VIRTUAL INSTRUMENTATIONS

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Abstract: The rapid adoption of the PC in the last twenty years has brought about a revolution in research, measuring and automation instrumentation. The invention of virtual equipment, which has many benefits for engineers and scientists who need greater efficiency, precision and performance. Every parameter within the industry or laboratory needs measurement, for measuring those quantities dedicated instruments are more often used. These instruments provide very accurate measurements and are reliable, but they can't be customized. They are considerably useful in industries, but they cannot meet the wants of scientists and research workers. The drawbacks of conventional instruments are removed by a virtual instrument. Virtual instrumentation combines sensing and hardware technology to provide versatile and complicated instruments for different control and monitoring applications. On this basis, we discuss various underlying concepts and technologies. The paper covers the general architecture of a virtual instrument, describes the most frequently used tools and platforms. This research work has intended to identify the clusters of embedded systems where the application of virtual instrumentation concept can be used; one can apply the concept of virtual instrumentation for developing different applications of signal and image processing, automotive, mechanics, control and simulation, embedded software designing, microprocessor coding, etc.

I. INTRODUCTION

An instrument is a tool designed to gather data from an area, or from a test unit, and present information to a user based on the data gathered. Such an instrument can use a transducer to detect changes in a physical parameter, such as temperature or pressure, and translate sensed information into electrical signals, such as variations in voltage or frequency [1]. The term instrument can also be defined as a physical software device performing an analysis of data acquired from another instrument and then outputting the data processed to display or record information. The second group of recording instruments can include oscilloscopes, spectrum analyzers and digital millimeters. Therefore, the types of source data obtained and analyzed by instruments may vary widely, including both physical parameters such as temperature, pressure, size, light and sound frequency and amplitudes, and electrical parameters like voltage, current and frequency [9].

Virtual instrumentation is an interdisciplinary field of sensing, hardware and software technology with the goal of developing flexible and complicated tools for control and monitoring applications. The idea of virtual instrumentation was born in the late 1970s, when microprocessor technology made it simpler for a computer to modify its functions by modifying its software. Flexibility is possible because the functionality of a virtual instrument relies very little on the dedicated hardware – typically just the application-specific signal conditioning module and the analog-to-digital converter used as an interface to the external world. The simple use of computers or specialized on-board processors in instrument control and data acquisition can not therefore be described as virtual instrumentation. Increasing numbers of biomedical applications use virtual instruments to gain insights into the fundamental essence of complex phenomena and the the costs of medical equipment and procedures [7]. A virtual instrument is characterized as a computer equipped with user-friendly application software, cost-effective hardware and driver software to perform the functions of conventional tools as shown in Fig. 1[3].

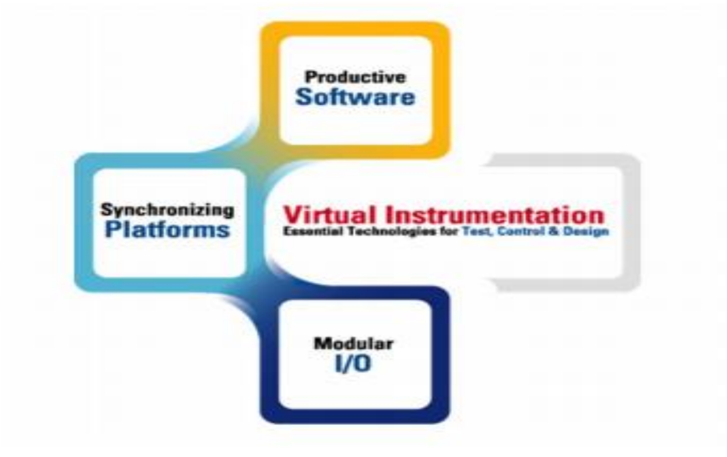

Figure 1. Outline of a virtual instrumentation concept

Figure 1 shows Virtual instrumentation combines productive software, modular I/O and scalable platforms

2. VIRTUAL INSTRUMENT VERSUS TRADITIONAL INSTRUMENT

Stand-alone conventional instruments such as oscilloscopes and waveform generators are very efficient, expensive and designed to perform one or more particular tasks specified by the supplier. However, it is usually not possible for users to expand or modify them [3]. The controls and controls on the instrument, the built-in circuitry and the features available to the user are all unique to the design of the device. In addition, special equipment and costly materials must be created to create these devices, making them very expensive and slow to adapt.

Through virtue of being PC-based, virtual instruments automatically profit from the advantages of the latest technologies implemented in off-the-shelf PCs. Such developments in technology and performance, which rapidly close the gap between stand-alone instruments and PCs, include powerful processors such as the Pentium 4, and operating systems and software such as Microsoft Windows XP, NET, and Apple Mac OS X. Such devices also provide easy access to powerful resources such as the Web, in addition to integrating powerful features. Traditional instruments also often lack portability though virtual instruments running on notebooks implement their portable design automatically.

Table 1. Traditional Instruments Vs Virtual Instruments

Traditional Instruments	Virtual Instruments
Vendor-defined	User-defined
Function-specific, stand-alone with limited connectivity	Application-oriented system with connectivity to networks, peripherals, and applications
Hardware is the key	Software is the key
Expensive	Low-cost, reusable
Closed, fixed functionality	Open, flexible functionality leveraging off familiar computer technology
Slow turn on technology (5–10 year life cycle)	Fast turn on technology (1–2 year life cycle)
Minimal economics of scale	Maximum economics of scale
High development and maintenance costs	Software minimizes development and maintenance costs

Table 1 shows the difference between traditional instruments and virtual instruments

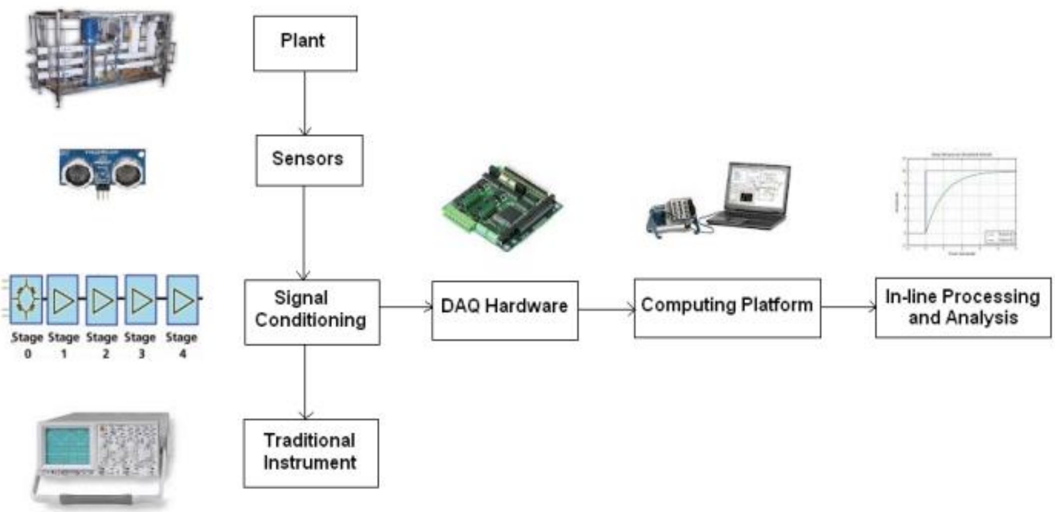

Figure 2. Signal flow in Traditional and Virtual Instrumentation systems

3. VIRTUAL INSTRUMENT ARCHITECTURE

The virtual instrument consists of the following blocks:[1]

- Sensor module
- Sensor interface
- Medical information systems interface
- Processing module
- Database interface
- User interface

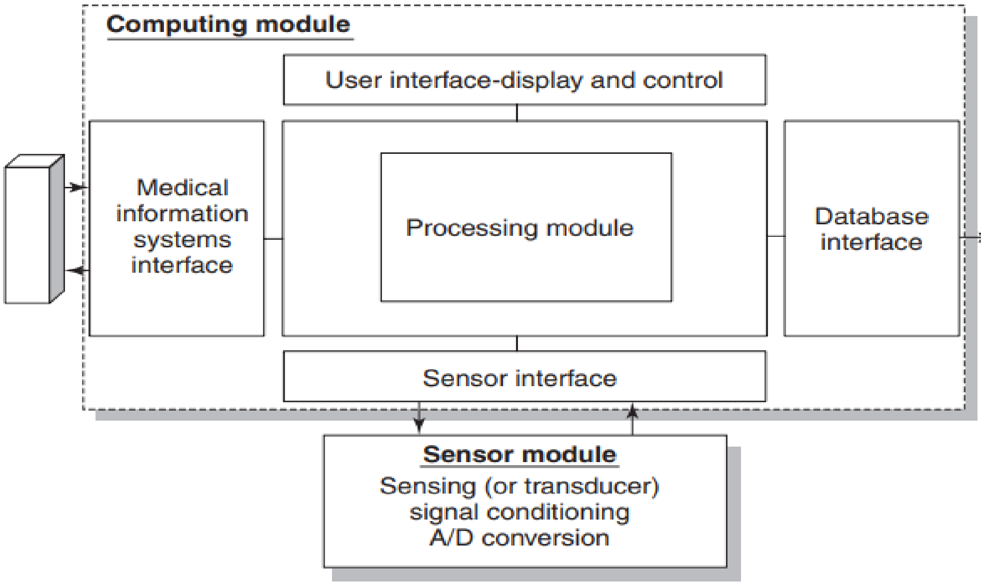

Figure 3. Architecture of a virtual instrument

The sensor module senses physical signals and translates them into electrical form, conditions the signal and turns it into a digital form for further manipulation. The sensor module communicates with a computer through a sensor interface. When the data is in digital form on a computer, it can be interpreted, combined, compared and otherwise manipulated or stored in a database. The data can then be viewed or converted back to an analog form for additional process control [11].

The sensor module performs signal conditioning and transforms it into a digital form for further manipulation. Sensor Interface used for communication between sensors modules and the computer. Processing Module: Integration of the general purpose microprocessors/microcontrollers allowed flexible implementation of sophisticated processing functions. Database Interface provide efficient management of data and standardized insertion, update, deletion and selection. Medical information system interface: Virtual instruments are increasingly integrated with other medical information systems, such as hospital information systems

4. TOOLS AND PLATFORMS

In this section, we define hardware platforms, operating systems and development environments that are often used in the development of virtual instruments.

4.1 Hardware Platforms and Operating Systems

Virtual instrumentation and "measurement revolution" are the direct product of another revolution — the Computing revolution offering a common digital instrumentation hardware platform based on Industry Standard Architecture (ISA) (64). Many personal computing systems have also been used, however. LabVIEW 1.0, for example, was built on a Macintosh computer that was still supported by LabVIEW [11].
Operating systems provide a uniform view of the underlying hardware through the device driver layer, which isolates the specifics of the sensor interface or sensor unit. Commonly used operating systems are Windows operating systems (MS DOS at the early days of computer instrumentation, 95/98/NT/2000/XP / CE), UNIX / Linux, and MacOS.

4.2 Development Environments

We describe two types of virtual instrumentation development environments:

- Conventional programming language environments
- Graphical programming environments

Table 2. Difference between Conventional programming language and Graphical programming language

Text Based Programming	Graphical Programming
Syntax must be known to do programming	Syntax is knowledge but is not required for programming
The execution of the program is from top to bottom	The execution of the program is from left to right
To check for the error the program has to be compiled or executed	Errors are indicated as we wire the blocks
Front panel design needs extra coding or needs extra work	Front panel design is a part of programming
Text based programming is not interactive	Graphical programming is highly interactive
This is the text based programming where the programming is not conventional method	The programming is data flow programming
Logical error finding is easy in large programs	Logical error finding in large programs is quiet complicated
Program flow is not visible	Data flow is visible
It is Text based Programming	It is icon based programming and wiring
Passing parameters to sub routine is difficult	Passing Parameters to sub VI is easy

4.2.1 Conventional programming language environments

In the late 1970s and early 1980s, BASIC became the dominant language used by dedicated instrument controllers. In the mid-and late 1980s, new programming languages became popular, particularly C, as they allowed high-level programming with efficient code. The first version of LabVIEW was written in C. Almost any programming language can now be used to build computer devices [1].

4.2.2 Graphical programming environments

4.2.2.1 LabVIEW

LabVIEW. National Instruments' LabVIEW made development of virtual instruments more accessible to laboratory users and physicians. LabVIEW is the most popular virtual instrumentation tool, and it has been applied to many fields, including virtual bioinstrumentation. LabVIEW was launched with the goal of providing a software tool that empowered engineers to develop customized systems. LabVIEW introduced GUIs and visual programming into computerized instrumentation. LabVIEW is a program development environment, like Java, C, or BASIC. However, although other programming systems use text-based languages to create code, LabVIEW uses a graphical programming language, called G. In LabVIEW, programs are formed as block diagrams. LabVIEW uses the data-flow programming model, in which the execution order is determined by the flow of data between blocks. LabVIEW is also a multitasking and multithreading system.

LabVIEW is a general-purpose programming system with extensive libraries of functions for any programming task. In addition, LabVIEW includes libraries for DAQ, instrument control, data analysis, data presentation, and data storage. It also includes conventional program development tools, such as a debugger; supports many devices and interface standards; has thousands more of built-in analysis, math, and signal processing functions; as well as provides support for SQL and ADO database connectivity, and open connectivity through XML, TCP/IP, wireless, and other standards[5].

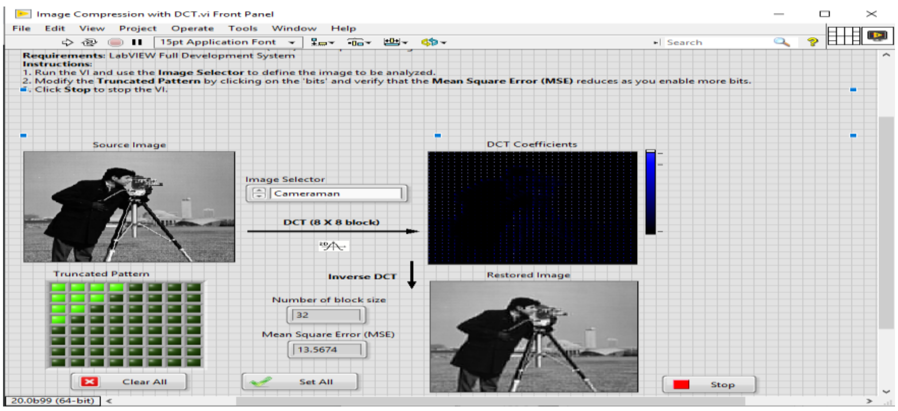

Figure 4. An example of the LabVIEW virtual instrument interface.

4.2.2.2 BioBench

BioBench is developed as an extension of LabVIEW for biomedical measurements to promote the development of virtual biomedical instruments. LabVIEW significantly simplifies programming by adding a visual notation, but it still takes a lot of work to construct a virtual instrument. BioBench is specifically designed for the acquisition and analysis of physiological data needs of the life science, medical research, and education markets. It has ready-to-run data acquisition and data analysis capabilities that can help you save time and money by integrating your personal computer with your physiological monitoring system.

Using National Instruments data acquisition hardware, you can use BioBench to acquire data from virtually any type of physiological, linear-voltage signal source. While your physiological data is being acquired, BioBench can save it to disk along with any notations you want to add. After you save your data to disk, you can use BioBench to open your data file for review and analysis.

Advantages of BioBench over LabVIEW:

- LabVIEW is a full programming language, where BioBench is the extension of LabVIEW
- In LabVIEW you must create the application yourself while BioBench is already made and ready to use
- BioBench is simpler to use than LabVIEW, i.e., shortened design time, but flexibility is substantially reduced
- There are no real additional capabilities in BioBench. LabVIEW can do absolutely everything Biobench does

5. APPLICATIONS OF VIRTUAL INSTRUMENTATION

5.1 Virtual Instrumentation in Biomedical

In the biomedical sector, virtual instrumentation has been increasingly accepted. In relation to the function of a virtual instrument, we can generally classify biomedical applications of virtual instrumentation in four categories.

- Examination, where a physician conducts an electronic or off-line analysis of patient measurements
- Monitoring, which can be used as a basis for real-time warnings and interactive alarms
- Training and education, where a virtual instrument can mimic or replay measured signals
- Biofeedback, where measured signals are transmitted back to a patient in real time

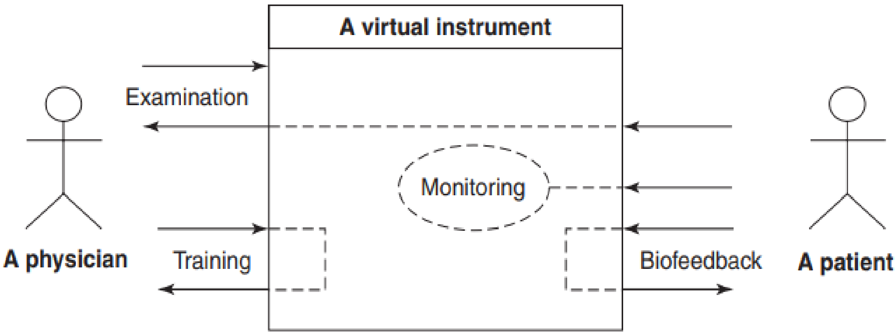

Figure 5. Types of biomedical applications of virtual instrumentation.

5.2 Virtual Instrumentation for Test, Control and Design

Virtual instrumentation has been widely used in test and measurement areas. It has gradually increased addressable applications through continuous innovation and hundreds of measurement hardware devices. The benefits that have accelerated test development are beginning to accelerate control and design.

5.2.1 Virtual Instrumentation for Test

The test was a long-established field for virtual instrumentation. While the rate of innovation has increased, so too has the demand to get fresh, differentiated products onto the market quickly. Consumer expectations continue to rise; in electronics markets, for example, a diverse convergence of functions is needed in a small space and at a low cost. Each of these requirements contribute to new needs for validation, verification and production research.

Virtual instrumentation is a creative solution to this problem. It blends fast software development with modular, scalable hardware to build user-defined test systems.

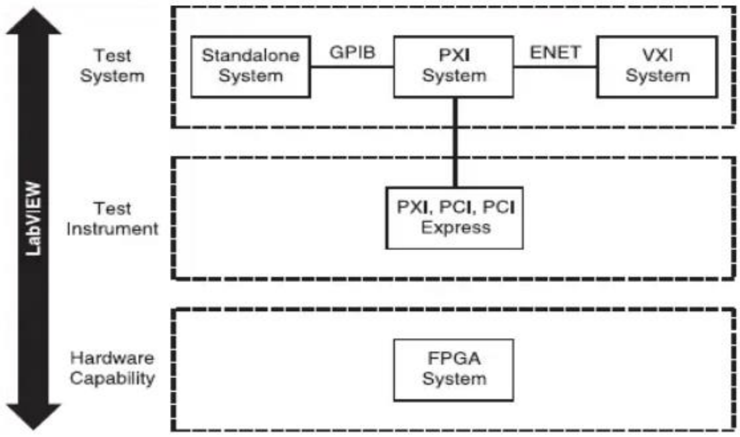

Figure 6. User-defined instruments and customizable hardware for test systems.

5.2.2 Virtual Instrumentation for Industrial I/O and Control

Both PCs and PLCs play a significant role in both control and industrial applications. PCs provide greater versatility and functionality, while PLCs provide outstanding robustness and reliability. Yet, as control needs become more complex, there is a recognized need to improve capabilities while retaining robustness and reliability. Some areas where virtual instrumentation used as I/O and Control [9].

- Automatic Controls and Dynamic System
- Robotics

5.2.3 Virtual Instrumentation for Design

Virtual instrument plays a critical role in the design and manufacture of today's electronic devices. Virtual instruments used in following areas for design.

- Signal and Image Processing
- Embedded System Programming
- Simulation and Prototyping

5.3 Virtual Instrumentation in Engineering Process

5.3.1 Research and Design

In research and design, engineers and scientists call for rapid production and prototyping capabilities. With virtual instruments, you can easily create a software, take measurements from an instrument to test a prototype, and evaluate the results, all within a fraction of the time needed to carry out tests with conventional instruments. When you need versatility, it is important to have a flexible open platform, from desktop to embedded systems, to distributed networks [3].
The demanding requirements for research and development (R&D) applications require seamless software and hardware integration. Whether you need to interface stand-alone tools using GPIB or directly acquire signals on your computer with data acquisition board and signal conditioning hardware, LabVIEW makes integration simple. With virtual devices, you can also automate a test process, remove the risk of human error and ensure accuracy of results by not adding unknown or unpredictable variables.

5.3.2 Manufacturing

Manufacturing applications require software to be reliable, high-performance, and interoperable. LabVIEW-based virtual instruments deliver all of these advantages by incorporating features such as alarm management, historical data patterns, security, networking, industrial I/O and business connectivity. Using this feature, you can conveniently connect to a wide variety of industrial devices such as PLCs, industrial networks, distributed I/Os, and plug-in data acquisition boards. Through exchanging code around the enterprise, the manufacturing sector can use the same LabVIEW software built in R&D or validation and integrate seamlessly with the manufacturing test processes [11].

6. CASE STUDY

6.1 Design and Development of Virtual Instrumentation System for Measurement of Human Body Parameters

Objective

To design and develop a system that is used to test biomedical parameters through wireless using a Lab VIEW. The system comprising body sensors that communicates wirelessly with the patients control device for external communication. The project focuses especially on wireless communication and multi sensor.

Problem with Existing System

There are several existing systems which are only used to calculate one or two biomedical parameters at a time. There is no method used for calculating more than two parameters at a time in a single method. In addition, all of the systems currently used are wired systems which make it difficult for the device to be portable and link to the web page on the Web. Microcontrollers and others are the controllers used in embedded systems.

Different Technologies of Wireless Communication

- Using Wap Technology
  A project that involves instruments to calculate parameters such as body temperature, ECG, pulse monitor and pass it to a computer so that the patient's wellbeing can be monitored by physicians in any part of the hospital. This reduces the workload of the doctor and also provides correct tests. Further, this device uses WAP technology which enables all parameters to be viewed on a mobile phone. The microcontroller board is used to evaluate patient inputs, and any abnormality detected by the patient triggers the monitoring device to cause an alarm. All process parameters are also reported online within a user-selectable interval. This is also helpful for future analyses and analyses of the state of the patient. For more practical medical applications, this project can be invented by adding blood pressure monitoring devices, dental sensors and announcing devices, making it useful in hospitals as a highly effective and devoted patient.

- Using RF Technology
  The project is designed and developed for remote monitoring of patients using a wireless communication network. The main objective of this project is to monitor the patient's body temperature and to demonstrate the same to the doctor by means of RF technology. In hospitals, the body temperature of patients must be continuously checked, as is normally done by doctors or other paramedical personnel. They observe and maintain a record of the body temperature of patients on an ongoing basis.
  The components used in this project include a microcontroller 8051, a power supply unit, a temperature sensor, an RF transmitter, a receiver module and an LCD monitor. The microcontroller is used as a central processing unit to monitor patients' body temperatures. The work of this project is illustrated by a block diagram consisting of a power supply block that provides electricity to the entire circuit and a temperature sensor that measures the patient's body temperature.

- Using Virtual Instrumentation
  This project develops a system for tracking human body parameters such as temperature, heart rate, ECG using embedded web server and Lab VIEW technology. The hardware is designed for Lab VIEW and wireless as well as for different sensors. Lab VIEW is used in the software component to provide the user with a GUI-based environment and wireless is used to create an embedded web server. It can be used on the Internet via a website or a network system so that patients' illnesses and biomedical parameters can be tracked worldwide. It is a low cost and low power system in both hardware and software terms.

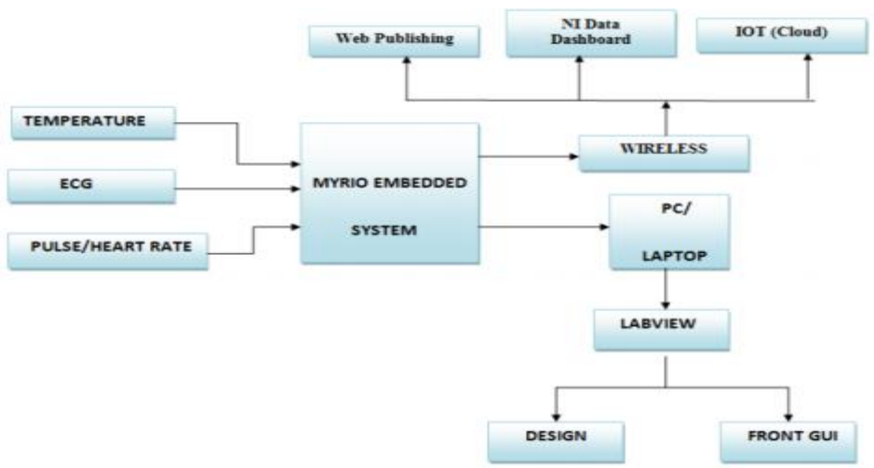

Figure 7. Block diagram of measurements of human body parameters through virtual instruments

7. CONCLUSION

In this paper we addressed the general architecture of a virtual instrument, describes the most frequently used tools and platforms. We also addressed the application of virtual instrumentation and their impact on different domains. The results show that virtual instrumentation has many advantages over the "conventional" instrumentation. Digital instruments are produced using industry-standard multipurpose parts, and very little depends on dedicated hardware. Digital devices are typically more versatile and scalable because they can be quickly reconfigured in software. In addition, standard interfaces allow the seamless integration of virtual instruments into a distributed system. Virtual instrumentation dramatically reduces the price of an instrument, as it is built on mass-produced general purpose computing platforms and specialized sensors for a specific application. We expect an increase in the number of hardware and software modules for the virtual instrumentation industry. They will provide building blocks for the next generation of devices and measurements. It wouldn't come as a surprise that the virtual prefix would soon vanish as virtual instrumentation became commonplace.

ACKNOWLEDGEMENT

This work is supported by National Instruments R&D India.

REFERENCES

[1] JOVITHA JEROME, "Virtual Instrumentation using LabVIEW", PHI Learning Private Limited, M-97, Connaught Circus, New Delhi, ISBN-978-81-203-4030-5, 2010.

[2] Z. Yi, J. Jian-Jun, and F. Shao-Chun, "A LabVIEW-Based, Interactive Virtual Laboratory for Electronic Engineering Education," International Journal of Engineering Education, Vol. 21, No. 1, p. 94-102, 2005.

[3] O. Gol, J. Machotka, Z. Nedic, "Project-Based Virtual Instrumentation in Engineering Education" Proceedings of the International Multi-Conferenceon Society, Cybernetics and Informatics (IMSCI 07) p. 223-227, 2007.

[4] Y. Ugurlu, "The role of Graphical System Design (GSD) in engineering education" – Case Study: Introduction of NI Application Contest –, The Japanese Society of Engineering Educational, Annual Symposium., p.322-323, 2010.

[5] Ugurlu, Y. "Measuring the Impact of Virtual Instrumentation for Teaching and Research". In: IEEE Global Engineering Education Conference (EDUCON), pp. 152–158 (2011)

[6] Portillo, E., Cabanes, I., Marcos, M., Orive, D., Sanchez, J.A. "Design of a Virtual-Instrumentation System for a Machining Process". IEEE Transactions on Instrumentation and Measurement 56(6), 2616–2622 (2007)

[7] J. Gopalakrishnan, G. Agnihotri, D.M. Deshpande, "Design and field implementation of auto Tuned virtual instrumentation corrosion controller". J. Inst. Eng. India Ser. B 98(1), 9–17 (2017)

[8] A. Lidozzi, M. Di Benedetto, V. Sabatini, L. Solero, F. Crescimbini, "Towards LabVIEW and system on module for power electronics and drives control applications", in IEEE Annual Conference on IECON 2016 (2016), pp. 4995–5000

[9] LabVIEW control design user manual, National Instruments, June 2008

[10] Q. Tang, Y. Wang, S. Guo, Design of power system harmonic measurement system based on LabVIEW, in IEEE Fourth international conference on natural computation (2008), pp. 489–493

[11] National Instruments, Application contest website(https://www.ni.com/en-us/innovations/white-papers/06/virtual-instrumentation.html)

[12] S. Begum and M Kumarnath.J "LABVIEW Based Module For Bio Signals Monitoring" International Journal of Computer Science and Mobile Computing Vol. 3,pp.423 – 431Issue. 2, February 2014.

[13] T.Bheema lingaiah, D.Hanumesh Kumar, C.Nagaraja, Solomon Woldetsadik "Development of Humidity and Temperature Measurement Instrumentation System using Lab VIEW" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 2,pp. 6365-6372, Issue 10, December 2013

[14] Seborg, D.E., Edgar, T.F., Mellichamp, D.A., Doyle, F.J.: Process Dynamics and Control, 3rd edn., pp. 145–146. John Wiley and Sons (2010)

[15] Cho Zin Myint, Nader Barsoum, Wong Kiing Ing "Design A Medicine Device For Blood Oxygen Concentration And Heart Beat Rate"Global Journal On Technology & Optimization Vol-1,pp. 66-71,June 2010