The Advantages Of Remote Labs In Engineering Education

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Application Note

Abstract

This paper will examine technologies that enable remote engineering labs in education. Examples are used to illustrate how each enabling technology can be used to access remote instrumentation in an education environment. In addition, the key benefits of utilizing a remote engineering strategy are summarized. And finally, potential downside considerations are discussed along with methods for minimizing implementation risks.

Index Terms — engineering education, LXI, remote labs, virtual instruments.

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Introduction

The widespread availability of local area networks (LAN) and web access has enabled many useful teaching and instruction processes, especially in the area of distance learning. In the engineering disciplines, educators are increasingly searching for ways to provide more hands-on time for their engineering students in an efficient, flexible and cost effective manner. This is especially true for electrical engineering departments that may have limited access to laboratories, particularly those with higher cost test equipment.

One solution that is gaining significant attention is the use of remote access to engineering labs and test instrumentation. Unlike virtual web simulations, remote access gives students hands on experience with direct control over test instruments and devices. Many of today's test instruments have built-in networking capabilities, which allow them to be accessed 24 hours a day from virtually anywhere, including from home, a dorm room, or local Wi-Fi cafe.

This paper will explore three technologies that enable remote access to instrumentation and we will offer some examples to illustrate how these instruments could be used in a remote lab environment.

1. LXI: LAN eXtensions For Instrumentation

LXI [1] is an instrumentation platform based on industry standard Ethernet technology designed to provide modularity, flexibility and performance to test systems. Though it is a relatively new standard, LXI has been gaining popularity in the test community. Over 1,300 products have been certified compliant.

A key advantage of LXI is that it uses industry-standard Ethernet technology and fits seamlessly into existing networks so equipment can be accessed from computers on the LAN. LAN-based connectivity enables access to remotely located systems. For example, LXI instruments can be connected anywhere there is LAN access, making remote lab work possible. LXI devices provide a built-in web interface, allowing setup and execution using any standard web browser.

An LXI Example: Data Acquisition

The Agilent 34972A Data Acquisition/Data Logger Switch Unit is a typical test instrument that can be set up to be accessed remotely. This product features built-in LAN (and USB) interfaces so it can be easily connected to a PC or laptop. An intuitive graphical Web interface offers remote control over the network for measurement configuration, data logging and data monitoring.

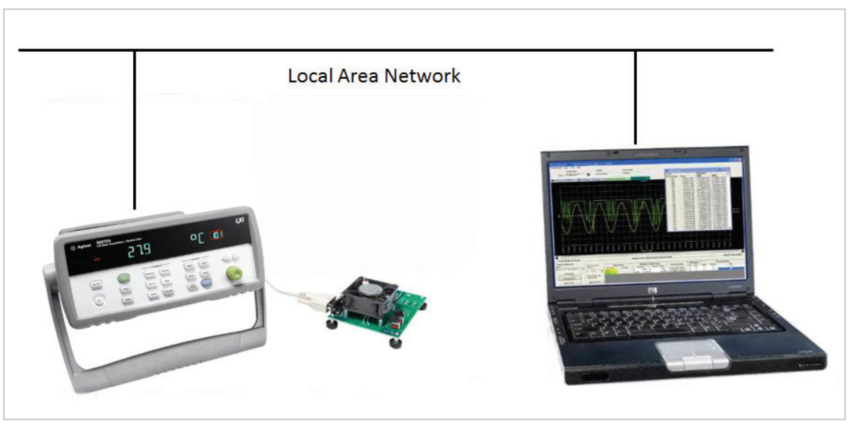

Figure 1. The Agilent 34972A data acquisition instrument takes measurements remotely over LAN

Students can login to the device by simply opening any common web browser, entering the IP address of the instrument, and opening the 34972A built-in web-server homepage.

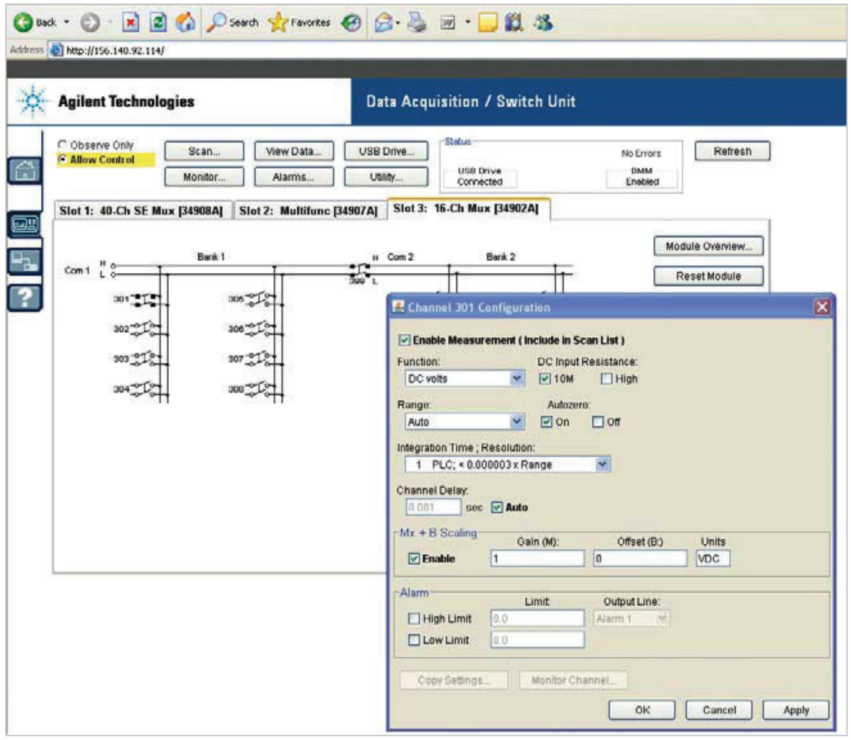

Figure 2. The Agilent 34972A instrument web interface

The data acquisition unit, when used with a demo device for example, can be an excellent tool for teaching the measurement basics of thermistors, thermocouples, and solar cells, as well as subsequent data analysis such as temperature profiling, thermal conductivity, and airflow effectiveness.

Another advantage of LXI is that multiple instruments can be connected (for example, data acquisition units, power supplies, function generators, etc.) to create virtually any test/measurement scenario. In the case of the Agilent 34972A, I/O control cards are available to control the connections to and from the device under test, providing additional lab flexibility.

2. Accessing Remote Instruments Via The World Wide Web

Many test instruments can be accessed remotely via a direct web connection. In this case, students can login remotely using the MS Windows remote desktop connection feature by simply specifying a ‘remote computer’ (instrument) name, login, and password.

Web-Interface Example - Semiconductor Device Analyzer

The Agilent B1500A Semiconductor Device Analyzer is an excellent tool for teaching students how to characterize electronic components such as resistors, diodes, capacitors and transistors.

Figure 3. The Agilent B1500A semiconductor analyzer can be accessed remotely to characterize devices

Students simply login as if the instrument was a remote computer. The application starts and the user is presented with a virtual user interface with which to set up the device under test (DUT), measurement parameters, and execute the tests.

In remote control mode, the B1500A can be controlled from an external computer. And by adding a multiplexing (MUX) device with automated switching capabilities, students can remotely switch between different DUTs during a lab session.

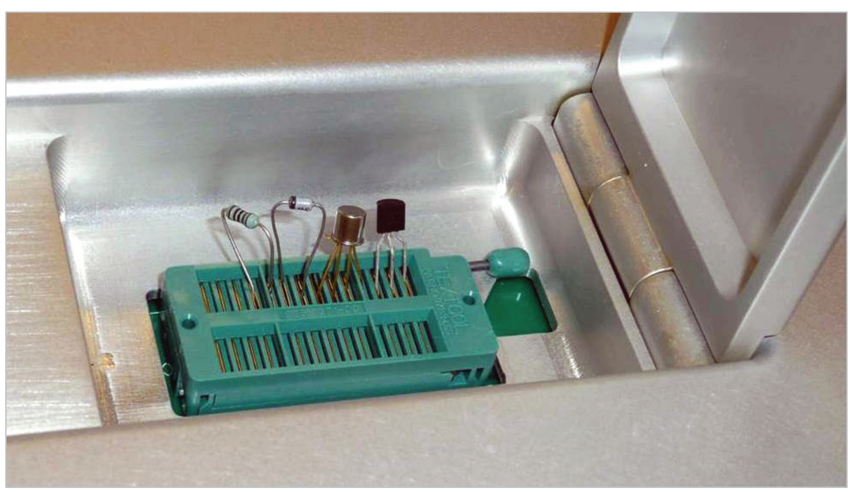

Figure 4. Using a MUX, students can remotely switch between devices under test. From left to right: resistor, diode, mosfet, and bipolar transistor

A lab setup could include different devices in the MUX socket to permit easy switching between different device types. After connecting to a DUT, students can load application tests and perform measurements on each device just as if they were sitting in front of the actual instrument.

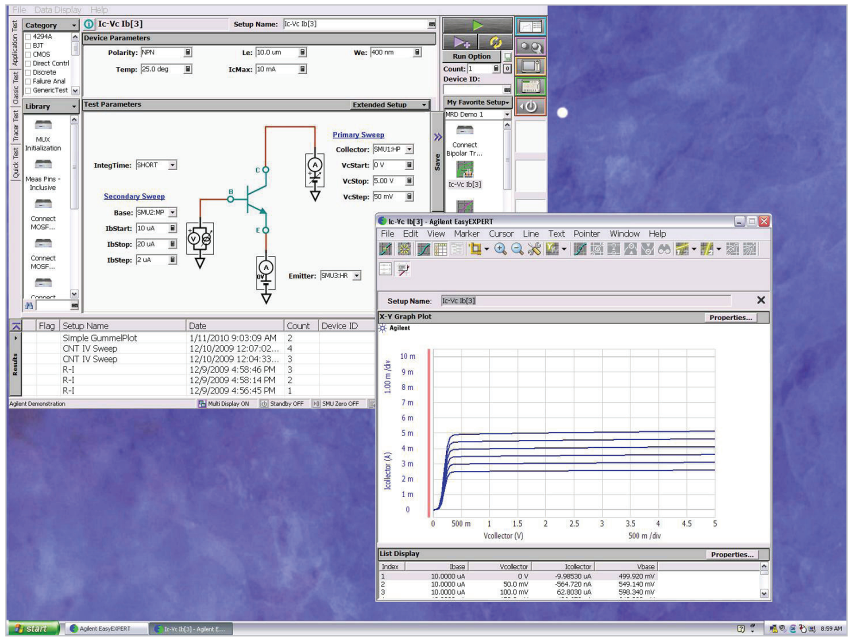

Figure 5. Remote user interface to the Agilent B1500A

The high cost of some instruments sometimes prohibits many universities from purchasing enough units to make it a viable laboratory teaching tool. However, the remote capabilities of the B1500A and other devices allow undergraduate students to access the instrument when graduate students are not using it for their research work or during other lab downtime.

3. USB: Universal Serial Bus

A third method for controlling instrumentation remotely is via a USB connection using a local PC as a server. Many test instruments are configured with USB interfaces, which make for a simple and easy method for accessing instrument controls.

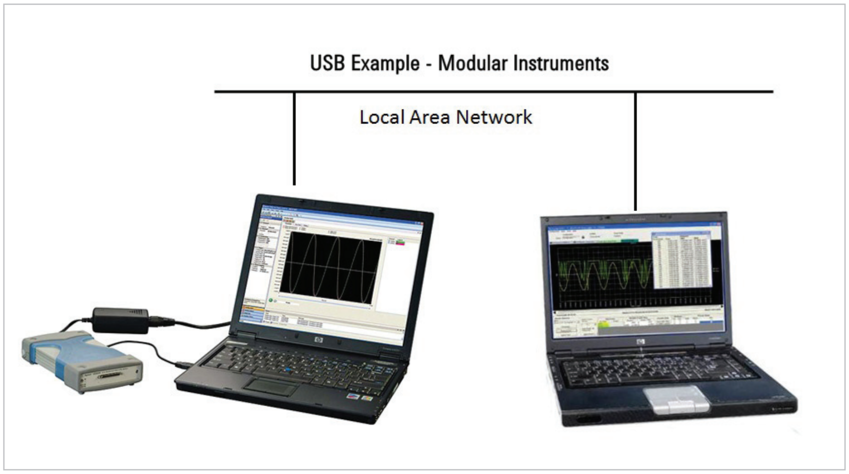

Figure 6. The Agilent U2700A USB-Enabled modular instrument accessed via remote pc-to-pc connection

A myriad of USB-enabled modular instruments are available on the market today, everything from oscilloscopes to function generators and digital multimeters. Modular instruments allow for flexible configurations, quick setup, and are an affordable option for cost conscious engineering departments.

An advantage of a USB connection is that it can provide quick, easy connectivity with a PC. With ‘plug and play’, the PC will automatically detect an instrument as soon as it is plugged in. And with hot swapping, you can connect or disconnect an instrument without rebooting the PC. A USB 2.0 data transfer rate of 480 Mb/sec is sufficient for most educational lab applications. Most major test equipment vendors provide IO libraries and support for the USB Test and Measurement Class (USBTMC [2]) specification, which provides compatibility with GPIB-style programming.

The concept of remote access can be extended to include USB configurations when the host PC is accessed remotely over a local area network. While this PC-to-PC communication may not be as effective as direct instrument access, this option opens the doors to a wide range of lab setup configurations.

Key Advantages Of Remote Engineering Labs In Education

There are many advantages of deploying a remote engineering laboratory in an educational environment. Such a strategy provides a way to provide more hands-on time for engineering students in an efficient, flexible and cost effective manner. This is especially true for electrical engineering departments that may have limited access to laboratories and higher cost test equipment in particular. One of the main benefits of a remote lab strategy is a more efficient utilization of equipment. Labs can be accessed during ‘off hours’ when the instrumentation would otherwise be sitting idle. It also gives students more flexibility to schedule their labs. Students can get lab time virtually any time of day or night. And with the proliferation of LAN access on today’s campuses, students benefit from the convenience and safety of remote access from virtually any university location.

And unlike a virtual instrument strategy that relies on simulated labs, a remote strategy gives engineering students the hands-on experience they need to experiment, explore and fully understand the concepts they’ll need to be successful upon graduation.

There are also financial benefits to the engineering department. Since equipment can be used more efficiently with a remote access strategy, fewer instruments are required to serve the same number of students. This is an important consideration when engineering labs call for higher end equipment. In addition, fewer teaching assistants are needed to staff and maintain the lab.

Potential Considerations To A Remote Strategy

Certainly there are factors to be considered when implementing a remote engineering lab. For example, an instrument lockup or LAN connection that goes down in an unstaffed lab would create issues for students trying to complete their lab assignments. A potential solution for this uncertainty would be to have backup equipment on hand and ready to use. A lab setup could optionally include the ability to remotely perform a soft or hard reset of the instruments should a lockup occur. Alternatively, an 'on-call' teaching assistant could be deployed to resolve equipment issues as needed. And it goes without saying that a reliable network is a prerequisite for a successful remote lab strategy. Network security may be an important issue for some labs, especially those shared with researchers. In this case there are a wide variety of network security tools available, including but not limited to firewall software, to mitigate concerns about network security.

Finally it is worth noting that there may be safety issues in an unstaffed lab such as a risk of fire. For some high voltage/current applications, a remote strategy may not be practical. However, for most educational labs, following recommended safety guidelines would go a long way towards addressing this risk. For example a safety shield could be used around devices under test to mitigate risk. This doesn't preclude basic safety steps such as fire alarms, sprinkler systems, fuses, and avoiding overloading extension cords and wall outlets. Other strategies can be deployed such as those utilized for network servers and routers, which are typically located in dedicated closets. A safety audit and review with the university safety officer would be a good first step when setting up an unstaffed remote lab.

Conclusions

A remote engineering approach is a feasible way to complement actual hands-on labs for all the reasons called out in this paper. There are technologies available today that make it not only viable, but cost effective as well. While there are potential pitfalls to implementing such a strategy, by taking the proper steps to minimize the downside risks, a remote instrumentation strategy can be an effective educational tool in an academic environment.

References

1. *"LXI Standard Revision 1.3", October 30, 2008;* ***http://www.lxistandard.org***
2. *"USBTMC: USB Test and Measurement Class"; Definition provided in the USB Test and Measurement Class spec found at* ***www.usb.org***

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