EMBEDDED DATA PROCESSING USING NI MyRIO AND LabVIEW FOR MAGNETIC FIELD MEASUREMENTS*

Hanna Gałach[a], Marek J. Peryt[a,b,†], Nikita Dunin[b]

[a]Faculty of Physics, Warsaw University of Technology, Warsaw, Poland
[b]Joint Institute for Nuclear Research, Dubna, Russia

(Received February 1, 2021)

In order to facilitate functioning of the equipment at the Multi-Purpose Detector (MPD), a part of Nuclotron-based Ion Collider fAcility (NICA) in Dubna (Russia), a magnetic field measurement system has been introduced. Its purpose is to control the shifts of the local magnetic field in order to eliminate its influence on measurements or equipment. The article concerns the functioning of the measurement system and improvements applied.

DOI:10.5506/APhysPolBSupp.14.625

1. Introduction

The Multi-Purpose Detector (MPD) is a part of Nuclotron-based Ion Collider fAcility (NICA) at the Joint Institute for Nuclear Research in Dubna, Russia. Its purpose is to study dense baryonic matter. In order to function properly, it requires a set of various equipment as well as systems to control its functioning. It also needs to take miscellaneous factors into consideration, such as temperature or magnetic field around the equipment. To provide for this need, a magnetic field measurement system has been introduced. Its functioning is based on the I^2C protocol, it has been programmed using the G graphical programming language, supported by the NI LabVIEW environment and the NI MyRIO device. One calibration method has been chosen amongst a few possibilities introduced.

* Presented at NICA Days 2019 and IV MPD Collaboration Meeting, Warsaw, Poland, October 21–25, 2019.

† Deceased.

2. Measurement system functioning

The measurement system works based on a MAG3110 magnetometer, provided by the NXP Semiconductors company [1]. The sensor has been connected to a MyRIO device and then configured, using the I^2C protocol, the program has been created using the LabVIEW environment, and the sensor has been initially calibrated by Krawczyk [2]. The sensor gathers data every 15 ms from each axis. The output are values for each axis as well as a combined value of the local magnetic field.

2.1. I^2C BUS

Briefly said, I^2C (Inter-Integrated Circuit) is a serial computer bus, of a master-slave type. It provides the possibility of communicating between numerous master and slave devices. Data is transferred in sequences of 8 bits, starting with a start condition, carrying information about the destination of the data transfer. Each data sequence is separated by an *Acknowledge bit*, carrying information about whether the data sequence has been transferred correctly. At the end comes a special *Stop bit* that simply ends the transfer. The undeniable advance of I^2C is the possibility to engage numerous masters and slaves. Its configuration is also supported by the LabVIEW environment [3].

3. Improvements to the system

There have been done a few improvements to the system in order to facilitate the measurement process.

One LCD has been connected. Another added feature was the process of data logging to an already existing file located on a USB drive connected to the MyRIO device. LCD has been configured using the UART (Universal Asynchronous Receiver Transmitter) communication standard. It is also supported by the LabVIEW environment. Whilst I^2C allows numerous masters and slaves, UART does not. The difference, however, is that UART allows only one master, but numerous slaves. Its physical layer also differs from the I^2C physical layer [3].

The second feature — USB data logging — has been achieved by modifying the code of the entire measurement system and adding this functionality.

Purposes of both additional improvements are:

— control of the system's functioning — LCD enables the viewer to see current measurements in real time,

— LCD makes it also possible to control the functioning of the measurements system,

— data logging creates a possibility of later analysis of the measurements and, therefore, optimization of functioning of both the equipment and the measurement system itself.

One of the planned improvements is to mount the sensor to an XYZ-scanner. It is a construction that would make it possible to move the sensor along all three axes. Such a solution provides information about the local magnetic field that is more precise than information gathered through measurements taken from one point.

4. Calibration

There are many possibilities to calibrate the sensor. One of the possibilities is calibration through interpolation, using a magnetometer and an accelerometer at the same time. There are a few factors that influence the value of a magnetic field. Among these are:

— soft iron,

— hard iron,

— bias,

— misalignment

that need to be taken into consideration. In order to calibrate the sensor, a program called Magneto [4] has been used. It creates a set of calibration values that take all four factors mentioned above. Then, these values need to be combined in a formula. The result is a final calibration value by which the measurements shall be corrected [5]. In order to obtain these corrections, one shall rotate the sensor in as many directions as possible in order to gather a bigger number of measurements. Integrating an accelerometer would make calibration (and measurements as a result) more accurate since it would provide more data — as another source of measurements.

5. Summary

The entire measurement system has been developed and improved but there is still room for further improvement. Apart from measuring the magnetic field of the magnets at MPD or BM@N, it could help improve the quality of functioning of other experiment's equipment by elimination of the influence of other devices, in order to measure the local magnetic field as accurately as possible.

REFERENCES

[1] «Xtrinsic MAG3110 Three-Axis, Digital Magnetometer Data Sheet», NXP Semiconductors, 2013.

[2] K. Krawczyk, «Wykonanie układu kontrolno-pomiarowego i badanie stabilności pola magnetycznego w magnesie głównym eksperymentu BM@N i MPD-NICA», 2018 (in Polish).

[3] J.-M. Irazabal, S. Blozis, «I^{2}C Manual AN10216-01», Philips Semiconductors, 2003.

[4] Sailboat Instruments, «Magneto v1.2».

[5] C. Konvalin, «Compensating for Tilt, Hard-Iron, and Soft-Iron Effects», FierceElectronics, 2009; T. Ozyagcilar, «Callibrating an eCompass in the Presence of Hard- and Soft-Iron Interference AN4264», NXP Semiconductors, 2015.