Fixed Magnetic Field Virtual Instrument for Hall Effect Measurement

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***Abstract* — This paper introduces a new and flexible Virtual Instrument (VI) developed using Agilent USB technology and based on the fixed magnetic field HALL measurement. By using LabVIEW 2009 Graphical Programming and the new class of Agilent USB Devices in this application, the University Transylvania of Brasov has developed a flexible instrumentation system with capability to measure conductivity of the new materials and Hall parameters. This development greatly benefits university research laboratories which are in need of flexible systems that can be configured easily, in accordance to testing needs. At the same time, this Hall Measurement System can be remotely controlled; providing a uniquely modern, Web-controlled educational instrument. This is a valuable tool especially for the physical engineering specialization program in universities. Students and researchers can create simple developments and add new Virtual Instruments based on the modular instrumentation which are well supported by LabVIEW.**

***Index Terms* — Hall Measurements System, Virtual Instrumentation, Modular Instrumentation**

I. INTRODUCTION

In 1878 it was discovered by Edwin Hall that there is a current in a direction, perpendicular to both the applied electrical field as well as the applied magnetic field in a metal. The Hall voltage is linearly proportional to the magnetic field and hence the Hall resistivity as a function of magnetic field determines the concentration of current carriers.

It is mentioned that the classical Hall Effect makes use of the Newton's law of motion, namely that the force acting on the electron is proportional to the acceleration. Since the electrons (and the same for the holes) are charged particles, they experience a force in a magnetic field which is called the Lorentz force. From this force and the Newton's law the resistivity can be defined by use of the relation between current and electric field, the simple and well know Ohm's law.

The **Van der Pauw Method** is a commonly used technique to measure the sheet resistance of a material but this method is often used to measure the Hall Effect, which characterizes a sample of semiconductor material and can be successfully completed with a current source, voltmeter, and a magnet.

Many engineers, researchers, and educators are continually looking for test instruments that offer flexible configurations, quick setup, and affordability. The ability to operate these capable instruments as space-saving solutions will be another huge benefit to all users alike.

To develop this virtual instrumentation, Agilent's USB based modular instruments have been selected: one U2781A six slot USB Modular Instrument Chassis (Fig.1) with one U2723A Source Measure Unit (for sample polarization), one U2531A Simultaneous Sampling DAQ (for tension measurements) and one U2751 4x8 2-Wire Switch Matrix (necessary for flexible and software controlled interconnections).

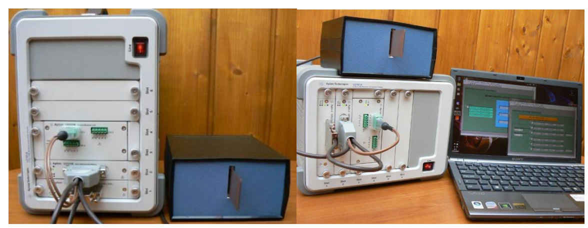

Fig.1 Hall Measurement System

II. FIXED MAGNETIC FIELD HALL MEASUREMENTS

For ~~our~~ developments four neodymium magnets were acquired and constructed into two systems with different configurations of fixed magnetic field. (Fig.1 and Fig.2).

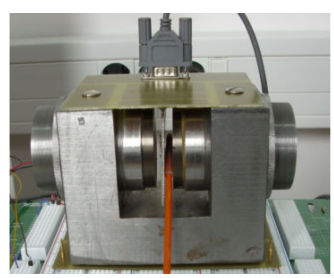

Fig.2 Magnet with reglabe distance

In addition, poles of 40mm in diameter are used in order to allow a relatively uniform magnetic field in the samples (sample size 10 x 10 mm or 15 x 15mm) with a gap of 8-10 millimeters between poles.

The measured magnetic field was 1.80 Tesla (for the system in Fig.1) and 1.57 Tesla for the second one (Fig.2)

A sample holder was built with a design that allows:

- Convenient location of the samples in magnetic field;
- Different holding mechanisms for the sample;
- Rotation of the sample in the magnetic field (because of the fixed permanent magnet field, we need to rotate the sample by 180 degrees);
- In future we intend to measure the magnetic field using AD 22151 sensor installed near the sample on the sample holder system

Preliminary tests were done using the Agilent Measurement Manager which allows fast configuration in testing of the system.
The main application starts by identifying the VISA devices inserted in the USB Rack.
All inserted modules can be configured and tested individually (Fig.3).

Fig.3 Agilent Measurement Manager

The U2751A Switch Matrix is controlled by a LabVIEW VI which offers the capability to enable eight different configurations for sample measurements using the van der Pauw configurations. The van der Pauw technique is used to measure the resistivity and Hall voltages of samples. The rearrangement of the different connections becomes complex as it is time consuming to change the connections to the sample while still maintaining the same experimental conditions.

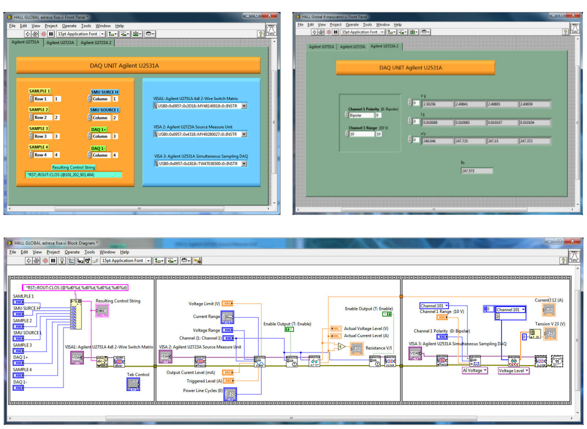

Fig.4 Hall System – LabVIEW Application Panels and Diagram

This device now can be easy integrated into a remote controlled laboratory. LabVIEW facilities can be used directly or a new client-server application could be developed easily.

III. Conclusions

The setup presented in this paper can be used in both laboratory work and for developing research areas in thin layers and nanosytems.

The system was tested with some Ni samples and the measurement result is in good agreement with the scientific publications.

It is proven that this modular system can be easily developed in the laboratory and can be adapted to different laboratory measurements using Agilent Measurement Manager (or VEE-Pro) and LabVIEW developed software.

With the future perspective in mind, it is possible to develop such a product for the market and to be used in university research laboratories.

Using LabVIEW Virtual Instrumentation with the Agilent USB Modular Instruments, this measuring system can be reconfigured for other applications. This family of USB-based modular instruments offers the flexibility to arrange and rearrange configurations to fit changing measurement needs – efficiently and affordably.

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