Development of Remote Access and Control Features for Digital Signal Processing Laboratory Experimentations

http://dx.doi.org/10.3991/ijoe.v12i08.5957

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***Abstract*—Remote instrumentation and collaborative learning methods have enhanced the experimental learning aspects of engineering education. Automation is changing the nature of these laboratories and remote access techniques are providing access to server machine from anywhere in the world through internet. This provides an opportunity to develop the remote instrumentation laboratories using which students can perform their lab experiments remotely all over the day and thereby increasing the productivity of the lab setups and measuring instruments.**

This paper presents the detailed architecture and the implementation details of remote DSP lab instrumentation. LabVIEW user interface is developed to control all the test instruments and their related hardware interfaces. Radmin tool is used as remote access tool to integrate multiple clients to server machine through wired/wireless internet access. Hardware interface is designed and developed to route data and control signals from data acquisition card to the respective hardware and to control the test instruments.

***Index Terms*—Virtual Laboratories, Remote Access Methods**

I. INTRODUCTION

The unprecedented growth in Internet technologies has created revolutionary changes in the use of collaborative learning tools with remote experimentation. Work on lab experiments and project works requires access to expensive hardware equipment. The high cost of these instruments along with time consuming development process in individual students' projects required within the educational process creates a significant bottleneck. The restricted university budget does not allow building of a several such development and test stands, and time schedule and university security conditions restrict the time when the instrumentation be accessible for students locally in a laboratory. Remote laboratory allows students to access the laboratory instruments and the programmable devices remotely to perform their lab experiments and project work. This implementation avails lab facility for complete twenty four hours a day and will increase the productivity of the lab setups and measuring instruments.

Remote instrumentation laboratory developed for DSP training [2] uses client server methodology and connects multiple clients to the server using Virtual Instrument application. Thin Client Server manages input and outputs between client and servers. Remote access tool [9] used for this type of laboratory implementation is selected based on real time access parameters like data speed, security protocol and ability to establish multiple user environment etc. Proposed architecture provide controlled server access to multiple clients and supports simultaneous multiple client access using Radmin tool.

The existing remote laboratories on Digital Signal Processor hardware uses either the server machine to control the test instruments using GPIB interface or control is established through the DAQ cards [1][2][3]. This makes architecture more specific and cannot be reused for other laboratory implementations. Proposed architecture is more generic and uses customized interface board to interface server machine with the test instruments and unit. By making minor modification on the interface card and adding test instruments, whole setup can be used for other laboratory implementations. This makes remote architecture more generic and capable of adopting new requirements with few minor modifications in the setup.

Remote access facility is provided through the server machine using webserver has limitations on the usage of software and less control on the hardware [5][6]. Proposed architecture uses remote access method which provide complete controlled access to the server machine where user can access all the softwares and data in the server machine. This tool also provides the log history which details out the client machine details with login and logout data.

This paper describes the design and implementation details of Remote access techniques for Digital Signal Processing lab and is organized as follows. Section II describes Remote DSP Laboratory architecture. Section III specifies the interface card architecture. Section IV details out the remote access tool used for the implementation with client server access methods. Section V describes the LabVIEW user interface developed for the remote client access and control. Section VI describes control flow diagram for setting up and using the remote DSP lab instrumentation. Section VII provides a case study for setting up and programming a microcontroller board using the same test setup. Conclusions are drawn at section VIII.

II. REMOTE DSP LABORATORY ARCHITECTURE

Digital Signal Processing laboratory experiments are executed using DSP kit TMS320CXX and code composer studio software. Remote lab is designed to provide remote access to DSP kit and the required software at distant location. Detailed Interface architecture of remote DSP laboratory is as shown in Figure 1.

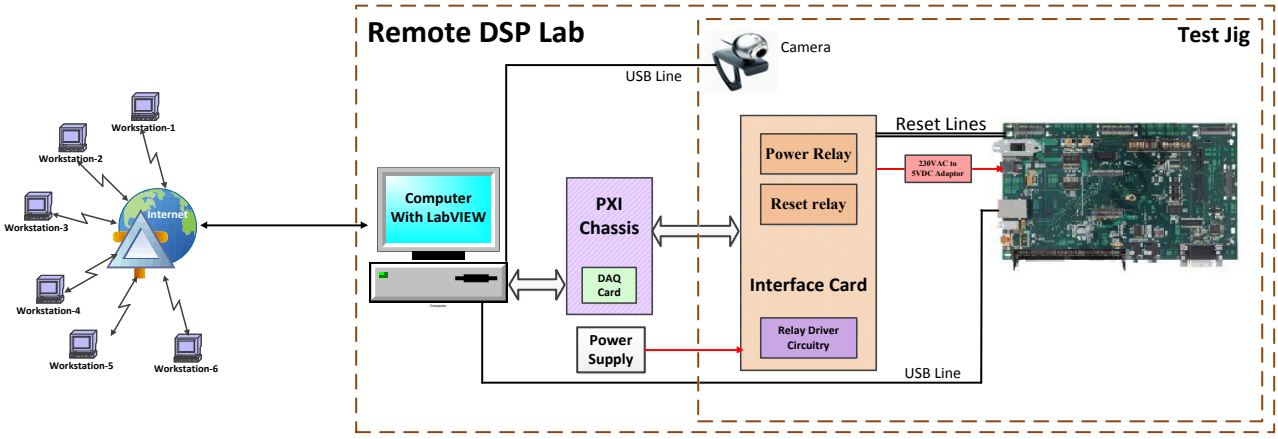

Figure 1. Interface Architecture of Remote DSP Lab

Remote clients are connected to the lab server via remote access tool.Radmin tool is used for the implementation as it is best suited for real time applications.User interface is developed using LabVIEW on the server machine which communicates and controls the test instruments and interface hardware like DSP kit. Customized hardware interface board is designed and developed which acts as interface between the Data Acquisition cards in server machine and DSP kit.

Camera is connected to server machine which provide continuous video of the experimental set-up to the remote user logged onto server machine. Power and position of the camera is controlled by LabVIEW VI located on the server machine.

III. INTERFACE CARD

Data acquisition card required for the interface is placed on PXI chassis and connected to the server. This chassis allows user to add additional data acquisition cards based on the future requirements. All lines on DAQ cards are controlled using LabVIEW user interface. DAQ card is selected based on number and type of IO and control lines required for the interface. Interface card is customized to route the control and data signals from user interface to DSP kit and test instruments via relays. Interface card block diagram is as shown in Figure 2.

All lines form DAQ card is routed to interface card via 68 pin interface connector. Interface card comprises below mentioned blocks

A. Relay Driver

Darlington transistor arrays in ULN2803A are used to drive power and reset relays. Digital output signals from DAQ card are routed to relay driver circuit. OUT1 and OUT2 signals from relay driver circuit is connected one of the coil on the relay. It provides the grounding path to the coil voltage when it is triggered. Digital signals at the input of relay driver circuit is controlled by the power supply and reset button on the user interface.

B. Power Relay

This relay controls the power input for the DSP kit.User commands the power input using power supply button on the LabVIEW user interface. Digital output line DO1 on DAQ card is configured for the power button.Signal from the DAQ card is driven using relay driver circuit and is fed to the coil of power relay. Enabling the power button

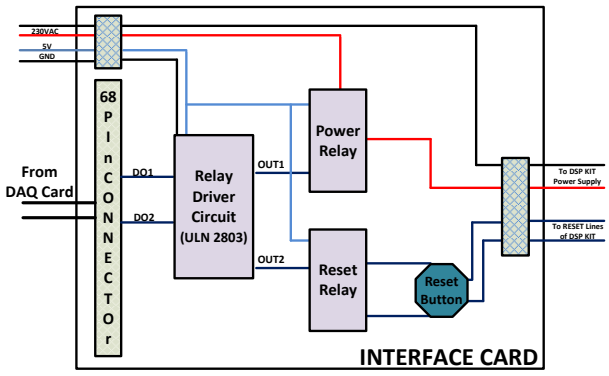

Figure 2. Interface Card Block Diagram

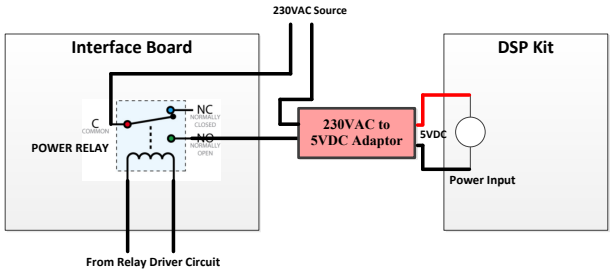

Figure 3. Power Input Relay Circuit

will provide grounding path for the relay circuit and relay will be switched to link 230VAC to the input of the DSP kit power adapter. Power input control relay circuitry developed on interface card is as shown in Figure 3.

C. Reset relay

User need to reset the DSP kit while flashing the code as part of the experiment. Reset button on LabVIEW user interface is provided to offer this functionality.This button will trigger the digital output line DO2 on DAQ card and further,the signal is driven from the DAQ card using relay driver circuit and is fed to the coil of the reset relay.Trigger on OUT2 line from relay driver will provide grounding path to the relay coil voltage and triggers relay which shorts the two reset lines on the DSP kit. Additional reset button is also provided on the interface card to perform hard reset. Reset control relay circuitry developed on the interface card is as shown in Figure 4.

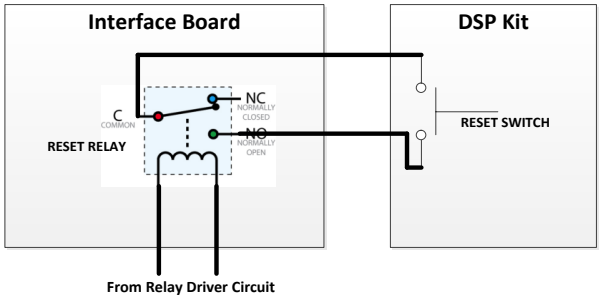

Figure 4. Reset Relay Circuit

IV. REMOTE ACCESS METHODS

Remote access technologies currently available have their own pros and cons. Selection of the tool is based on its end application. Team Viewer, Remote desktop access, Virtual network computing, Web server and Radmin are few available remote access tools and methodologies. Each tool is investigated for its ability to meet the virtual laboratory implementation requirements. The tool selected should operate with maximum reliability and provide high security.

Based on the comparison and analysis, Radmin tool is one of the best tools available for Remote Laboratory applications. This supports simultaneous multiple user access and data transfer between the machines. It is suitable for real time applications.

Radmin server software is installed in the server machine and Radmin viewer on the client machine. Server and client software required is of lower cost. Client software can be installed in any number of systems. Multiple users can work and watch simultaneously on single server machine. This tool also provides the log history which details out the client machine with login and logout data.

Radmin server on the server machine is switched ON for remote access enable and admin can set access permissions for specific remote computers using server configuration window. On client machine, Radmin viewer application is triggered and the remote server machine is identified by its IP address. Server access user ID and password are entered into security window to get complete access of the server machine. This provides first level security for the remote access system.

V. USER INTERFACE USING LABVIEW

User interface developed using LabVIEW can be used for remote accessing, data sharing and other desktop sharing operations between two remote computers. It supports most of the operating systems like Windows, Linux, Mac OS, Android, Windows RT, Windows Phone and BlackBerry systems. It is the freeware which can be used for non-commercial applications. It allows user to establish Virtual Private Network connection with partner. It facilitates data acquisition using DAQ cards to capture analog and digital data.

For virtual lab implementation, user interface is developed using LabVIEW. User login window checks for the user credentials to provide access to the main operating window as shown in the Figure 5.

It has additional tab for administrator login as shown in Figure 6. This allows administrator to add new users, change password and deletion of the existing users.

Figure 5. User Login Window

Figure 6. Admin Login Window

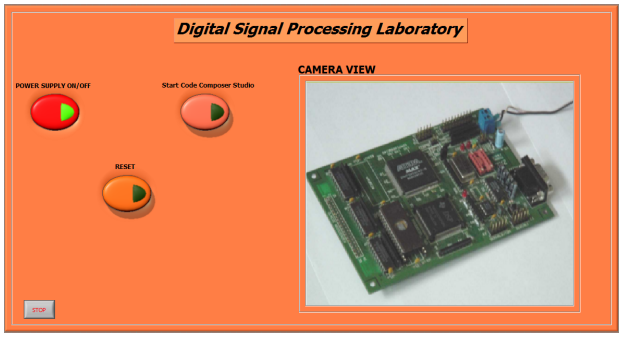

Figure 7. User Interface for Remote DSP Lab

Once the user login with valid user ID and password, the control is routed to main VI as shown in the Figure 7. This window provides access to all the hardware and softwares to conduct laboratory experiments with live visual images.

The main user interface developed has customized buttons to control below mentioned features

A. Power Supply Control

Power input to DSP kit is controlled using the power button on the user interface. This sends command to the power relay on the interface board which switches the power input to the DSP kit.

B. Start Code composer Studio

This button will launch code composer studio software. User needs to select the workspace location from user interface and configure the code composer studio using target information. Target can be connected by selecting a proper connection and device type on the user menu. Code to be executed is written in new source file and further built, debugged and run on the target to perform the experiments.

C. Reset

As part of the code execution using code composer studio, a control to reset the DSP controller is provided which can be used while debugging the code. Remote reset on the hardware can be achieved by designing reset circuitry on the interface board. It is controlled remotely using the Reset button on the LabVIEW user interface. This button sends command to the Reset relay on the interface card.

VI. REMOTE ACCESS FLOW CONTROL

The Remote access flow control describes the steps involved in setting up client and server for remote DSP lab instrumentation.

A. Server

Server machine in the laboratory is configured to receive remote access request from external clients. Test setup is made to run all the experiments remotely. Server machine is connected to PXI chassis using NI cable and required data acquisition card is placed in the chassis. External power supply is configured to power up the interface card by providing required voltage for relay driver circuit and relays. Power relay output lines are connected to DSP kit power adapter and reset relay output lines are connected to the reset lines of the DSP kit. Power input to the interface card is kept ON for the entire duration of remote access. Web camera connected to server displays the complete experimentation system to a remote user. Network connectivity to the server machine should be verified for its functionality which allows server machine to be connected with external world. Radmin server application should be started on the server machine to receive Radmin client requests for remote access.

B. Remote Client

On client machine, Radmin viewer tool is opened to establish the remote access connection. Lab server IP address and the access password are ported into tool to acquire complete control of the server system. LabVIEW user interface located in the server machine is opened using either user or admin credentials. User credentials takes user control to DSP Lab experiment window and admin credentials allows access to add or delete user window. DSP kit can be powered ON by using the Power Supply button on the user interface. Code composer studio is accessed remotely by using start code composer studio button on the user interface. Workspace location is selected on the workspace window. Device and connection type is selected on new target configuration window. New project creation is done by keying device details in project settings window. New source file is opened and experiment code is written. Build, debug and run the code and verify the functionality on the DSP kit.

Code composer window is aligned on the user interface window such that a live image of DSP kit is available for the user during experimentation. Client remote access user window is as shown in Figure 8.

The user can log off simply by switching OFF the power remotely using graphical interface. Further, remote session is terminated by closing the Radmin viewer. This exits the remote user completely from the server machine and system will be ready to accept remote access request from other users.

VII. REMOTE ACCESS EXPERIMENTATION

To demonstrate the generic application of the remote laboratory test setup, a DSP board is programmed remotely using the same test setup and verified for the functionality. DSP board is connected to the server and two reset lines from microcontroller board is connected to interface card. Radmin server engine is initiated on the server machine to enable remote access as shown in the figure 9.

Client user is logged into server machine using Radmin viewer application. Server machine to be accessed is identified using its ip address. Server access user id and password is entered into security window to get complete access of the server machine as shown in figure 10.

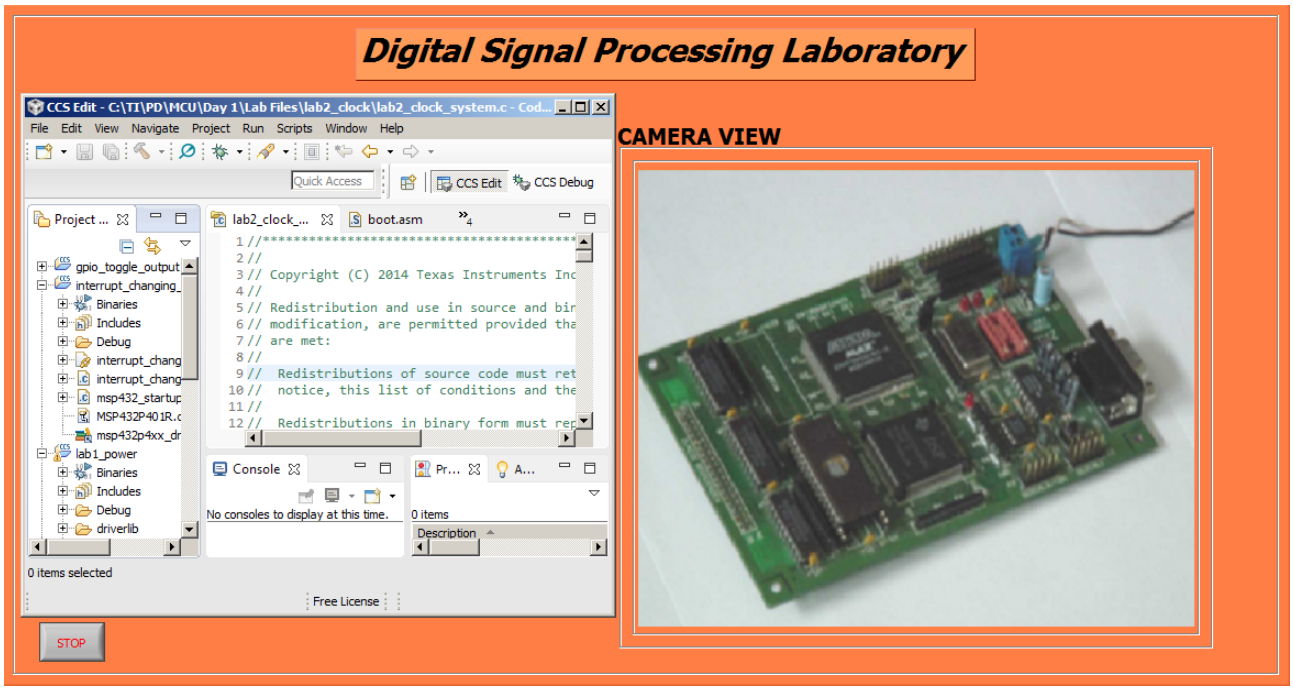

Figure 8. CCS work window along with camera view

LabVIEW user interface is opened on the server machine to get access to the microcontroller board. Live visual images of the controller board is displayed as part of the user interface. Controller board is powered ON using the control on the user interface. Further, code composer studio application v6.1 is opened to start the programming. TI resource explorer of code composer studio is opened and workspace is selected on the popup window as shown in figure 11.

Target is connected by selecting a proper connection and device type on the user menu. New project file is opened and code for blinking LED is written and further built, debugged and run on the target in the source code entry window as shown in the Figure 12. Program functionality is verified by observing the LED blinking on live image capture.

VIII. CONCLUSION

Design of virtual instrumentation of Digital signal processing laboratory is presented with the detailed architecture. The DSP lab experiments can be conducted remotely by logging into the lab server machine using LabVIEW user interface. Power ON/OFF and Reset functions on DSP kit can be controlled remotely using DAQ cards and relays on interface board. This implementation facilitates the remote access of the DSP laboratory hardware and visualizes the real experiments. This architecture avails lab facility for students all over the day for entire year which increase the productivity of the lab setups and measuring instruments.

As demonstrated in the case study, same test setup can be reused for other project related application with minor modifications. Further this facility can be extended to perform other lab experiments and project related activities.

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Figure 9. Radmin server setup window

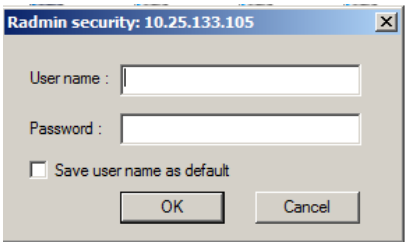

Figure 10. Radmin server login window

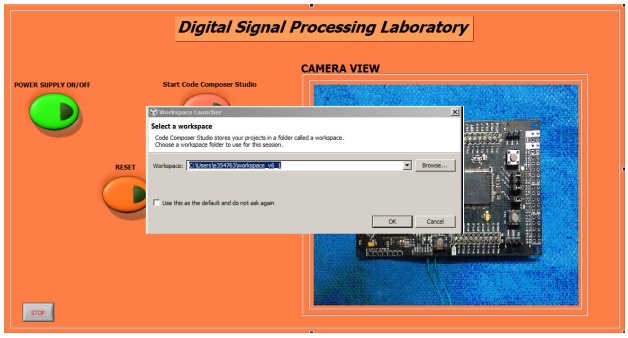

Figure 11. Workspace Selection Window

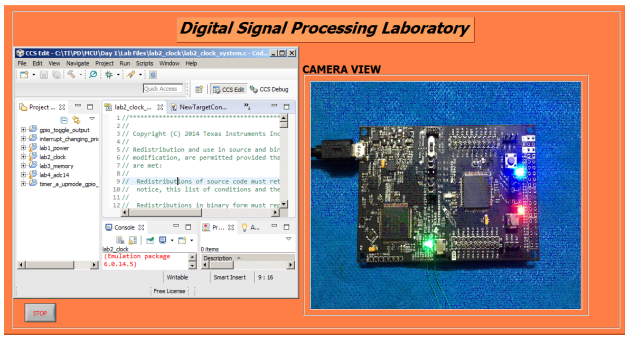

Figure 12. Source Code Entry Window

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[10] "Radmin Remote Access Software Key Features for Remote Computer" Control: 25

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Submitted 16 June 2016. Published as resubmitted by the authors 24 July 2016.