing high performance geophones.

## ACKNOWLEDGEMENTS

Peter Maxwell of the SENSOR division of Input/Output Inc. has provided valuable information on geophone testing methods currently used.

Mark Products, Geospace and SENSOR will all provide elements for testing on this system.

The CREWES Project and the Department of Geology and Geophysics at the University of Calgary have provided support and instrumentation for the testing equipment.