Multifunction iLab Implemented Laboratory

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Abstract - **This paper introduces a new and flexible Multifunction System. By using LabVIEW 2010 Graphical Programming and or VEE-Pro with the new class of Agilent USB Devices in this application, at the University Transylvania of Brasov was developed a Flexible Laboratory Instrumentation System (FLIS) for new nanostructurated materials. This development offers great benefits to university research laboratories which need flexible systems that can be configured easily, to match the testing needs. At the same time, this FLIS Measurement System can be remotely controlled using MIT’s iLab Shared Architecture and is providing a uniquely modern, Web-controlled collaborative platform in research and education.**

Index Terms: iLab; Remote; Online Laboratories; Virtual Instrumentation; E-Learning;

I. INTRODUCTION

It has been developed an Online Laboratory Grid node at “Transilvania” University of Brasov based on the iLab Shared Architecture and an Flexible Laboratory Instrumentation System FLIS for new nanostructurated materials, using Agilent Modular USB instruments technology as a Remote Application. Application was already included in Lab2go - A Repository to Locate Online Laboratories.

Lab2go is a central access point where people can find actual information about current projects, research results, state of the art technologies, contacts to developers or institutions and a list of links to available laboratories is currently completely absent. It is a web application using Semantic Web technologies combined with simple mechanisms which have the potential to foster the information flow and contribute the evolution of online laboratories [1].

Nevertheless, each online laboratory developer has his/her own security policies and adopt a preferred technology to deliver the access to online laboratories. Grid technologies can be used to set up an effective network of remote laboratories for education purpose by sharing instrumentation and resources. However, the evolution of remote laboratories from the current client/server architecture to grid-based architecture requires well-defined tools for location, security, and integration of resources, and further research is currently being conducted to examine this issue [2-4].

Several universities have developed their own architectures to share online laboratories across institution basis. One of these architectures is the ISA (iLab Shared Architecture) developed at the Massachusetts Institute of Technology. The services provided by ISA are used to provide access control, framing and maintenance of user sessions for this laboratory.

The MIT’s iLab Shared Architecture is a software architecture that offers Online Laboratory developers and users a common framework to use and share Online Laboratories.

Overall, this architecture divides an online laboratory into three distinct parts: the Lab Client, the Service Broker and the Lab Server. The Lab Client is the user’s interface to the iLab while the Lab Server connects to the laboratory hardware and manages the execution of user submitted experiments. The MIT’s iLabs Shared Architecture (ISA) specifies that Lab Clients and Lab Servers contain lab specific functionality. The Service Broker is responsible for providing functionality that is generic and useful to all iLabs.

The ISA provides a framework for the deployment of iLabs in a distributed fashion using web services. This allows online laboratories developed on the ISA to be made available to users worldwide using standard network protocols.

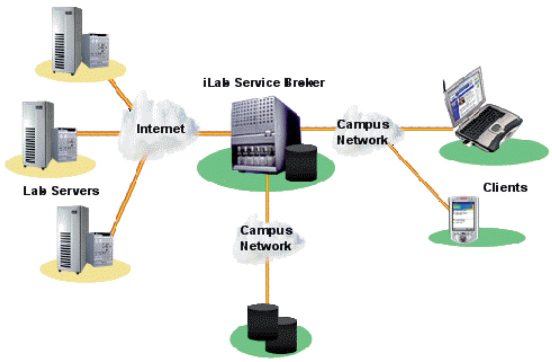

Fig. 1 iLab Shared Architecture

For storing experiment data the Service Broker provide the functionality: Experiment Storage Service (ESS). The ESS is a stand-alone web service that allows Service Brokers, Lab Servers and Lab Clients to store experiment data. This includes binary data (images, video or audio) and XML based text/numeric data. As an independent system, a single ESS can potentially be used by many Brokers and their associated laboratories.

The session is initialized when the user logs on to the Service Broker and himself authenticates. The user must schedule a laboratory and only at the scheduled time the laboratory can be launched by redeeming the reservation. Scheduling Services in the ISA consists of two separate, web services-based systems, the User-side Scheduling Service (USS) and the Lab-side Scheduling Service (LSS). User-side Scheduling Service is used in conjunction with the LSS to allocate laboratory time to users.

Using the USS, the user who wants to schedule time on a given laboratory must select from a set of available blocks of time published by the LSS. Once a time is selected, the USS stores the reservation for later redemption and the LSS removes it from the list of available time blocks

The first implementation of the iLab Shared Architecture at "Transilvania" University of Brasov was made in August, 2010 with one Hall Measurement System (Fig.2) and a digital electronic interactive laboratory developed in cooperation between "Transilvania" University of Brasov from Romania and Carinthia University of Applied Sciences from Austria. It is presented as an attempt to enable students to perform remotely and in real time several distinct experiments. The digital electronic laboratory is based on a CPLD Integrated Circuit, of the type (Altera CPLD MAX series), which can be programmed with the Altera MAX+PLUS II software. The digital signals are generated and the responses are acquired by a data acquisition board controlled by LabVIEW.

II. MODULAR DEVICES

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

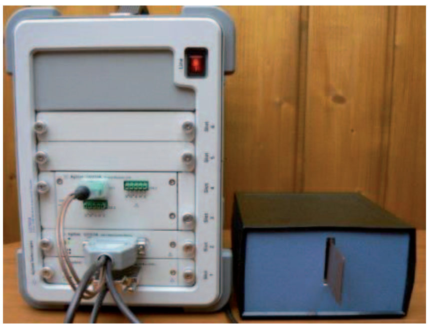

Fig. 2 First module – the Hall Measurement System

In Fig.3 these devices are presented as independent USB devices that can be used without the necessity to use the U2781A six slot USB Modular Instrument Chassis. Any of these devices come with: power sources, USB cable and one block connector and can be used independently as a measurement device.

Fig. 3 Agilent USB devices:U2351A,U2751A and U2723A

All these USB devices have as software the Agilent Measurement Manager AMM. This AMM automatically tests the presence of any Modular Device or Modular Instrument Chassis attached to the computer and offers a fast solution to select, configure, test and use these devices (Fig. 4).

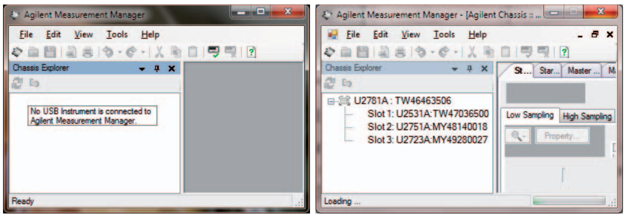

Fig. 4 Agilent Measurement Manager AMM

From Fig.5 it can be seen that this Measurement Manager offers the necessary support for the researcher to make tests and developments using "simulated instrumentation devices". This facility can be used in the development stage before the researcher decides to acquire and use a new modular instrument.

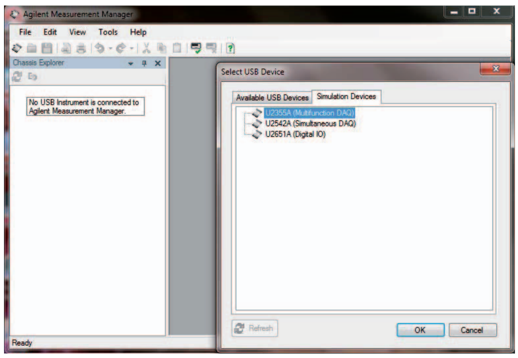

Fig. 5 AMM selection for "simulated devices"

The control and AMM interface for one of these USB DAQ U2531A is presented in Fig. 6, a four channel Simultaneously Sampling (14 Bits 2 MS/s) modular instrumentation device. As one can see, all the four channels were selected and the AMM control makes a continuous simultaneous acquisition on these channels.

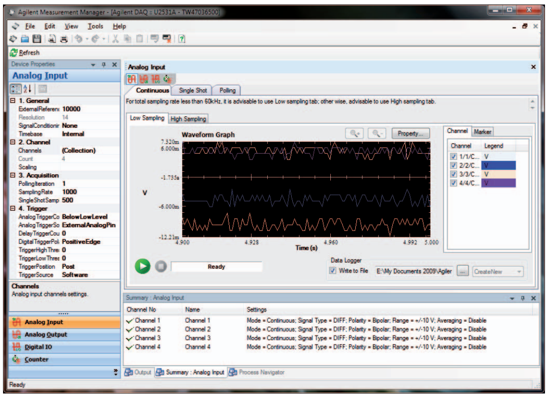

Fig. 6 AMM software control

III. LabVIEW and VEE-Pro Measurements

In 1878 it was discovered by Edwin Hall that there is a current in a perpendicular direction 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 [5].

Four neodymium magnets were acquired for developments and were constructed in two systems with different configurations of the fixed magnetic field (Fig.2 and Fig.7).

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 until 15 x 15mm) with a gap of 8-10 millimeters between the poles.

The measured magnetic field was 1.80 Tesla (for the system in Fig.1) and 1.57 Tesla for the second one (Fig.6). One external Cryomagnetics' Model GM-700 Hall Effect Gaussmeter was used for these measurements. It was also used to calibrate the field sensor developed on the sample holder presented in Fig.7.

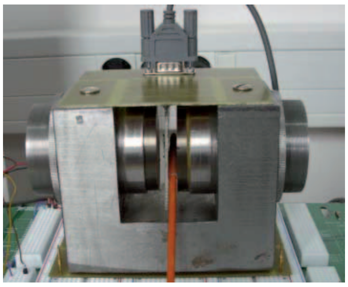

Fig. 7 Magnet with adjustable distance

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);
- On one side of the sample holder, we measure the magnetic field using the Analog Devices AD 22151 sensor which was installed on the sample holder system near the sample (see the Fig. 7)

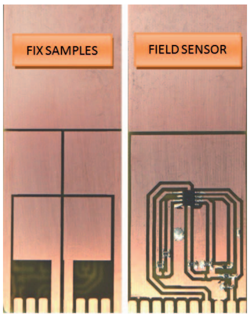

Fig. 8 Sample holder with Analog Device AD22151 field sensor

A second structure of the sample holder offer the posibility to heat the samples and measure electrical conductiona and/or Hall measurements versus temperatures in the reange of 20-80 degree Celsius (Fig. 9). The heater was drived by 5V/1.8 A.

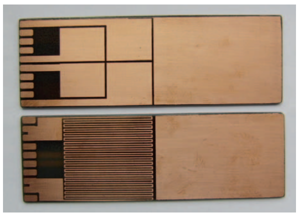

Fig. 9 Sample holder with heating facility

Preliminary tests were done using the Agilent Measurement Manager AMM which allows fast hardware identification, selection and configuration of the testing system.

The main application starts by identifying the VISA devices inserted in the USB Modular Instrument Chassis.

After detection and selection all inserted modules can be configured and tested individually (Fig.10).

Fig. 10 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 the 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.

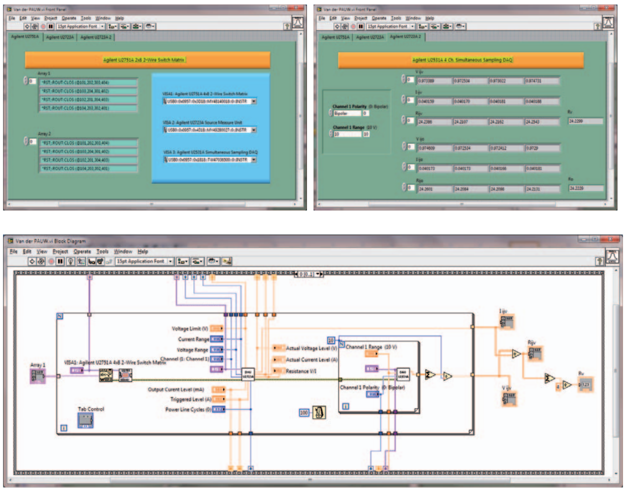

Fig. 11 Van der Pauw Rezistivity, LabVIEW Panels and Diagram

One sequential structure was selected for the LabVIEW application (see the "DIAGRAM" of one of the virtual instruments in Fig.11). For this reason, in the application "PANEL" one "TAB structure" was used which offers an easy understanding of the modular structure imposed by this multifunctional developed device.

In the TAB structure the user can select "step by step" all that is necessary to configure the system and to perform the measurement (Fig.12): configure the Switch Matrix U2751A, configure the Source Measure Unit U2723A, configure the DAQ U2531A and read the tensions

The developer can easily add in the future new sequences or modify the actual development using these structures (Fig.12), the TAB in "panel" and the SECVENCE in the Virtual Instruments "diagram".

For example, one sequence that will use the Cannel 4 of the USB DAQ U2531A module can be inserted for field measurement because we added the magnetic field measurement for some sample holders by Analog Device system (AD22151), and the result will be used in the final HALL measurement.

In the applications Diagrams of the virtual instruments (from Fig.11 and Fig.12) it is also easy to "insert","delete" or "modify" one sequence - function of the future researcher needs.

The Four Probe Method is one of the standard and most widely used methods for the semiconductors' resistivity measurement. In its useful form, the four probes are collinear. The error due to contact resistance, which is especially serious in the electrical measurement on semiconductors, is avoided by the use of two extra contacts (probes) between the current contacts [6].

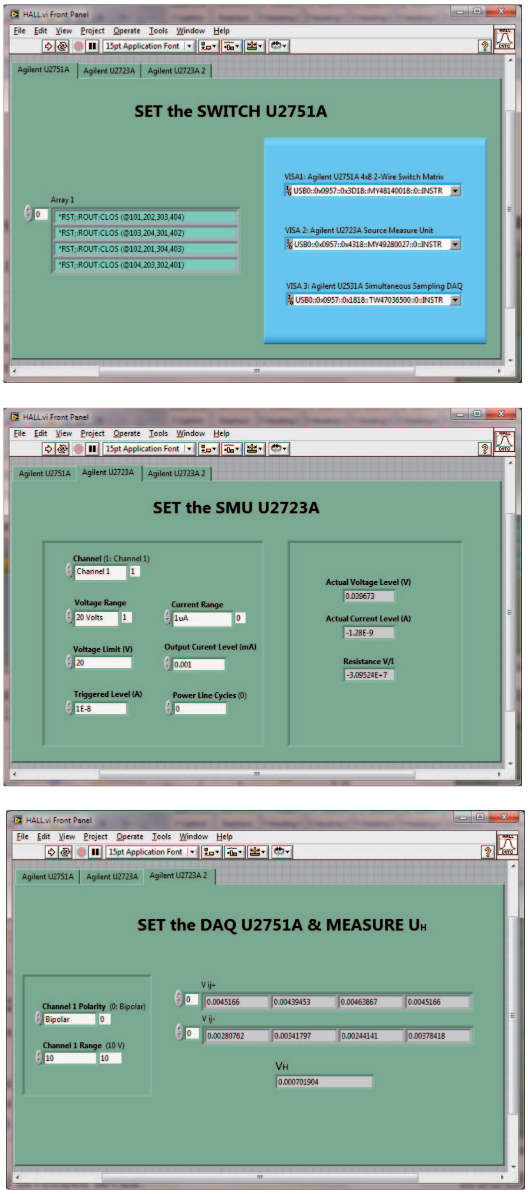

Fig. 12 LabVIEW Control Panel (selecting the TAB structure)

In this arrangement the contact resistances may all be high in comparison with the sample resistance, but as long as the sample and contact resistances are smaller than the effective resistance of the voltage measuring device (potentiometer, electrometer, electronic voltmeter or in our case the multipurpose developed device), the measured value will remain unaffected. Because of pressure contacts, the arrangement is also useful especially for quick measurements on different samples or sampling different parts of the same sample.

Fig. 13 presents one modified Virtual Instrument used to measure the "current-tension" characteristic for one device using the "Four Probe" measurement technology.

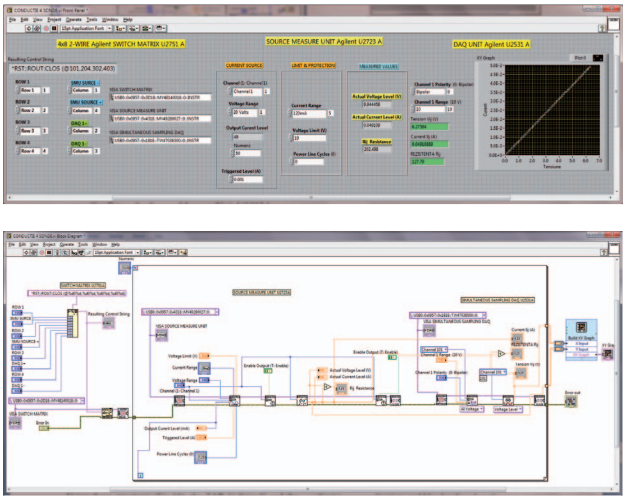

Fig. 13 Virtual Instrument adapted for I-V measurements

Using the facilities offered by the Agilent Measurement Manager AMM we can easy implement similar measurements: conduction, Van der PAUW sheet resistance, HALL etc or any new ones. Before the AMM to be configured we must start the "Command Logger" and by this we can save all the easy steps necessary to configure one new measurement.

After this we need to save the command logger file, necessary step to be able in future to convert this file in one VEE-Pro file. In the Fig.14 you can see the AMM configuration and the logger.

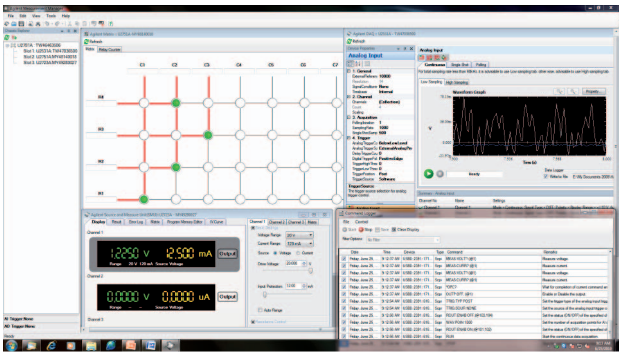

Fig. 14 Using AMM with "command logger"

After all the setup was done must save the "command loggers" in one file. This file will be transformed in one preliminary VEE-Pro application (Fig.15). The last one can be edited and easy finalized by anybody with beginner knowledge of VEE-Pro.

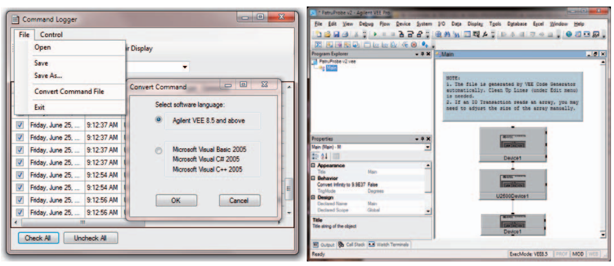

Fig. 15 Conversion from "command logger" to VEE-Pro Application

In Fig. 16 we present the application developed via the above technology. This VEE-Pro application offers the possibility to researcher to make one I-V (current-tension) characteristic for any thin layer material.

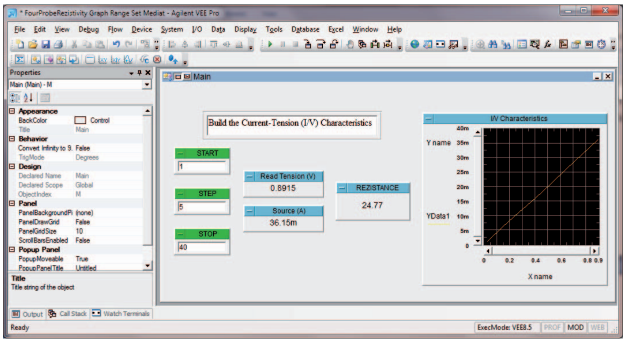

Fig. 16 I-V Characteristics controlled in VEE-Pro

With similar steps we was able to developed more VEE-Pro applications and we present in Fig. 17 the diagram of the HALL VEE-Pro application for HALL measurement.

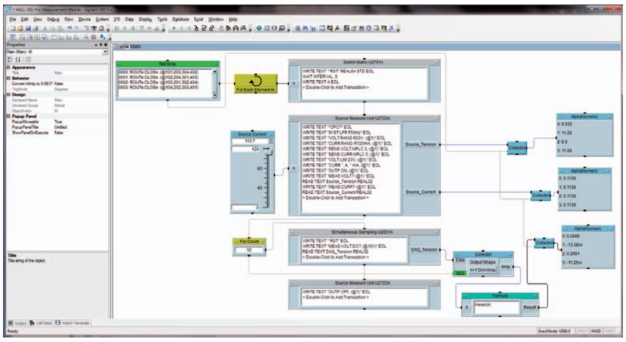

Fig. 17 The Hall Measurement VEE-Pro Application

After this the two developments was iLab implemented we continued the developments to add new facilities to this FLIS Laboratory [7].

IV. New FTIR Components

First we adapted the new U2941A Parametric Test Fixture for electrical measurements (Fig.18) and we developed two Helmolts coils for magnetic sensors measurements (especially in low bipolar magnetic field).

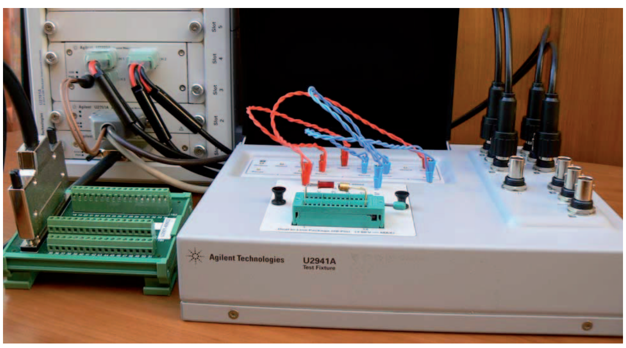

Fig. 18 Electrical measurements using Test Fixture with FLIS

This two new integrated systems was driven by the same Source Measure Unit SMU USB U2723A and combined with the free channels of the USB U2531A Simultaneous Sampling DAQ system (for tension measurements).

The final system (Fig.19) for electrical and magnetical materials characterization developed will be added to the Hall measurement facility and will be the proposed Flexible Laboratory Instrumentation System FLIS.

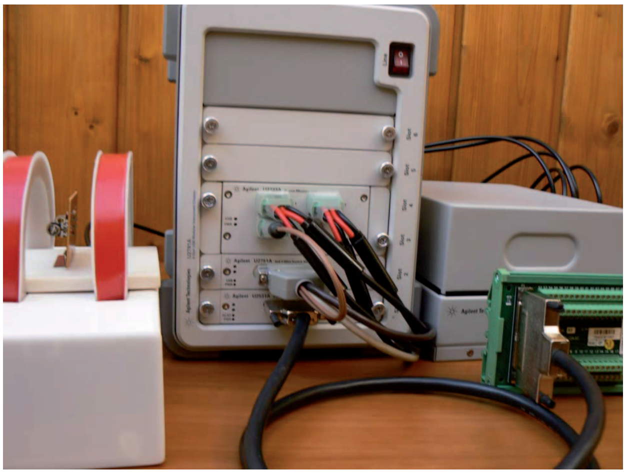

Fig. 169 The Flexible Laboratory Instrumenstation system FLIS

V. CONCLUSIONS

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

The system was tested with some diferent 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 this future perspective in mind, it is possible to develop such a product for the market and for the implementation in university research laboratories.

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

Implemented in iLab this FTIR laboratory offer one complex facility well received in students training.

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