DETECTION FERROUS OBJECTS USING LABVIEW

D. Swisulski and M. Woloszyn
Department of Electrical and Control Engineering
Technical University of Gdansk, Poland

Abstract: The ferrous objects disturb evenly distributed Earth magnetic field. It is possible to detect the ferrous objects by measuring the magnetic field. Detection of objects under water in the Baltic Sea is difficult due to large natural magnetic anomalies. In order to eliminate the anomalies, the prediction technique in measurements was used. Before the prediction, the measured signal is filtered to remove unwanted frequencies and this way the object can be detect using a threshold peak detector. LabVIEW was used to simulate the detection of objects in the Baltic Sea.

Keywords: detection, ferrous objects, signal processing, magnetometer

1   INTRODUCTION

The ferromagnetic object disturbs in its space an equal of the magnetic field of the Earth, causes the characteristic magnetic anomaly. The anomaly depends on many factors as: shape and size of the object, its orientation relative to the vector of the Earth magnetic field and the magnetic properties of the object. The ferrous object can be located by measuring the local magnetic field [1, 2, 3, 4]. Detection of objects can be performed for example by using a fluxgate, proton or optically pumped magnetometers. The detecting system can be installed on a helicopter or aeroplane. Detection of objects in the Baltic Sea is made difficult due to very large natural magnetic anomalies. These anomalies are about 100 nT/km (Fig. 1).
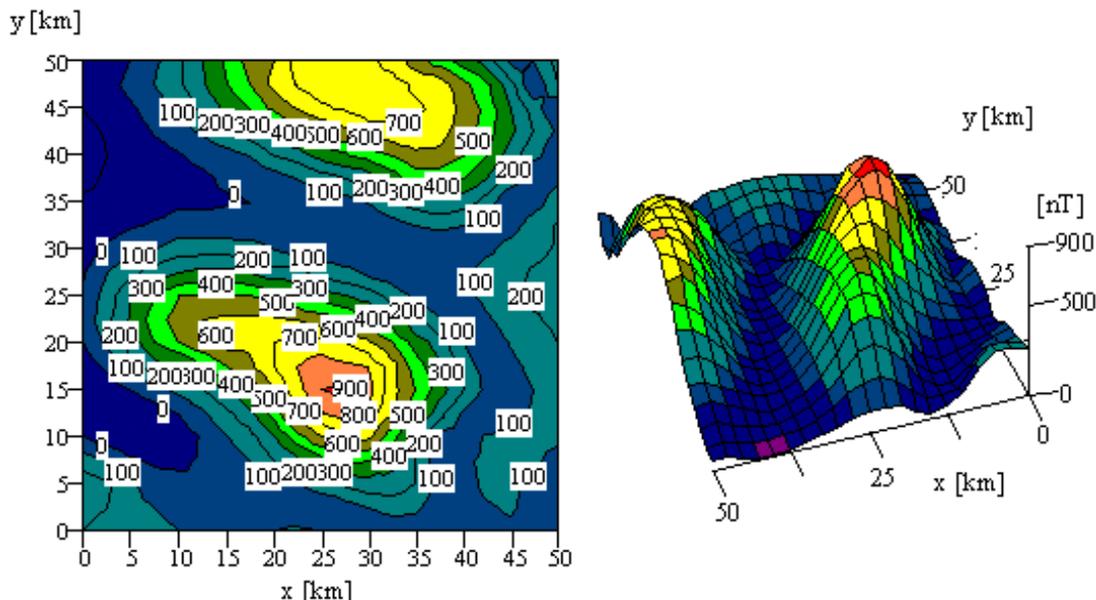

Figure 1. The magnetic anomalies in the Baltic Sea

The average value of the magnetic induction of the Earth is 50000 nT and signals generated by ferrous objects which must be detected is on the order of several nT.

2   MAGNETIC SENSOR

The magnetic anomaly relates to ferrous object can be detect by using a fluxgate, proton or optically pumped magnetometers. The cesium optically pumped magnetometer is a very high

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precision magnetometer (high sensitivity – 0.01 nT). The cesium magnetometer provides a scalar measurement of the earth's magnetic field. The measurement is expressed as the total field intensity in nano-Teslas and may range from 20000 – 100000 nT at the earth's surface. The sampling rate of this magnetometer is on the order of 10. In computer detection simulations of ferrous objects, it is assumed that the signal is measured by the use of an optically pumped magnetometer.

3   MEASUREMENT CONDITIONS

The signal from the ferromagnetic underwater object is measure by a magnetometer installed on a helicopter or an aeroplane. The detected signal depends on many factors, as:

- a ferromagnetic properties of the object,
- geographic position of the object,
- shape and size of the object,
- distance between the magnetometer probe and the object etc.

The signal has a shape similar to a positive or a negative or a full sinusoid. The duration of the signal range from 2 s to 12 s. Signal which has duration greater than 12 s is due to detection of small objects. In the Baltic Sea are large natural magnetic anomalies, so detecting objects is very difficult. Removing the large magnetic trend from the measured data can be helpful in detection of objects.

4   METHOD OF REMOVING TREND AND DETECTION OF SIGNAL

The signal connected with a underwater object can be detect „on line" or with any time delay. Locating objects through "on line" method complicates a correct and clear-cut signalling of object existence [5]. The new locating software system uses prediction and signal analysis with time delay. The duration of detect signals can be up 12 s. Therefore the measured signals could be analysed for example in a 20 s window. A 12 s signal generated by a ferrous object, always will appear in this analysing window. The method of gathering of signals for prediction and analyse of signals showed in Fig. 2.
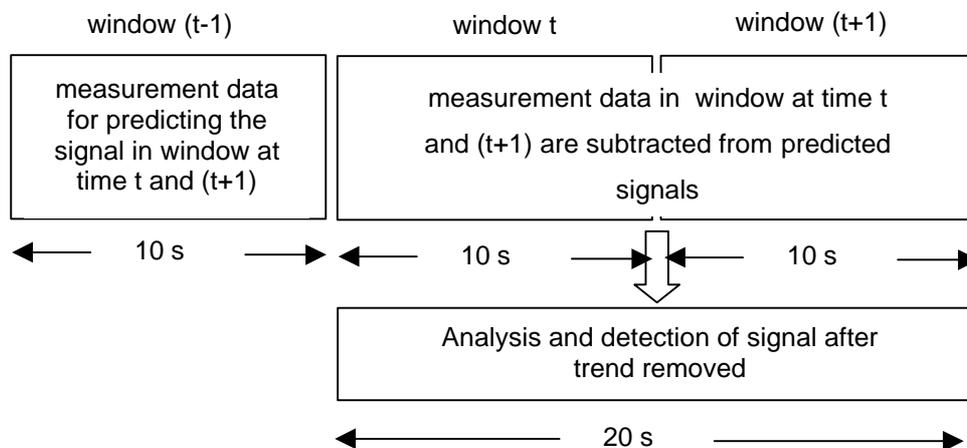
Figure 2. Block diagram of the method of removing a magnetic trend and signal analysis

Parameters for the prediction function are computed based on measured signals in window (t-1). Signals in windows at time (t) and (t+1) are subtracted from the predicted signal. In this way, we obtain a 20 s window with a signal minus the large magnetic trend. Next, the decreased magnetic trend must be maximally decreased in order to decrease the slope of signal to null level. With this aim in mind, the window is divided into 10 sub-windows, in which the signal is approximated by a first degree of polynomials. The slopes of given functions are taken into analysis. These functions, whose slopes are most different from standard slope, are rejected in 4 sub-windows. For the other sub-windows, the mean value of the slope of the signal is calculated. Such a mean approximated function is subtracted from signal in the 10 sub-windows. Now the slope of signal must be nearer to the null level. Next, for the chosen sub-windows, a mean standard deviation is calculated to obtain a detection level value, which is taken in the detection block. Therefore, the method allows analysis and detection the object in 10 s intervals.

4.1   Computer program

To aim research of an effectiveness of proposed method of removing the trend and detecting of the object, a computer program in LabVIEW [6] environment has been written.

LabVIEW (Laboratory Virtual Instruments Engineering Workbench) is a development environment based on the graphical programming language G. LabVIEW is fully integrated for communication with hardware such GPIB, VXI, PXI, RS-232, RS-485, and plug-in date acquisition boards. It enables to control functional block of measuring systems, to arrange acquisition of measuring date and to present the results of measurements. LabVIEW has also built-in libraries to use software standards such as TCP/IP Networking and ActiveX.

The program makes possible to choose following parameters:
- amplitude and period of natural magnetic anomaly (800 nT, 200..1000 s),
- value, type and duration of useful signal (connected with the object) (several nT, 2..12 s),
- stochastic magnetic disturbances (several nT),
- amplitude and period of disturbance connected with motion of measurement probe (1 nT, 30..120 s),
- amplitude and period of fast magnetic disturbances (0.5 nT, 60..200 s).

The effectiveness of a first and a second (parabolic) degree of the polynomial were researched in the simulation of the detection signal.

4.2   Results of researches

To aim research of an effectiveness of removing of a magnetic trend and detecting objects has been made computer simulations. The figure Fig. 3 shows the e.g. signal with a large trend and the prediction signal. The Fig. 4 shows the signal after the parabolic prediction. The Fig. 5 shows the signal after the correction of the parabolic prediction and the detection of signal. The computer researches have showed parabolic prediction is better than linear, especially when magnetic trend is parabolic type.
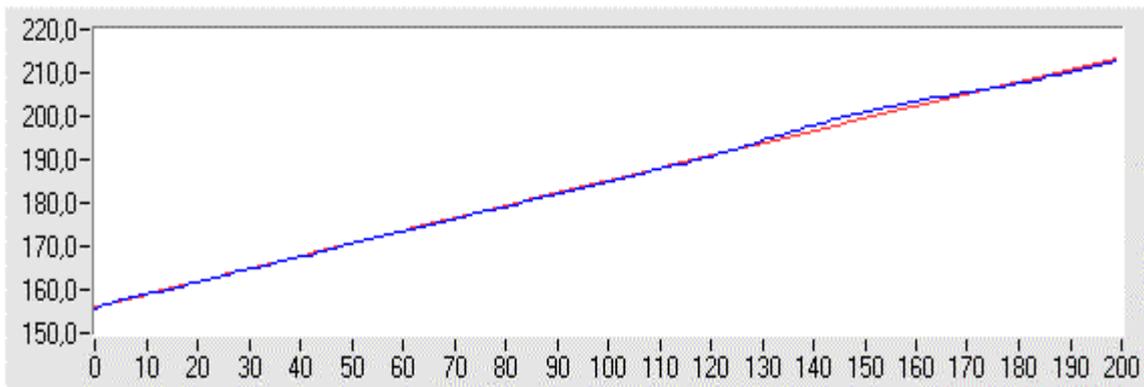

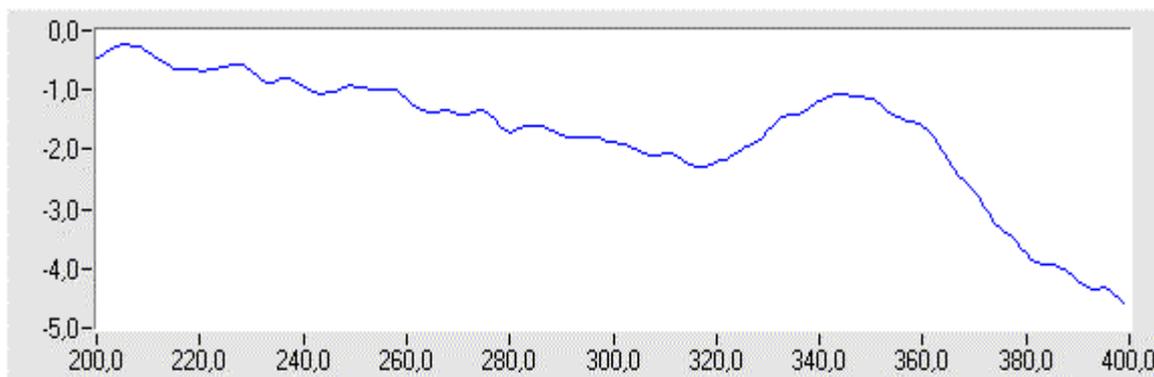**Figure 3.** The signal with a large trend and the prediction signal.

Figure 4. The signal after the parabolic prediction

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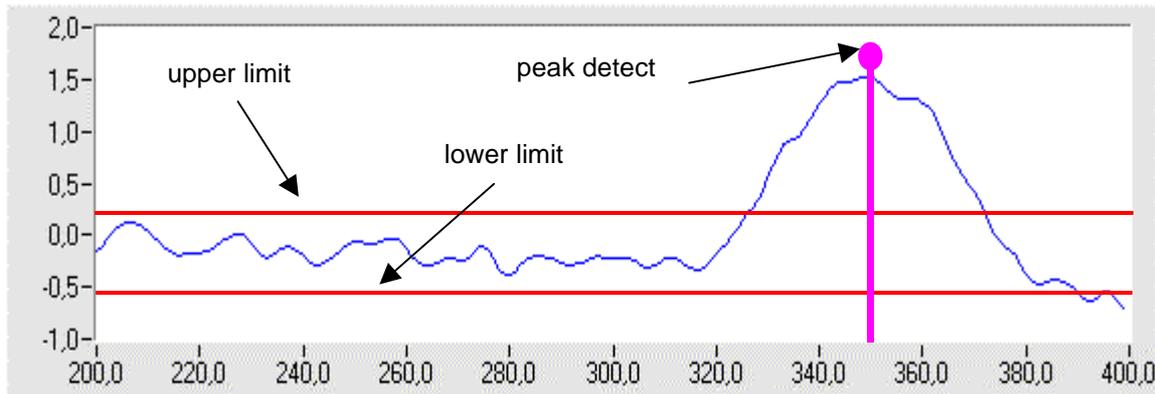Vienna, AUSTRIA, 2000, September 25-28

Figure 5. The signal after the correction of the parabolic prediction and the detection of signal

5 CONCLUSIONS

The results of computer simulations showed a good detecting of signals greater than 1 nT. Based on researches we can put following conclusions:
- a quality of a prediction method is dependent from type of magnetic disturbances,
- for low alternate disturbances a parabolic type better results give a parabolic prediction,
- the algorithm of taking down a slope of signal to null level is complicated and for a big magnetic disturbances is less effective.
- authors will research an effectiveness of a neural nets for prediction and detection of signal in the future.

REFERENCES

[1] McAulay A.D., Computerized Model Demonstrating Magnetic Submarine Localization. *IEEE Transactions on Aerospace and Electronic Systems*, vol. AES-13, no 3, p. 246 - 254, 1977
[2] McFee J.E., Das Y., Fast nonrecursive method for estimating the location and dipole moment components of a static magnetic dipole. *IEEE Trans. Geosci. Remote Sensing*, vol. GE-24, p. 663-673, 1986
[3] McFee J.E., Das Y., Locating and Identifying Compact Ferrous Objects. *IEEE Trans. Geosci. Remote Sensing*, vol. 28, no 2, p. 182-193, 1990
[4] Woloszyn M., Lokalizacja i identyfikacja obiektów o wlasciwosciach ferromagnetycznych metoda magnetometryczna. *Rozprawa doktorska*, Politechnika Gdanska, Gdansk 1997
[5] Nagiello Z., Woloszyn M., Magnetometr cezowy do wykrywania obiektów ferromagnetycznych. *IV Szkola-Konferencja, Metrologia wspomagana komputerowo.* s. 345-348, Warszawa, czerwiec 1999
[6] LabVIEW, *User Manual, National Instruments Corporation* 1996

AUTHORS: Dr. P. Dariusz SWISULSKI and Dr. P. Miroslaw WOLOSZYN, Department of Electrical and Control Engineering, Technical University of Gdansk, ul. G. Narutowicza 11/12, 80-952 Gdansk, Poland, Phone (48) 058 3471397, (48) 058 3471127, fax. (48) 058 3471802
e-mail: dswis@ely.pg.gda.pl   and   mwolosz@ely.pg.gda.pl