APPLICATIONS OF VIRTUAL INSTRUMENTATION IN DIFFERENT DOMAINS OF EMBEDDED SYSTEMS

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ABSTRACT

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, mechatronics, control and simulation, embedded software designing, HDL & microprocessor coding etc. The graphical tool used in virtual instrumentation such as LabVIEW can be used for designing various applications of different embedded system domains. With a heavy emphasis features of LabVIEW like user friendly interface, quick design time, existing code reuse, large no of vi database and verity of I/O support. The available graphical tool now provides better mechanism to downloaded software to embedded systems this is especially important in creating hardware prototype for apps of embedded systems this forms of flexibility available in virtual instrumentation decreases time. Virtual Instrumentation concepts can be used in different domains of embedded system is explained by implementation of Virtual Function Generator using sound card and controlling stepper motor using RS-232 in this research work. AVR Atmega8 used as intermediate controller to extract the control signals sent from LabVIEW via RS-232.

Keywords: AVR Microcontroller, LabVIEW, Stepper Motor, RS-232, Virtual Instrumentation, Automotive, Signal processing, Embedded systems.

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INTRODUCTION

Embedded System designing is the challenging field since it has been grown up. It is the combination of both hardware and software. In the earlier days, designing of firmware for the hardware of the system was really challenging. Gradually, it started to become easier because of various protocol supports and far advanced semiconductor devices. Now days it is still not much more flexible of upgrading of both hardware and software in the running system.

Embedded systems generally having any type of microprocessor as a main controller that performs various operations as per software loaded in the ROM. The loading procedure of software is tedious process from beginning. Designing cycle of such software regarding specialized hardware is again a challenge. After designing, testing and verification is more difficult. Due to the revolution in semiconductor technology and various communication protocols development have provided much more portability but still designing cycle of such a system is long and debugging is not much flexible.

Applying the Virtual Instrumentation technology in the Embedded Systems becomes very efficient way of product designing. VI can be used in many different domains of Embedded Systems like, signal and image processing, automotive, mechatronics, control and simulation, embedded software designing,

HDL modeling etc. Virtual Instrumentation has provided much more flexibility in many challenges regarding Embedded System Designing. The main idea is to use commercially available, general purposed computer as the main controller of the system instead of using special purpose embedded controller. In the PC side software complexity can be increased up to many levels so, job can be done with simpler modular hardware having comparatively less complexity. Designing, testing and verification can also be easier using GUI interface in the designing procedure. So, the overall designing period can be decreased [1, 2].

When the any designing challenge regarding virtual instrumentation comes across, the easiest solution that everyone can see is the NI LabVIEW. LabVIEW has unique stacked features. Faster prototyping with a graphical development of control or measurement application using drag-and-drop graphical icons instead of writing sequential lines of text gives the quick result instead of writing lines in the traditional way. Easily Reuse Embedded Code and Existing intellectual property that provides a framework that combines all of the functionality needed to accomplish system design goals. So, designer never requires starting from scratch. Ultimate flexibility with a real-time and FPGA-based architecture designer do not require to learn HDL languages; Signal Processing is more easier in the graphical way as comparing traditional way that requires all knowledge regarding

signal processing algorithms and equation. Large range of I/O support like USB, RS-232, Ethernet, Modbus etc. makes interface of I/O device becomes easy. Various I/O modules are available from NI to interface the external hardware in LabVIEW environment.

This paper further proceeds in four different sections to describe the concept, its implementation & results. The basic concept of how the concept of VI can be used for developing various applications in different embedded domains described in second section. Third section describes the Hardware & software implementation & obtained results of different application of two different domains of embedded systems. Finally, Aim of this work concluded in fourth section.

APPLICATIONS Of VI IN VARIOUS DOMAINS Of EMBEDDED SYSTEMS

LabVIEW is most commonly used Virtual Instrumentation tool in different domains of Embedded Systems due to its great flexibility.

Signal & Image Processing:

Using LabVIEW in the signal processing area design can be easier with the readily available tools and processing blocks. LabVIEW is used to create basic signal measurement and generating instruments like function generator, oscilloscope, spectrum analyzer, logic analyzer, voltage and current meters etc. virtually. Image processing application includes many picture editing and capturing

applications for embedded devices. Complex signal transforms and algorithms are directly available in the blocks. Camera interfacing can be easy with the expansion toolkits [3].

Automotive:

Due to graphical user interface, many testing and validation tools for manufacturing process can be made flexibly by measuring & controlling speed, acceleration, position, vibration etc. parameters. Different protocols like CAN, LIN and Modbus are widely supported in LabVIEW [3].

Mechatronics:

Designers can expedite the task of prototyping robots if they have access to real-world data such as sensor input, as well as the ability to control actuators such as motors. LabVIEW Robotics includes a new palette of VIs to configure, control, and retrieve data from some of the most commonly used sensors in autonomous vehicles. From low-cost infrared sensors to high-definition light detection and ranging (LIDAR) sensors, LabVIEW Robotics gives users the power to quickly retrieve sensor data so they can focus on implementing higher-level intelligence and control. In addition, LabVIEW Robotics offers a variety of ways to connect to and control motors, whether they are brushed DC motors, brushless motors, or stepper motors [3].

HDL Coding:

By incorporating third-party IP into NI LabVIEW software, wide range of algorithms

that are fine-tuned to Xilinx field-programmable gate arrays (FPGAs) to achieve high performance while taking advantage of code reuse. The LabVIEW FPGA Module offers two methods for importing external IP: the Component-Level Intellectual Property (CLIP) Node and the IP Integration Node combined with the Xilinx Core Generator. This white paper examines these two methods [3].

Control & Simulation

Using built-in instrument and I/O drivers interfacing to the external world can be done quickly. Simulation of various control system can be done with the help of many signal generation and mathematical functioning blocks [3].

IMPLEMENTATION & RESULT

In this Research work how the concepts of Virtual Instrumentation can be used in developing various applications in different embedded domains explain by developing prototype models for signal processing & automotive domains.

Signal processing domain includes designing of Virtual Function Generator using sound card of PC. Automotive domain includes Stepper Motor control using 8 bit microcontroller with RS-232 control link. Both implementations used NI LabVIEW as a Virtual Instrumentation developing tool. AVR Atmega8 used as intermediate controller to

extract the control signals sent from LabVIEW via RS-232.

Implementation of Stepper Motor Control Using RS-232:

This implementation aims to create the VI logic of stepper motor controlling steps. Once those step sequences are generated, the next step is to take them to outside. The easiest way is to use parallel port of PC but as LabVIEW has very less support for parallel port, RS-232 can be the second easier interface. The problem with RS-232 is that some external circuit is needed to convert control logic signals from serial to parallel.

LabVIEW is the main tool for designing functionality. AVR ATmega8 is used to extract serial command to appropriate bit values to its pins. MAX232 is used as logic

Fig.1: Flowchart of LabVIEW program of stepper motor control

level converter between microcontroller and

RS-232 port. ULN2803 is used as output driver to provide enough current to motor.

Figure.1 shows the basic flowchart of LabVIEW program. For interfacing RS-232 in LabVIEW, VISA is used so at very first, VISA is initialized at desired baud rate. Then particular data is written in the string format to the VISA Write block. While loop is rotated until the termination condition is found. After exiting from while loop VISA resource is closed and finally buffer is cleared.
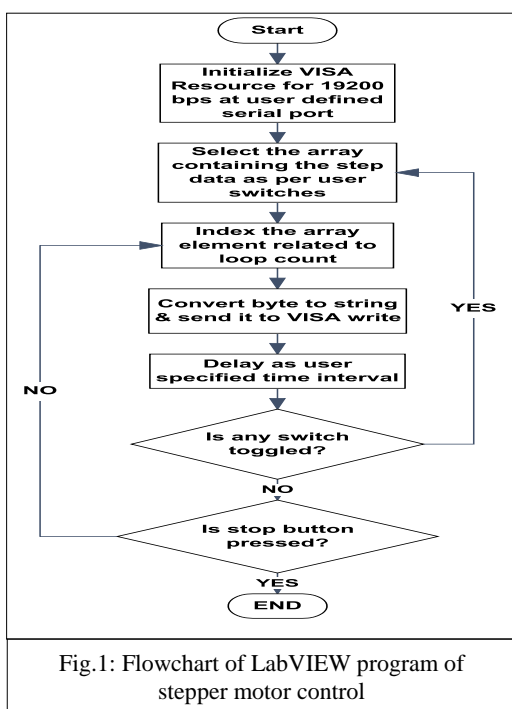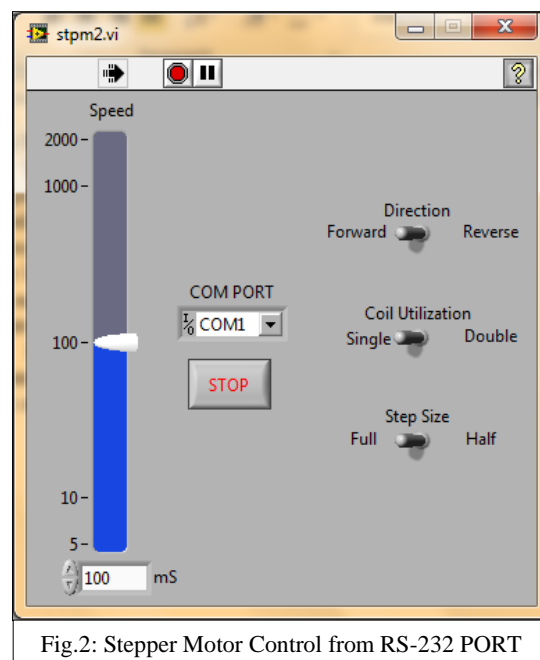

Fig.2: Stepper Motor Control from RS-232 PORT

RS-232 is widely supported by NI-VISA (One kind of I/O driver software of LabVIEW). [7, 8] Here Direction can be toggled any time during the run condition. Speed can be adjusted be changing the step delay that ranges from 5 ms to 2 sec. Coil Utilization can also be changed to change torque. Step size can be set from half to full at running condition.

Implementation of Virtual Function Generator Using Sound Card:

The job of Function Generator is to generate different function signal at user specific frequency, amplitude and phase. inside the LabVIEW [6], job of Function Generator of generating signals at specific parameters can be easily done with the internal function generator block of waveform generation but the real opportunity is to get that generated signal to outside world. Interfacing ports requires complex hardware circuitry while simple interfacing port like RS-232 is not much faster than the sampling rate of signals.

Fig.3: Flowchart of LabVIEW program of Virtual Function Generator
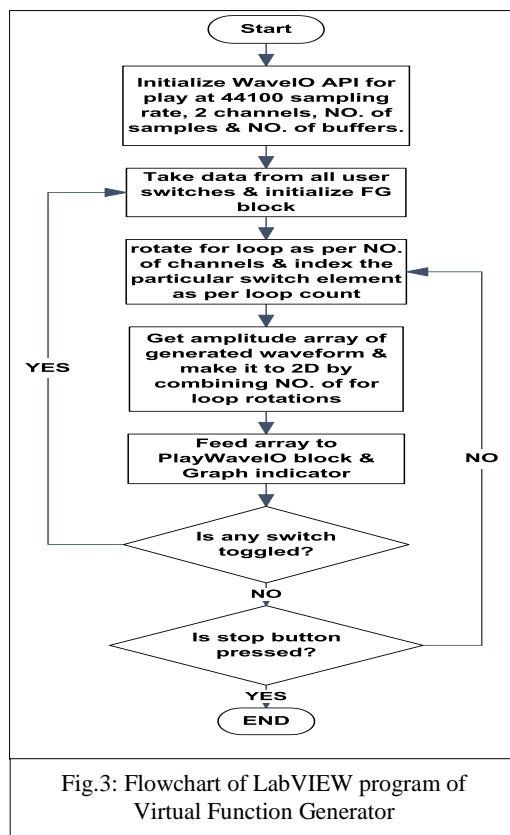
Sound card of PC is designed for the signals having higher sampling rates; the most common is 44.1 kHz. Interfacing of sound

card is possible with Wave-IO API utility designed as Sub-VI for LabVIEW [4].

The Design consist of two different channel function generator supporting generation of sine, triangular, square, saw-toothed waves at frequency range 0 to 22050 Hz with 0.1 Hz resolution, amplitude range 0 to 0.6 V with 0.0002 mV resolution and phase range 0 to 180° with 1° resolution. In the case of square wave duty cycle can be varied at 1% of resolution.
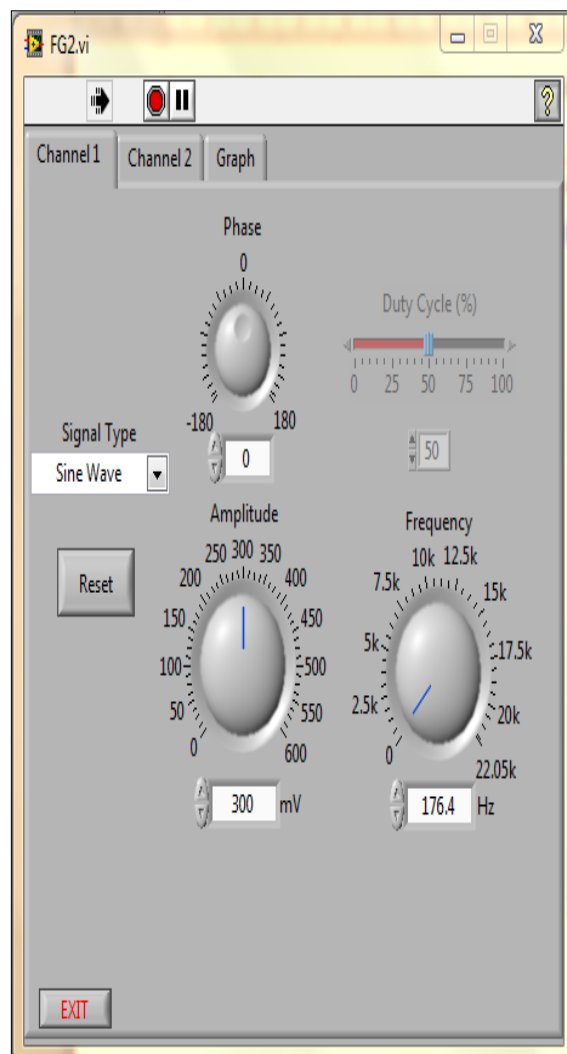

Fig. 4: 2-Channel Function Generator using sound card

CONCLUSION

LabVIEW is really a powerful tool to create VI. Virtual Instrumentation is superior among many ways than traditional instrumentation. Signal processing can be simplified by using readily available mathematical and processing blocks. Soundcard is the simplest way to bring signal to outside world. Due to the limitation of sound card amplitude is limited up to 0.6 V and signals with sudden change do not respond very well. For simple digital I/O applications, RS-232 is very much suitable interface and well supported by LabVIEW. If acknowledgement is taken back from serial port then extra delay must be used that is depended on the serial shifting time of the serial shift register.

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