Performing Long-Distance and Distributed Data Logging

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Introduction

In this measurement brief we will discuss two low-cost ways you can perform long-distance and distributive data logging. The explosion of wireless connectivity across the globe has led to a wide range of off-the-shelf wireless networking products. The majority of these products have one thing in common: they can connect to an Ethernet network. This capability means they can serve as an I/O pathway for measurement instruments that have an Ethernet port. Instruments that are built on the LXI standard have this capability. With this type of setup, the computer that controls the instruments and records the measurements does not have to be located with the instruments. Now, when you perform long-distance remote data logging, you no longer have to make frequent trips to the test site to start tests or retrieve logged data. This is especially true when you use smart instruments that have built-in data-logging capabilities like the 34410/11A DMMs.

In this brief we will look at two low-cost ways to do remote and distributed data logging:

1. *Via a long-range Ethernet bridge*
2. *Via a cellular router*

Snapshot:
Utility company tests load stations remotely

A utility company needed to conduct research to increase efficiency at three of its load stations. For the research company engineers needed to log two voltage measurement points at three different load stations. Their main challenge was to find a way to remotely access and control the instrumentation at each station. The stations are distant from the utility company and are located miles apart from each other. The team had a limited budget, so the solution had to be cost effective. They decided to implement a system that consisted of a single computer located at the utility company, three cellular routers, and six Agilent 34410A DMMs. The computer runs software that connects the DMMs to the Internet via a cellular provider's network and then to the cellular routers. The utility company chose an Agilent 3441 because its Ethernet I/O interface can be connected and controlled from the cellular router. Also the 34410A has built-in data logging capabilities to keep network traffic to a minimum and still achieves precisely timed measurements.

Effective Low-cost Data Logging

There are two effective ways to do low-cost remote and distributed data logging:

1. Via a long-range Ethernet bridge:

This method consists of two transceivers that each connect to an Ethernet network. The transceivers typically use a 900-MHz ISM-band communication protocol. The bridge setup is shown in **Figure 1.**

2. Via a cellular router:

The second method enables you to connect to the Internet from almost anywhere as long as there is cellular network coverage. The cellular router setup is shown in **Figure 2.**

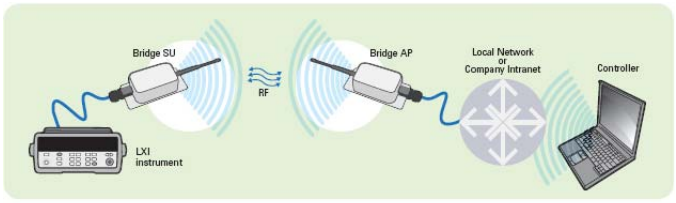


Figure 1: ***Long-range Ethernet bridge setup***

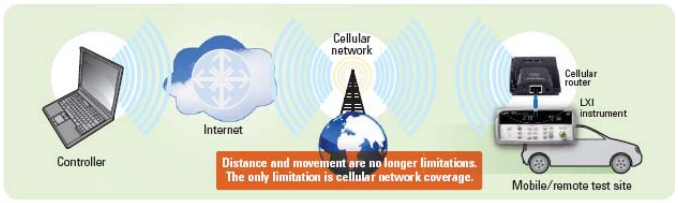


Figure 2: ***Cellular router setup***

Long-distance Ethernet bridge

Long-distance Ethernet bridges consist of at least two transceivers that use the 900-MHz ISM band for long-range RF transmission of data. On the other end of each transceiver is an Ethernet port, so the RF transceivers serve as a long-distance bridge. The RF protocol typically employs some type of encryption for securely passing data between the two Ethernet nodes. The line-of-sight range can be up to 15 miles, depending on the

surrounding topology and the number of walls or barriers in the signal path. One of the transceivers is set as the access point and is connected to the Ethernet network containing the computer or controller. A second transceiver serves as a slave unit, which you connect to the remote instrument. Multiple slaves units, typically up to 16, can be connected to a single access point. This makes it a great solution for distributed data logging applications with a single computer. If you are connecting the bridge access point to your company intranet, consult your IT department to make sure you comply with company IT policy.

Cellular router

Cellular routers are just like the routers you have at home, except instead of using an Ethernet connection to access the Internet, they use a cellular data connection. Cellular routers offer the greatest distance flexibility as they enable you to monitor and control LXI instrumentation across the globe (anywhere a cellular tower is accessible). They also offer the greatest flexibility on the controller side since they can be accessed from anywhere there is an Internet connection, such as your home or local cafe. Further evidence of a cellular router's flexibility is its ability to log data in a moving ground vehicle. The cellular protocol is robust enough to transfer a data connection from one tower to another.

To connect to the Internet, the cellular router needs a USB mobile broadband device or equivalent. This requires a monthly data plan from a cellular provider. Negotiate a static IP address with your cellular provider for the mobile broadband device to ensure the IP address is not suddenly changed and you lose connection to the instrument. Getting a static IP can come with additional costs depending on your cellular provider.

Security can be a concern when you use a cellular router. An LXI instrument acts as a server and the computer controlling it acts as a client. Consumer routers typically block incoming connection requests for security reasons because they assume every device on their local network is a client. Since the LXI instrument connected to the router is a server, we need to use the router's DMZ or port-forwarding settings so our computer can access it. DMZ tells the router to send all incoming connection requests to a specified IP address (the LXI instrument) on the router's local network. DMZ has one drawback: Anybody who knows the IP address of your mobile broadband device can access the instrument. Also, using DMZ allows you to access only one instrument on the router's network. Port forwarding means you open a specific network port or range of ports to a specified IP address on the router's network. That means you can access multiple instruments from the same router. It's more secure because to access the instrument you have to know its IP address as well as the open port.

Measurement Tip

Controlling an instrument remotely over a long distance through multiple network protocols means that you will face longer latencies and more frequent connection losses. Be sure to make your software robust enough to handle these issues. If you are using a driver, increase the connection timeout setting.

Examples Using Both Wireless Remote Access Methods

Here we will look at some examples using both methods to connect and retrieve logged data from an Agilent 34411A DMM. The 34410A and 34411A DMMs are great solutions for long-distance remote data-logging because they have built-in data logging capabilities. When you are remotely logging data, the computer needs to connect to the instrument only twice, once to set up and start the data log and then again to retrieve the data after the data log is complete. Also the data log samples can be precisely timed without any worry of network latency since the timing is controlled in the DMM's hardware versus through an I/O connection with a remote computer.

For our comparison, we will perform two tests with both methods. For the first data log, the DMM will be located approximately 1 mile from the computer. For the second data log, the DMM will be located approximately 15 miles away from the computer. In both tests there is one wall in between the computer and DMM. For each test, the DMM has already initiated a data log of 300 voltage measurements on a 5-VDC bias that has significant power line noise on it. A simple program was written to connect to the DMM and fetch the 300 logged measurements from memory. The program times the latency it takes to connect to the DMM and retrieve the logged measurements. **Figure 3** shows a screenshot of the program being run at the 1-mile location using the cellular router.

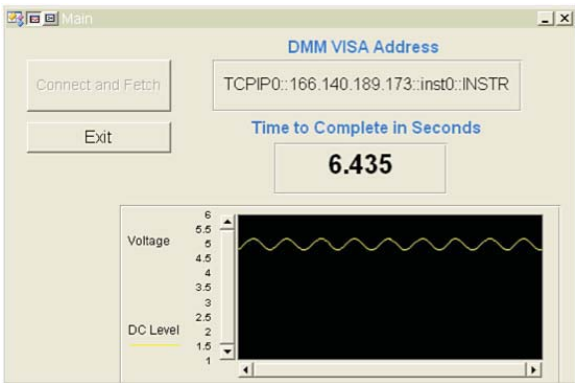


Figure 3: ***Cellular router test run at 1 mile***

Each test was run five times for both remote wireless methods. **Table 1** shows the results.

1-mile Test

	Run 1	Run 2	Run 3	Run 4	Run 5	Avg
Bridge	9.577 s	2.187 s	0.788 s	9.379 s	3.37 s	**5.06 s**
Router	8.079 s	4.9 s	5.342 s	7.644 s	6.436 s	**6.48 s**

15-mile Test

	Run 1	Run 2	Run 3	Run 4	Run 5	Avg
Bridge	N/A	N/A	N/A	N/A	N/A	**N/A**
Router	8.389 s	12.83 s	8.154 s	10.51 s	5.072 s	**8.991 s**

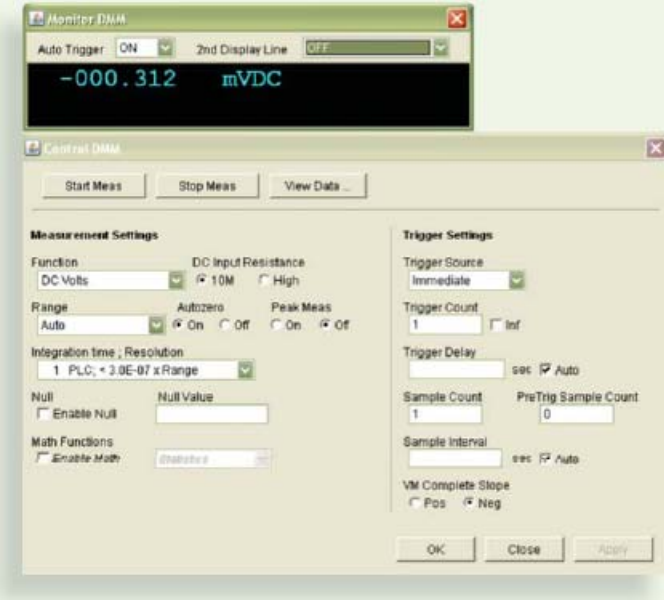
Table 1: ***Test results***

For the 15-mile test, the range was too great for the bridge to connect. The bridge was rated for 15 miles line-of-sight with no walls between the transceivers. It was not surprising it could not connect considering there was a wall between the transceivers and the test was done in a residential area with lots of interference. The router had no problems connecting from 15 miles away because it is built on the same protocols that power the Internet and allow us to communicate with a server across the globe.

The tests give you an idea of the latencies you can expect when using these long-distance remote wireless methods. You can see from the results of the test that both methods have similar IO latencies, and the latencies for both methods are not very repeatable. As evident from the test times, when doing long-distance remote data logging that requires precision timing between each measurement, with either method you want to choose an LXI instrument such as the 34410A DMM that has built-in hardware data-logging capabilities.

Measurement Tip

Most LXI instruments like the 34410A and 34411A DMMs have a built-in Web interfaces that allow you to control the instrument and fetch readings from memory. In the example above, a simple custom program was used because we wanted to time the latency. In the case of the bridge method, we could have set up a data log, executed it, and retrieved the logged measurements using the DMM's built-in Web interface with no special software needed. Note that when the LXI instrument is behind a router, as is in the cellular router method, the LXI instrument control feature often cannot be accessed because of a communication conflict in the instrument's built-in Web server. The screen capture below shows the DMM's web interface configuration.



Conclusion

Combining LXI instruments with off-the-shelf wireless networking products like cellular routers and Ethernet bridges makes long-distance remote and distributed data logging much easier and cost effective. With these wireless networking devices, we no longer have to have a computer located remotely with the instrument and have to make frequent trips out to the test site. Instead you can initiate tests and collect logged data remotely from the office or the local cafe. The drawback to this remote-control method for data logging applications that require precision timed measurements is network latency. Network latency can easily be overcome by employing LXI instruments with built-in data-logging capability, such as the 34411A and 34410A DMMs, that require remote access only to initiate the measurements and then later to collect the logged data.

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