Development of Time Controlled Shooting Box for Seismic Surveys

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Abstract)

A time controlled shooting box is being developed to work with seismic experiments, specially deep seismic refraction surveys. This equipment will be available to the Brazilian scientific community through PEG-ON along with the other equipment of the Tectonic Studies Network.

Introduction

In recent decades, the vision of the crust and upper mantle has been revolutionized by the systematic studies of the continental lithosphere, mainly through seismic methods surveys. As a result of these surveys, geological features could be traced to greater depths of the lower crust and certain features of the deep crust could be designed to the underlying mantle. In Brazil, such studies are rare, but in the last ten years the interest of the geoscience community in this type of study has increased and a set of equipment (400 Texans and sensors) was acquired by Tectonic Studies Network sponsored by Petrobras could be used by the scientific community through the PEG-ON (Geophysical Equipment Pool of National Observatory).

The deep seismic refraction surveys (DSR) achieved in the Tocantins Province, in 1998 (Berrocal et al., 2004; Perosi, 2000), were pioneers in the country. At that time, the equipment was lent by the PASSCAL program (Program for the Array Seismic Studies of Continental lithosphere) which is one of the facilities offered to the international seismological community by North American consortium IRIS (Incorporated Research Institutions for Seismology), which promotes studies of continental lithosphere and other seismological studies. This loan was obtained through Dr. Walter Mooney (U. S. Geological Survey) and Dr. Simon Kemplerer (Stanford University). Due to lack of experience of Brazilians in this type of experiment, the USGS has sent two technicians and firing units with time control laptops specifically built for this purpose. This equipment allowed the GPS synchronization, control of milliseconds at the time of the explosion and automation in the procedure of fire, reducing the possibility of errors inserted by human factors. In 2008, he made the first stage of studies of DSR in Borborema province, which was a line of about 800 km NO-SE direction, between the states of Ceara and Pernambuco. In these surveys were used electronic fuses that allow to control the time of origin, but not as efficiently as the PASSCAL units. Therefore, we decide set up a project to make firing units (shooting boxes) that met the needs of the project and also the future that could be used by others that wish to use the equipment for deep seismic experiments of the PEG-ON.

Method

The seismic refraction method (Sheriff & Geldart, 1995) is based on the propagation of elastic waves through the layers of Earth's interior, where they are refracted or reflected in the discontinuities found by following the principles of Fermat and Huygens and Snell's lawl, which allow the reconstruction of the trajectories of seismic rays from the source to the recording sites. Using energy sources with their very precisely known parameters (location and time of origin), it is possible to infer these trajectories and their velocities using the time of registration of these waves. This is achieved by analyzing the path-time curves, especially the primary wave arrivals recorded. The accuracy in locating points and determination the time of origin are essential parameters for the data processing and a good model interpretation.

Thus the construction of a shooting box that responds to these needs is very important to optimize the execution of seismic surveys, especially in academia. From preliminary research, it was decided that the prototype of the proposed equipment would be divided into modules (Figure 1) to facilitate the development and connection of these. The apparatus consists of a microcontroller, a EEPROM memory, a LCD module, a GPS unit, a serial/ USB communication circuit, keyboard programming and a power supply sized for the equipment. (Collis, 2009; Filho, 2005; Finanger, 2002).

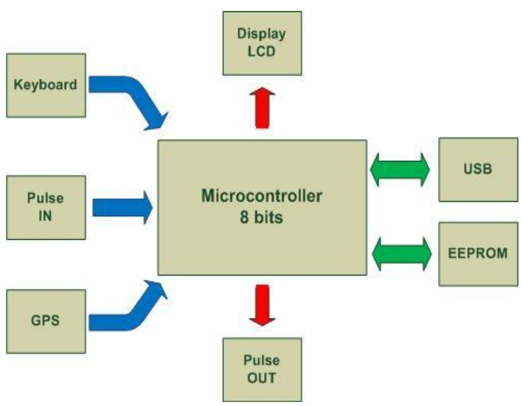

Figure 1: Block diagram showing the modules and the direction of data flow.

To develop this project all the electronic circuit was mounted on a protoboard (Figure 2), that enables the development and modification of the circuit, as well as the reprogramming of the firmware (internal software control) from the box without the need to use a microcontroller external recorder.

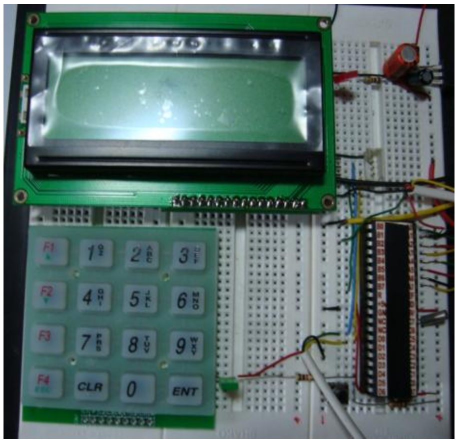

Figure 2 - Protoboard with a microcontroller, LCD, matrix keyboard and power supply.

The GPS module (Global Position System) aims to provide the UTC (universal time clock) to the microcontroller, a quartz crystal is used to help the time control. Both the hardware and firmware are designed to work with the box in two distinct modes of operation, controlling the time of detonation and as time recorder external pulse. In the first case, the box receives a schedule of up to 50 detonation windows (pre-determined time) via USB or keyboard, when this time is equal to the internal clock of the box, an electrical pulse is sent to the fuse. It is possible choose the electric current settings which most fits the type of detonator arrangement (cable + electrical fuse). For extra safety, the device includes a trigger where the detonation occurred only if this is engaged by a person. If, for some reason, the detonation is aborted by the operator will be possible to perform a new detonation from two ways: by inserting a backup window for each desired time of detonation in the initial programming or by inserting a new shoot time by keyboard or USB without affecting the sequence of other windows. Even in this mode the box provides an optocoupler output to be connected directly to the trigger seismographs, enabling them to start recording at the exact moment of detonation. The second mode of operation is to monitor a port connected to an external detonation circuit, at the time this port to receive a pulse on the box will store in the EEPROM, the exact time of the pulse, thus enabling the operator to recover the data using the port USB or viewing them through the LCD display. In both modes of operation is possible to store or view the location of shot points (location of the box) from the coordinates provided by GPS module (Datum WGS84) included in the circuit. Now the project is in the assembly phase (Figure 3) to do the testing field.

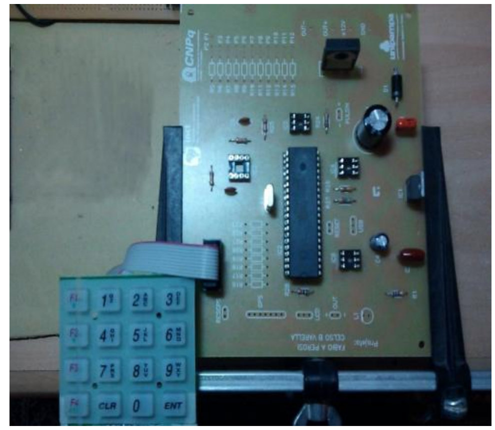

Figure 3: Printed Circuit Board, previously mounted.

Results

All the electronics are mounted on a printed circuit board, where the power supply can supply 5 volts at 3 amps to control modules, since the power module which is connected directly to the fuse can provide 12 Volts with 11 levels current at 0.5 amp, selectable by a key. The GPS module is fully integrated into the system, where data from it, are analysed by an algorithm responsible for verifying their validity, before pass the data to the internal clock or data storage equipment. Both USB communications port as the keyboard are integrated into the shooting box to enable the operator to perform settings, data recovery (for the computer or display on the LCD of the box) and its maintenance. The external EEPROM available on this device has a storage capacity of 64Kb thereby providing a significant increase in the number of windows programmed.

This equipment were adopted some protection circuits such as the use of capacitors responsible for filtering the voltage from the power supply thus avoiding the instability of the system, following this were inserted optocouplers that possess in order to isolate the control circuit, the power system of the box, as well as signals from external equipment.

Conclusions

Through this research several important features such as: the creation and development of equipment that does not exist in Brazil, participation in multi-institutional projects, where this equipment can be used by other research groups of universities. We hope that these shooting boxes can help and improve the quality of acquisition and processing of seismic data.

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