Keysight Technologies
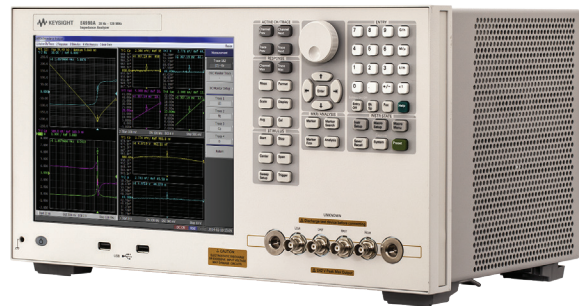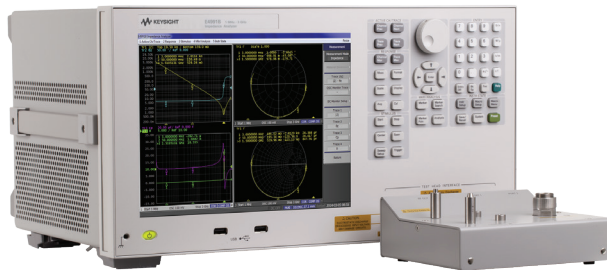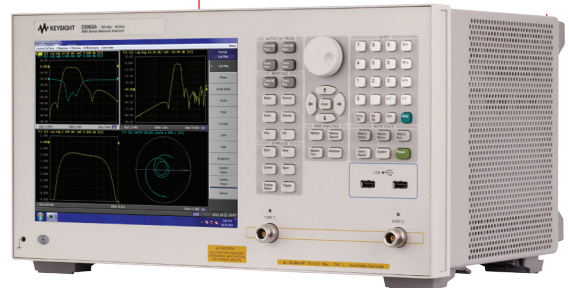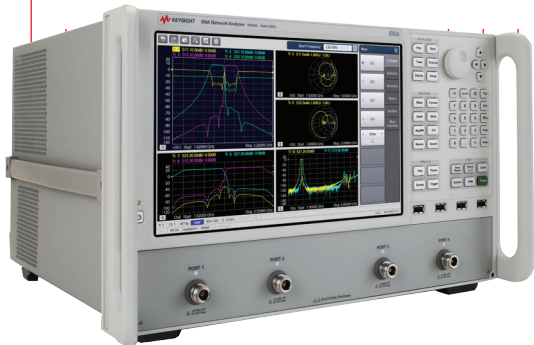# Impedance Analyzers and Network Analyzers
Optimizing Connections Using USB and LAN Interfaces

Application Note

KEYSIGHT
TECHNOLOGIES

Unlocking Measurement Insights

Introduction

Since the Keysight E4990A and E4991B impedance analyzers were released, all Keysight impedance analyzers, the E4982A LCR meter and benchtop network analyzers now have Universal Serial Bus (USB) and Local Area Network (LAN) interfaces (Figure 1). Whether you're setting up an ad hoc system on a lab bench or designing a permanent solution for a manufacturing line, General Purpose Interface Bus (GPIB), LAN, and USB are the most popular interfaces for connecting measurement instruments to PCs.

Although GPIB has been the standard interface for connecting test instruments to PCs and for providing programmable instrument control for decades, no major enhancements have been done since the 1990s. On the other hand, USB and LAN are computer-industry standard I/O technologies, and most of PCs offer built-in USB and LAN interfaces. The USB and LAN standards have been continuously enhanced and the performances have improved rapidly in response to the growing needs for high-speed digital applications (Figure 2). This application note describes the benefits of using modern USB and LAN interfaces compared to GPIB.

Impedance Analyzers

E4990A
(20 Hz to 120 MHz)

E4991B
(1 MHz to 3 GHz)

E4982A LCR Meter
(1 MHz to 3 GHz)

Network Analyzers

PNA Family
(300 kHz to 1.1 THZ)

ENA Series (5 Hz to 20 GHz)
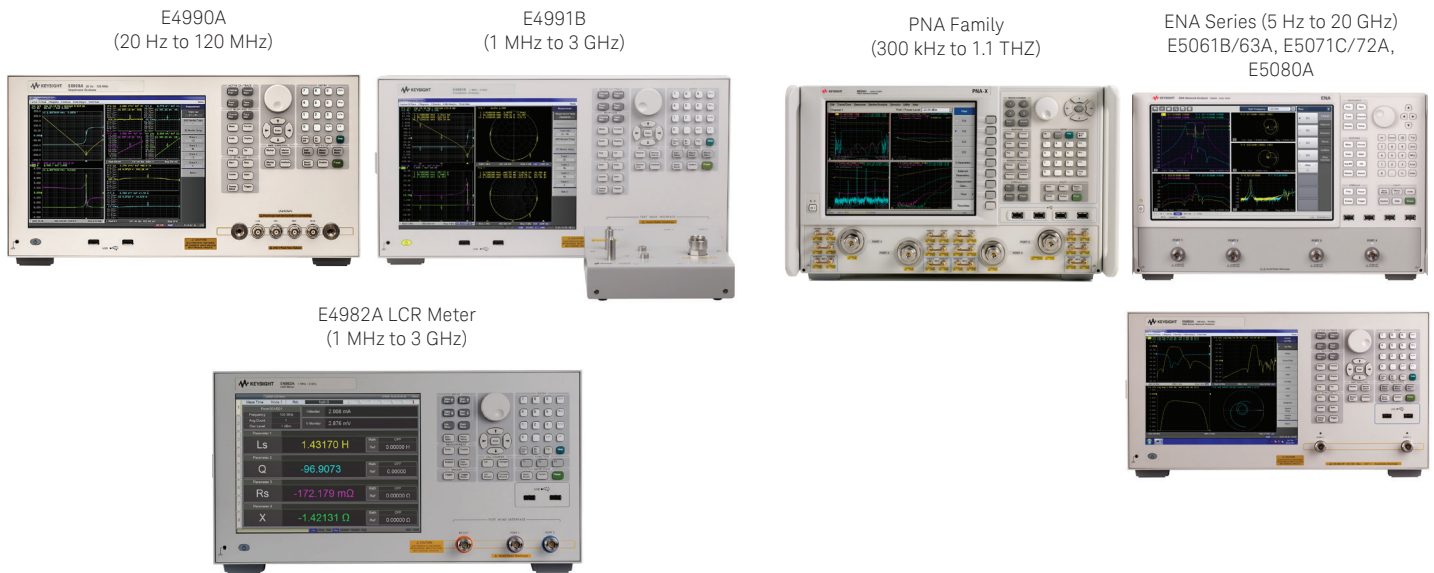E5061B/63A, E5071C/72A,
E5080A

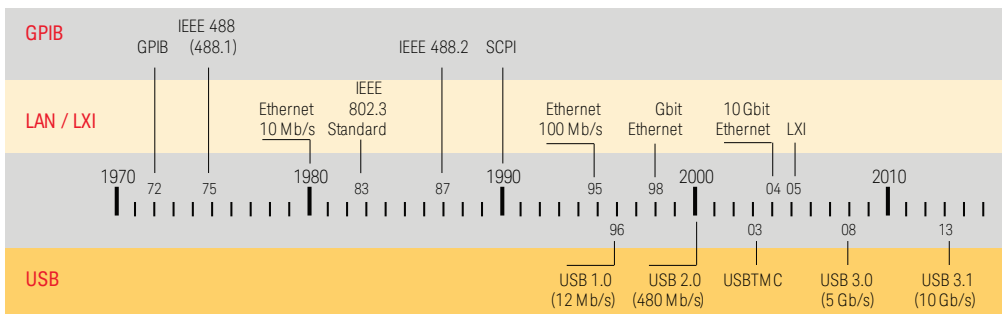Figure 1. Keysight benchtop impedance analyzers and network analyzers

Figure 2. Enhancement history

Comparing I/O Options

GPIB

GPIB, formerly called HP-IB and also known as the IEEE-488 bus, is the traditional interface on test and measurement instruments. GPIB is easy to connect, provides excellent electrical and mechanical reliability, and it has been the clear choice for most test automation needs for more than 40 years. The biggest drawbacks to GPIB are the size and cost of the connectors and cables, as well as the need to install an interface card in your PC, since GPIB is not a standard PC interface. The 1 Mbyte/s (8 Mbit/s) maximum data transfer rate is also becoming a bottleneck against high-speed manufacturing test needs with large size data transfers. GPIB supports up to 14 devices that can be connected to your PC. Cable length is limited to 2 meters (times the number of devices) up to a maximum length of 20 meters. When you use GPIB, each instrument on the bus needs to have a unique address from 0 to 30. You may have to manually change an instrument's address when you configure your system.

USB

USB is widely available on PCs, and its low cost and simplicity make it a great choice when you need to create a test solution quickly. Keysight and other test equipment vendors co-developed the industry-standard USB Test and Measurement Class (USBTMC) and USB488 I/O protocols. These protocols, along with Keysight's IO Libraries Suite, allow you to easily switch from GPIB to USB connections by changing the instrument VISA address to that of the USB interface. All Keysight benchtop network analyzers and impedance analyzers provide a USBTMC port (USB Type B plug). Users can easily connect a control PC and measurement instruments directly using USB cables or via a USB hub (Figure 3). This short time-to-measurement aspect of USB is particularly attractive in engineering labs and other environments where instruments are frequently moved, shared, and reconfigured. USB is capable of data transfer rates of up to 480 Mbit/s with USB 2.0 high-speed mode. You can connect up to 127 devices with a USB interface. USB instruments have unique instrument addresses that are given based on the manufacturer, the instrument serial number, and the product ID number. Unlike the remote control using a LAN interface, users can enjoy high-speed remote control without connecting the test instrument to the network.
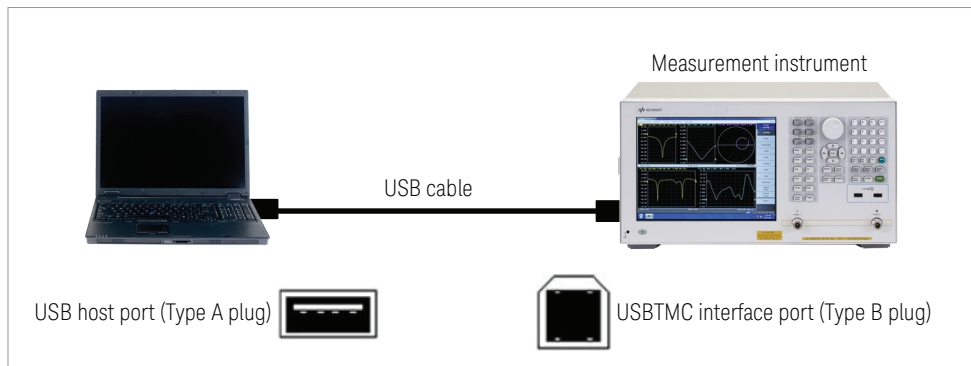

Figure 3. USB cable connection

LAN

LAN is also an attractive alternative to GPIB. LAN technology combines openness, low cost, high speed, and dependable mechanical characteristics. The locking mechanism of LAN connectors provides a more secure system connection than USB. The LAN eXtensions for Instrumentation (LXI) standard, based on proven standards to test and measurement such as VXI-11 and IVI drivers, provides ease-of-use and flexibility for measurement instrument connections such as web browser-based connections and wireless LAN connections. You can easily switch from GPIB to LAN connections by changing the instrument's VISA address to that of the LAN interface. LAN is capable of data transfer rates of up to 100 Mbit/s with 100Base-T Ethernet and up to 1 Gbit/s with 1000Base-T Ethernet. There is no limit to the number of instruments that can be included in a LAN-based system. The biggest disadvantage of using LAN interfaces is it typically requires more network knowledge and configuration effort compared to USB and GPIB interfaces.

Table 1. Advantages and disadvantages of GPIB, USB, and LAN interfaces

Interface	Advantages	Disadvantages
GPIB	– Common interface for test and measurement instruments	– Need to install an interface card in your PC – Relatively expensive – Limited cable lengths permitted between PC and instruments
USB	– Quick, easy setup using an embedded serial number – Low cost – Good data-throughput performance	– No locking mechanism in the connector
LAN	– Good data-throughput performance – Low cost – Remote access makes it easy to control system from remote location	– Requires LAN knowledge to set up

Hardware cost comparison

Table 2 shows the typical costs comparison when you connect a single measurement instrument to your PC. Because you need a GPIB PCI card for using GPIB interface, the hardware cost is much expensive than USB and LAN interfaces. The typical initial cost ($US) for GPIB interface is more than 50 times higher than USB and LAN.

Table 2. Typical costs for GPIB, USB and LAN interfaces

Interface	Single Instrument	
GPIB	PCI card + cable	$600
USB	Cable	$10
LAN	Cable	$10

Speed comparison

Individual I/O bus specifications for data transfer rates usually give only the theoretical maximum transfer rate. The actual data transfer rate depends on a number of factors. These factors include PC microprocessor speed, PC software and driver overhead, I/O card hardware, and instrument-specific hardware and firmware. In general, there is no appreciable difference in bus speed when you send a simple SCPI command, but you can see a remarkable improvement with the higher performance buses (USB and LAN) in the time required to transfer large amounts of data. Figure 4 shows the transfer time comparison when you query 1601 points S-parameter trace data against the E5061B ENA series network analyzer. The transfer time via USB and LAN interfaces is more than 10 times faster than GPIB interface.

Remember that the improvement factor of how much the total test speed will be improved depends on your test system. GPIB might be better than the other interfaces in some cases such as it queries only a few values per test cycle. You need to execute a benchmark test against your system for clarifying the speed improvement. Keysight can help you run a benchmark test.
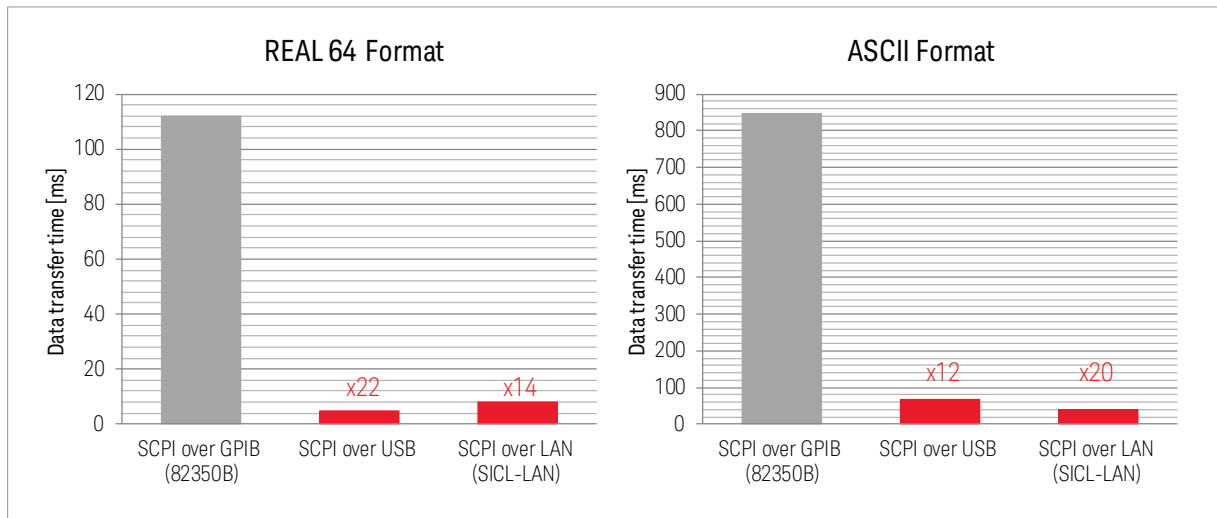

Figure 4. Data transfer time for a large amount of data (1601 points) acquisition using the E5061B network analyzer

Communicating with USB or LAN Connected Devices

If you're using the Keysight IO Libraries Suite with SCPI commands, you can easily change the I/O interface from GPIB to USB or LAN by changing the VISA address when you open the instrument I/O in your test program.

Here is the code sample for getting the product information. The GPIB address for this measurement instrument is 17. Figure 5 shows an example of USB interface's VISA addresses. In this case, just modify the rm.Open() function to inst.IO = rm.Open("USB0::0x2A8D::0x-0001::MY55100054::0::INSTR"), then you can control the instrument via USB interface. You can use the copy and paste function to modify the address.

Visual Basic code example

Dim rm As New Ivi.Visa.Interop.ResourceManager

Dim inst As New Ivi.Visa.Interop.FormattedIO488

inst.IO = rm.Open("GPIB0::17::INSTR")

inst.WriteString("*IDN?")
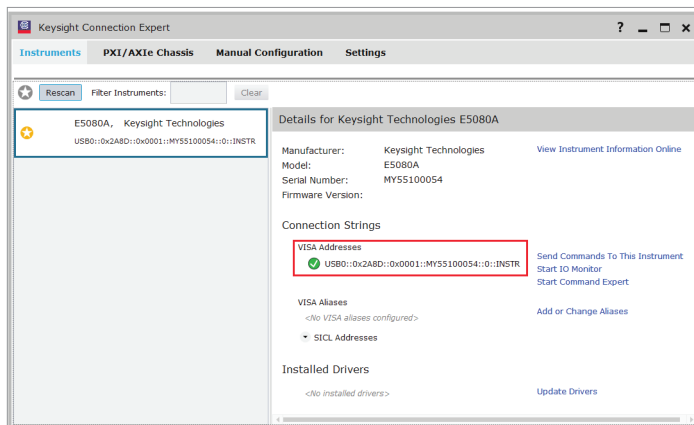
Dim str As String = inst.ReadString()

inst.IO.Close()

Figure 5. USB VISA address format example

Figure 6 shows an example of the LAN interface's VISA addresses. In this case, modify the rm.Open() function to inst.IO = rm.Open("TCPIP0::169.254.248.195::inst0::INSTR"), then you can control the measurement instrument via the LAN interface.
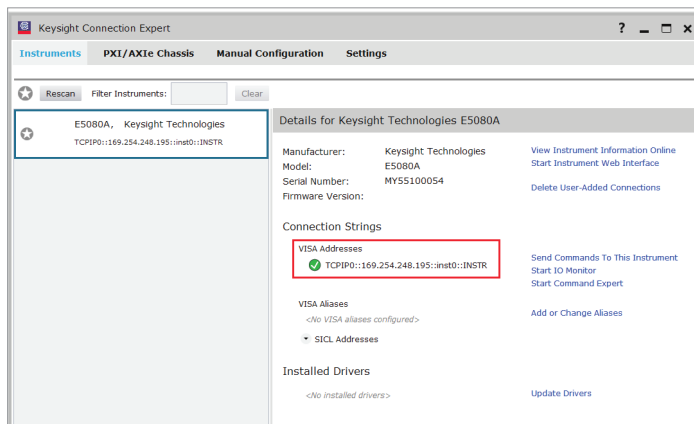

Figure 6. LAN VISA address format example

Useful Software Tools

Keysight Command Expert

Keysight Command Expert is a free software that provides fast and easy instrument control regardless of connected interfaces. It helps you build and debug instrument command sequences, and integrate sequences into the Visual Studio, Excel, LabVIEW, MATLAB, and Keysight VEE. The Command Expert supports impedance analyzers and network analyzers. This software can be downloaded from **www.keysight.com/find/commandexpert**.
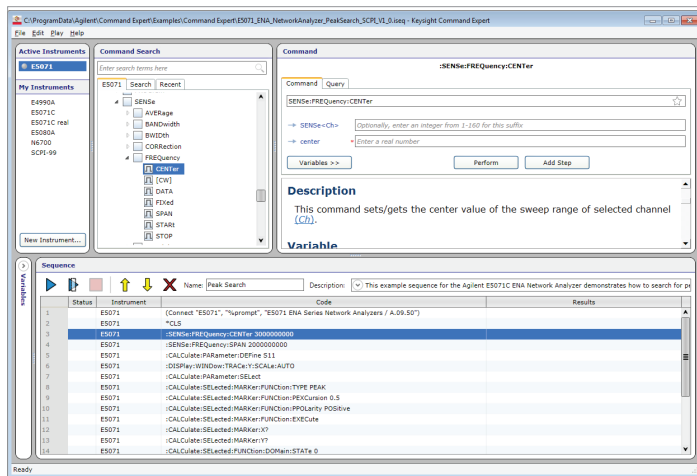
Figure 7. Keysight Command Expert

Keysight BenchVue

Keysight BenchVue helps you to easily capture the measured data and exchange the state files from your PC. This enables you to improve efficiency for evaluating your devices in R&D environments. BenchVue supports network analyzers, and impedance analyzers will be supported in the future. This software can be downloaded from **www.keysight.com/find/BenchVue**.

Figure 8. Keysight BenchVue

Conclusion

As USB and LAN are widely available as industry standard I/O interfaces on PCs, they are becoming the popular interfaces for connecting measurement instruments to PCs. Comparing costs, data transfer rates and ease of implementation will help you choose the interface most appropriate for your application.
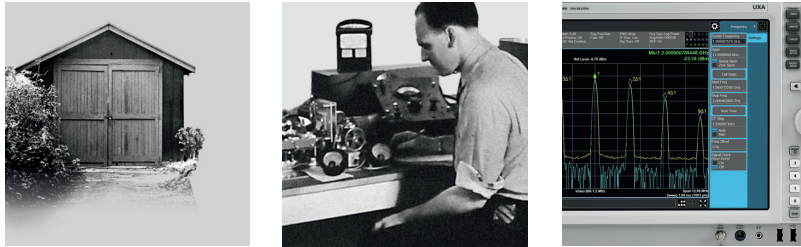
For R&D applications, where the number of instruments in a system is usually small and a quick and easy interface setup is desired, USB is usually the best choice. For manufacturing, LAN is usually the best choice. LAN is typically the better of the two alternatives for larger systems because of its network flexibility, and a more secure system connection with the locking mechanism connector.

Related Keysight Literature

Publication Title	Publication Number
Test-System Development Guide: Computer I/O Considerations (AN 1465-2)	5988-9818EN
System Developer Guide: Using LAN in Test Systems: The Basics (AN 1465-9)	5989-1412EN
System Developer Guide: Using USB in the Test and Measurement Environment (AN 1465-12)	5989-1417EN
Network Analyzer Selection Guide	5989-7603EN
LCR Meters, Impedance Analyzers and Test Fixtures Selection Guide	5952-1430E

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