DESIGN, CONSTRUCTION AND TESTING OF A LOW COSTMULTI-CHANNEL

SEISMIC DATA ACQUISITON SYSTEM

BY

PHILIP IGBINIGIE IDEHEN

B.Sc. (Physics), Ife

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OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA

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CERTIFICATION

We certify that this research work was carried out by Mr. IDEHEN, Philip Igbinigie with registration number (SCP11/12/H/2076) in the Department of Geology, Faculty of Science, ObafemiAwolowo University, Ile-Ife, Nigeria under our supervision. The thesis had been read and approved as meeting part of the requirements for the award of Master of Science (M.Sc.) in Applied Geophysics.

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Dr. A. A. Adepelumi   Date
(Supervisor and Head of Department)

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Dr. K. P. Ayodele   Date
(Co-Supervisor)

DEDICATION

This research is dedicated to the Most High, and I praise and honour Him that lives forever, whose dominion is an everlasting dominion and His kingdom is from generation to generation.

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ABSTRACT

A seismic data acquisition system (SDAS) was designed and constructed using locally available electronic materials. This was with a view to developing a low cost SDAS that can be compared with the conventional imported equivalent.

Three circuits were designed for the low cost SDAS. First was a +12 V DC power supply unit composed mainly of a two 12 V battery connected in parallel and bridge rectifier. Secondly, a trigger circuit was designed using a 555 timer configured in monostable mode to trigger low and high signal generated from a sledge hammer in less than 3 s time lag. This time lag would allow the milliseconds seismic wave to travel from the point of generation to the geophone. Lastly, the analog signal conditioning circuit was designed using instrumentation amplifier with high Common Mode Rejection Ratio (CMMR) for increased signal to noise ratio and amplification of the seismic signal. These circuits were soldered on a veroboard. The output of the trigger and analog signal conditioning circuit were fed into two of the analog pins of an Arduino board. The Arduino aided analog to digital conversion of the seismic signal and USB interfacing with Personal Computer (PC). The entire components were assembled in a light and portable plastic box. LabVIEW software was used to design a Graphical User Interface (GUI) to display the seismogram on PC during data acquisition and to program the Arduino to trigger the SDAS during any seismic wave generation. The expected seismic signal was displayed on the GUI during any seismic signal excitation. Field testing of the constructed low cost seismograph was carried out. A traverse length of 25 m with shot points at 5 m interval was used.

At every shot point, the SDAS was able to pick and display the seismic signals. The first arrival times obtained for each shot point at 5 m, 10 m, 15 m, 20 m and 25 m interval were 49.01 ms,

42.37 ms, 37.17 ms, 40.11 ms, and 49.55 ms respectively. These results showed the inability of the offsets to vary directly with expected time of first arrival, indicating that the seismic signal timing device might not have functioned properly.

The study concluded that although the SDAS identified and picked the seismic signal, the first arrival times were not accurately recorded.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

A Seismic Data Acquisition System (SDAS) is an assembly of seismic components with a fundamental purpose of detecting, amplifying and recording of ground motion or seismic waves resulting from a known source and in a known location. A simple and low costSDAS comprises mainly of a seismic source, geophones, spread cable and seismograph. The seismograph is the most expensive of these items and usually imported from developed countries to developing countries like Nigeria. Therefore, ability to construct a low cost seismograph will result in constructing a low costSDAS. Necessity is the mother of invention, so goes the popular saying. The necessity to address the problem of high cost of imported seismograph gave birth to the need to constructinga low cost seismograph, expected to be of comparable quality using locally available materials.

Seismograph is an instrument that detects, amplifies and records motions of the ground, including those of seismic waves generated by earthquakes, nuclear explosions, sledge hammers and other seismic generation sources.The word seismograph is often used synonymously with seismometer (which is now commonly called geophone for land seismic), but there is a distinction. A seismograph detects, measures and records ground motion (graphs), seismometers is the sensor part of an instrument that measures and amplify ground motion (www.eos.ubc.ca/course/eosc256week3).

Far back around 132 AD, Chang Heng of China's Han dynasty invented the first seismoscope which was called HoufengDidong Yi (which is now called a seismograph). It was a large bronze vessel, about 2 meters in diameter; with eight points around the top were dragon's heads hold bronze balls. When there was an earthquake or seismic wave, one of the mouths would open and drop its ball into a bronze toad at the base, making a sound, and indicating the direction of travel of the wave. On at least one occasion, probably at the time of a large earthquake in Gansu in 143 AD, the seismograph indicated an earthquake even though it was not felt. Available text says that inside the vessel was a central column that could move along eight tracks. This was thought to refer to a pendulum, though it was not known exactly how this was linked to a mechanism that would open only one dragon's mouth. The first ever earthquake recorded by this seismograph was supposedly somewhere in the east.

Basically, a seismograph works on the principle of Inertial or Newton's First Law of Motion which states that "a body will continue in its state of rest or remain in uniform motion along a straight line except acted upon by an external force." In Figure 1.1, the fundamental working principle of a seismograph is shown. The equipment consists mainly of an inertial mass which remains stationary unless a force is applied to it, a frame which can be used to represent ground motion and a rotating drum.

Figure1.2shows the squiggles left by the pen or produced by digital computer records. These squiggles are called Seismogram. A seismogram is a visual representation of ground motion at a point in space as a function of time. Seismograms are used to calculate the location and magnitude of seismic waves. It is a graph of ground displacement (in nanometers) versus time (in milliseconds). When there is no seismic wave or ground motion,the reading there is just a straight line except for small wiggles caused by local disturbance or noise.

Modern seismic refraction survey now includes the use of laptop or personal computer (PC) in the display and storage of generated seismic signal on the field. This research work did not hesitate to take advantage of this advancement in information and computer technology. A PC

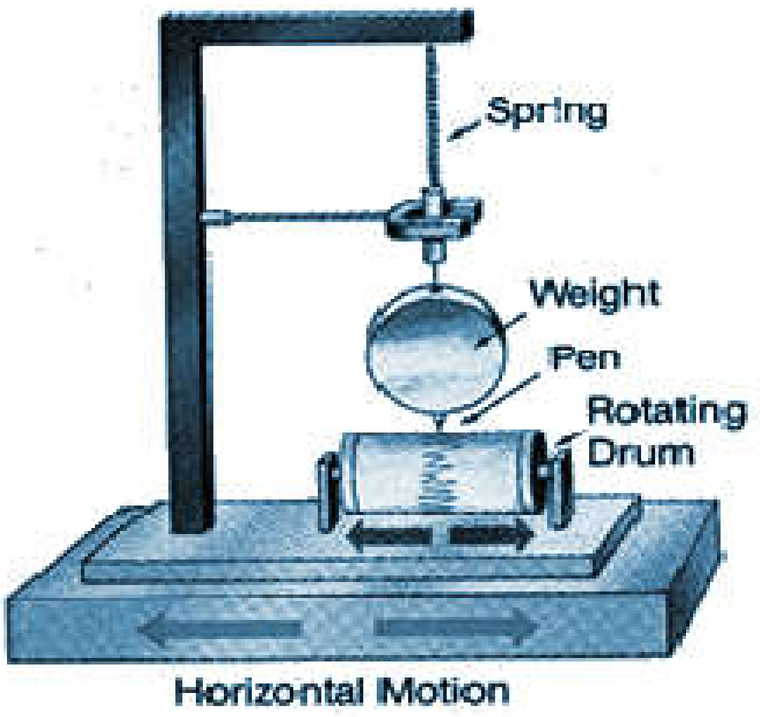

Figure 1.1: Working principles of Seismic Recording System (Adapted from http:// www.tryengineering.org)