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Abstract

Proton Precession Magnetometers (PPM) are user-friendly instruments commonly used to measure the geomagnetic field by means of temporary acquisition stations. In particular, the Geometrics G - 856 is the most commonly utilised PPM in Italy; we tried to improve the instrument performance. The digital card of the instrument has been replaced by a programmable microcontroller card which allows new useful functions, joint to a new alphanumeric liquid crystal and a bigger memory space. Thus, it is possible to use the instrument in base station for long period Geomagnetic field acquisition. This paper is a reference for using and repairing the Geometrics G - 856 magnetometer.

1. Introduction

The earth's magnetic field is a vectorial field, represented by a vector **F** whose components are function of the position on the Earth and of time. The field that we measure at the earth's surface is the vector sum of a number of different constituent fields each of which originates in a different place and varies differently in time and space :

1. The main field, generated in the earth's core; it can be approximated for its 94% by a dipole at centre of the earth, inclined by about 11° with respect the axis of rotation.

2. The crust field, generated by the rocks of the earth's crust which are mainly magnetised by the main field.

3. The external field, generated by electric currents that flow in the ionosphere and magnetosphere regions.

4. The induced field, generated by external field time variations of electric induced currents in the crust and in the mantle.

The main field is subjected to slow time variations (secular or paleomagnetic): this is a feature of internal origin. The external field is subjected to more rapid variations (diurnal variations, magnetic storms, substorms and micropulsations). Thus the geomagnetic field is a complicated function of space and time.

Measurements are always made for specific purposes, to study some particular aspects of either time or space variations. Most important kinds of measurements are :

1. Magnetic observatory measurements. At a magnetic observatory the three components of the field are continuously recorded. Time resolution varies from few seconds up to 1 minute. Time is referred to the Universal Time (UT). The total intensity of the field is usually measured by the proton precession magnetometer (PPM). Observatories supply the most accurate information on time variation of geomagnetic field.

2. Regional survey measurements. The regional survey consist of a network of sites at which the three components of the field have been measured at least one time, with an "absolute" instrument. The network may cover one or more countries. The goal is to determine as accurately as possible the regional characteristics of the main field .

3. Local surveys measurements. These are carried out over a restricted local area usually in the research for economical valuable minerals.

4. Paleomagnetic measurements : The measurements of residual magnetisation of rocks and artefacts can be considered as a measurement of the field on a large time scale.

Magnetic instruments fall into three rather distinct "generations". The oldest one uses permanent magnets or induction coils with only mechanical auxiliary equipment. The second generation uses the properties of high permeability materials or atomic particles, with essential back-up by electronic circuitry. What could be called the third generation, relies upon low temperature quantum effect device (SQUID) technologies, and it is by now well established.

Proton Procession Magnetometer (PPM) is a second generation instrument and is widely used in various fields of Geomagnetism. It is very common in local field surveys. It is used as a standard at most observatories, as well as a regular "absolute" instrument for calibrating variometers. Although it measures the total field it can be adapted to measure the field components, properly compensating the components one does not want to measure.

2. Electronic operation

The electronic circuitry of a Geometrics PPM can be shown separately in two parts : an analog part which generates and measures all the analog signal required by the magnetometer circuit, and a digital part which controls the analog part and stores and controls the acquired data.

The block diagram of the analog circuit of a Geometrics PPM is show in fig.1; it is composed by a timing circuit which synchronises all the electronics parts in the magnetometer, switches on the polarisation magnetic field (for a time < 5s), and then starts begins the measurement process. Timing block is formed by integrated circuits U18, U19, U20, U21, U22 on the electronic circuit (fig. 3). Measurement blocks are: a filtering block for tuning the electronic circuits to the precession signal frequency U1 Q1-Q8, a low noise amplifier Q16, a Phase Lock Loop circuit for frequency muitiplication U4 U6 and a counter (U8 U9) connects to the digital part.

The PLL circuit synthesises a square signal of frequency 256 times the precession signal frequency in order to increase the resolution of the counter circuit. The counter gate is open for a time T = 0.46 sec. and, said n the counter value and f the precession frequency, we have :

$$256\ f = 256\ B[nT] / 23.4874 = n / T$$

Thus the relation between the counter number and the field value in PPM is :

$$B[nT] = n\ 23.4874 / (\ 256\ T\ )$$

The maximum resolution is $\Delta B = 0.2$ nT.

The digital circuit of Geometrics magnetometer has been completely replaced by a GRIFO GPC F2 card. The main components of the card are : the processor 8052 H BASIC masked, with 8K of ROM, 256 bytes of RAM, 3 programmable Timer Counters, I/O digital port and clock frequency of 11.0592 Mhz.

A bigger liquid crystal display and numeric keyboard have been connected to the GRIFO card for additional measure information and user communications (see fig. 2).

It is possible to connect the card to a Personal computer by a serial port connector located on the front panel of the magnetometer (see fig. 4). The maximum transmission speed is 58 Kbauds. The program can be written or modified by means of any editor software transferred to the magnetometer card and saved with the EPROM programmer build in the card. The program block diagram is shown in fig. 5 . It has a simple structure; for any pressed key only one sub procedure is activated.

On keypad some operations possible are:

RECALL	control memory data
STORE	store data in memory
READ	test measurement
TUNE	tune the instrument to the magnetic field
TIME	set and display time and date
FIELD	show time at measurement before fill in memory space
OUTPUT	download memory data by serial link
AUTO	set acquisition step
ERASE	delete all memory data
CLEAR	cancel the last operation
SHIFT	data enter in multidata operation
ENTER	operation enter.

Moreover the magnetometer can be programmed to acquire remote commands through the serial port.

The program drives the analogic circuits through digital card I/O ports, by the J2 connector shown in fig. 4.

3. Analogic circuit

The analogic electronics components of the "Geometrics" magnetometer (see fig.3) are frequently subjected to break down. Continuous data acquisition for long time stress the instrument operations. For magnetic observatories purpose quick repairs of the faults are needed in order to maintain a regular data acquisition.

We show here the operating points that can be useful for the research of break down causes.

1) Supply voltage : the magnetometer must be supplied by a steady tension of 12 V, and so we can measure the 5 V supplies for all integrated circuits and 12 V on bias coil. It is worth to point out that the instrument must be set in polarisation state because when the field measurement finishes the voltage supply switches in stand by state for battery saving. We can test the bias of polarisation coil by measuring the voltage of 12 V when the pins 20 and 21 on J2 (see circuit) are on logic level one. At last we can measure a -15 V on TP 10 for the filtering selection (U1) on the analogic card
2) Tuning circuits : the precession signal can be measured with an oscilloscope on TP2. The amplitude of the signal depends on the resonance frequency of the filters. We can control if the right magnetic field is selected in tuning set, by injecting a sinusoidal test signal in the coil (connector J1). The resonance frequency can be calculated inverting eq.2. Resonance damping effects can be seen by shifting the test signal frequency and by verifying the modulation effect on the oscilloscope.
3) Low noise amplifiers : with the above test signal we can check also the amplifiers output signals on TP1.

4) PLL : After each field measurement process, we find on TP4 a square signal with a frequency 128 times greater than the test signal frequency.

5) counter circuit : the counter of precession signal is built in by two 4040 counters in series. On input TP8 it is present a pulse signal with a frequency 256 times the precession frequency. Test signal of great frequency precision is required for the counter stability.

6) timing circuits : the timing of all the circuit blocks is carried out by a crystal quartz of 2.857 MHz connected with a binary counter and a decimal counter.

4. Field Measure

A prototype of this instrument has been tested at the astronomic observatory of Colleurania Teramo (in the ambit of a Sismo-magnetic research project of the I NG) where intensity of geomagnetic field has been measured with a sample rate of 5 minute from 18th December to 11th January.

In Fig. 6 is shown the intensity F of geomagnetic field at the test site.

Acknowledgement

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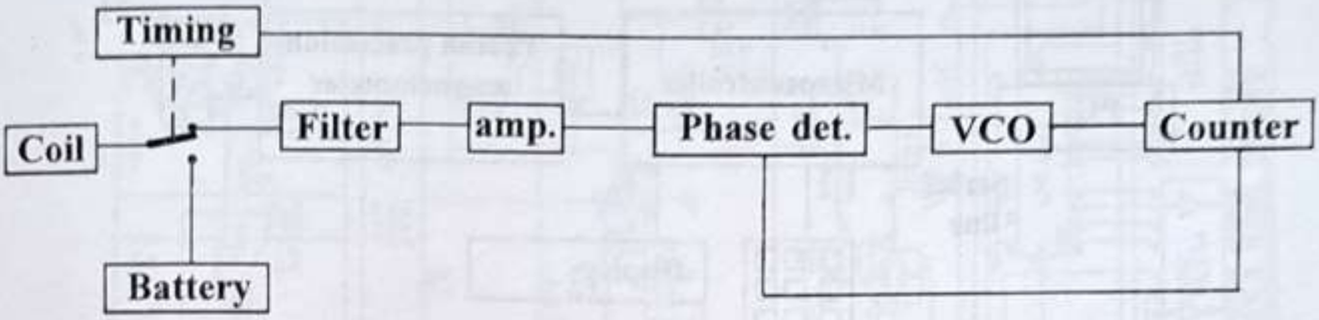
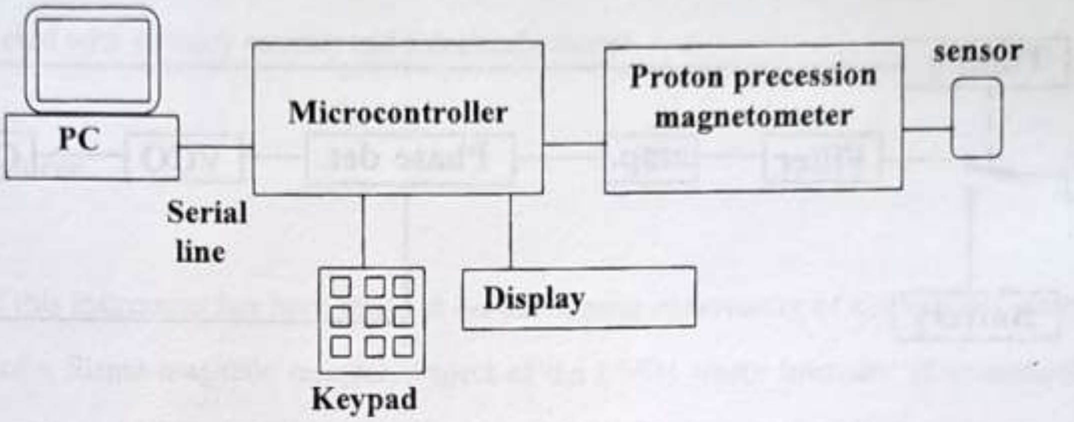


Fig. 1



PC
Microcontroller
Proton precession magnetometer
sensor
Serial line
Display
Keypad

Fig. 2

A - B input coil
C ground
L TX serial port
M Rx serial port
N 12.5V EPROM recorder
S ground
K 12 V
J 5 V

Fig.4

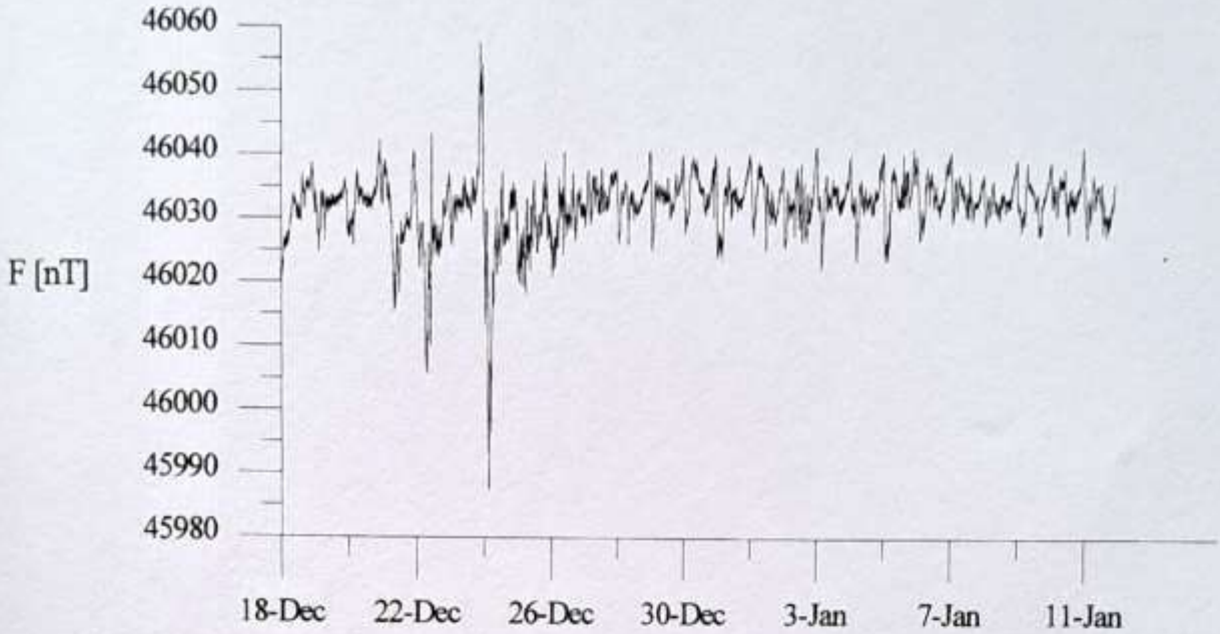

46060
46050
46040
46030
F [nT]
46020
46010
46000
45990
45980
18-Dec
22-Dec
26-Dec
30-Dec
3-Jan
7-Jan
11-Jan

Fig. 6