



Solutions for

Extending the Measurement Plane up to 1 km in Vector Network Analysis

Application Brief

Most network analysis is performed on the test bench or in a production environment. In these situations, all ports of the device-under-test (DUT) are readily available to the vector network analyzer (VNA).

In contrast, a variety of applications place a greater distance between the VNA and the DUT. Examples include radar test ranges; in-building, airborne or shipboard RF distribution systems; and satellite communication terminals. Even with the best-performing coaxial cable, high-frequency signals will suffer tremendous attenuation over long spans. The most common solution is to downconvert the stimulus and response signals; however, this introduces mixing products that must be dealt with to ensure accurate measurement results.

A new alternative uses the opposite approach. Agilent's new Optical Extenders for Instruments—the OXI Series—eliminate long runs of coax by converting RF signals to and from optical wavelengths and using single-mode optical fiber that has negligible loss. The OXI solutions enable transmission and reception of signals of up to 50 GHz with very high isolation over distances of up to 1 km.

This application brief outlines the problem and the solution, explains how to extend the measurement plane, and describes the OXI modules that enable accurate, cost-effective measurements over long distances. If you believe these products have value for your applications, please call Agilent to discuss the requirements and implementation strategy.



Sketching the problem and the solution

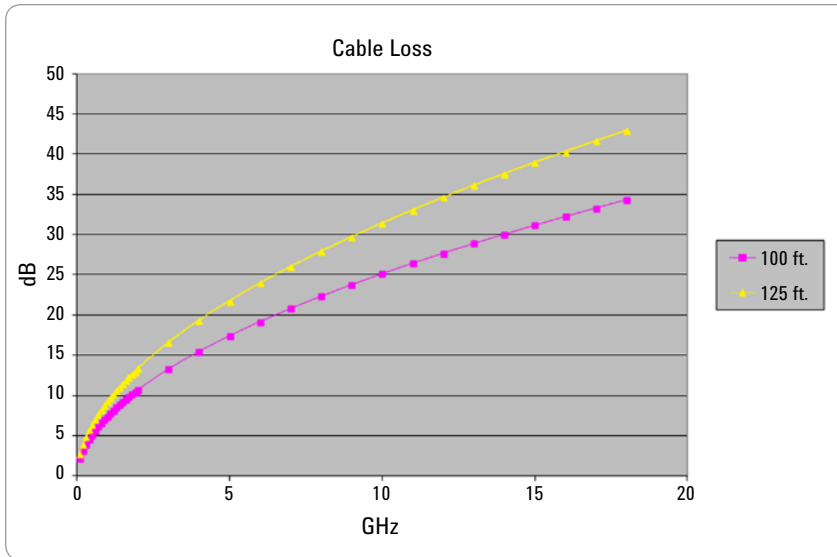


Figure 1. In long runs of coaxial cable, signal loss increases with frequency.

To illustrate the problems associated with long runs of coax, consider signal transmission over a 100-ft distance. The first issue is signal loss, which would exceed 25 dB even when using the high-performance, low-loss cables designed for test and measurement (Figure 1). The second issue is cost: a 100-ft high-performance cable will cost \$10,000 or more.

In contrast, single-mode optical fiber can be roughly 10% of this cost when purchased in bulk and typically experiences about 0.2 dB of loss per kilometer. Adding a preamplifier will dramatically reduce the loss incurred

in the RF-to-optical and optical-to-RF conversions. In addition, noise figure is also improved. Given these advantages, replacing coax with fiber is a very appealing alternative.

It is only recently that such optical solutions have been possible at frequencies up to 50 GHz. The enabling technologies are drivers that can modulate an RF signal onto single-mode fiber as an optical signal and detectors and drivers that can convert the received signal back to RF. These components are the result of development work in lightwave communications, which is moving from 10 Gb/s to 40 Gb/s, 100 Gb/s and beyond.

Extending the measurement plane

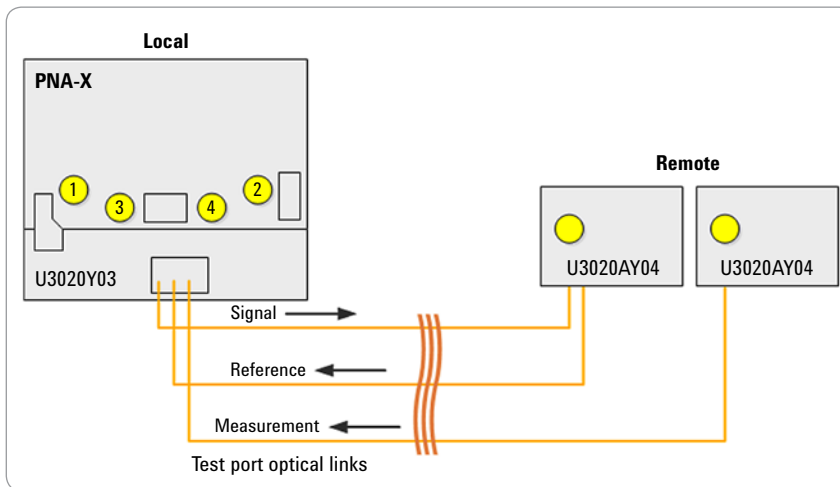


Figure 2. The standalone local and remote OXI units can be used to place two test ports up to 1 km away from the PNA-X.

Designed to support the PNA Series vector network analyzers, the optical port extenders in the OXI Series include two standalone units: a local converter (U3020AY03) and a remote microwave optical module (U3020Y04) that allow optical extension of one or more VNA ports. The remote module provides electrical-to-optical and optical-to-electrical signal conditioning for the local converter, and neither module requires external control.

For long-range testing, the local converter accepts the REF, TEST and SRC signals from the PNA and converts them into optical signals

that are transmitted to the remote optical module at distances of up to 1 km through a trio of fiber-optic cables (Figure 2). If additional RF output power to the test port is required, an amplifier can be used and the gain backed out of the measurement result. If necessary, attenuation can be applied to the return path to the PNA.

One important note: the quality of the optical fiber will have a significant effect on the measurements. Contact Agilent for information regarding the requirements the optical fiber must meet for your application.

Leveraging the versatility of PXIe



Figure 3. The family of OXI modules adds greater capability at the remote end when using fiber optic cable for long-distance measurements.

In general, PXIe modules deliver the benefits of the standard: a compact, modular and scalable architecture. Looking specifically at the Agilent OXI Series, these modules deliver on the potential to reduce solution cost and complexity. They simply plug into a PXIe chassis and don't require a dedicated instrument controller—and you can mix and match modules at any time to address specific measurement needs.

Currently, the OXI Series includes six modules. Five are 3U high and occupy two slots each: an RF-to-optical converter transmitter (M9403A), an optical-RF-converter receiver (M9404A), an RF reflectometer (M9408A) and two USB hubs (M9406A and M9407A; see following section). The sixth module is a one-slot 3U preamplifier (M9405A). All are shown in Figure 3.

The M9403A transmitter modulates an RF signal onto a 1550-nm single-mode optical signal, and the M9404A receiver demodulates the optical signal and presents the resulting RF signal at its output. Both modules operate from 300 kHz to 26.5 GHz (optionally to 50 GHz). These modules take the place of the U3020AY04 at the remote end of the measurement configuration (Figure 4)

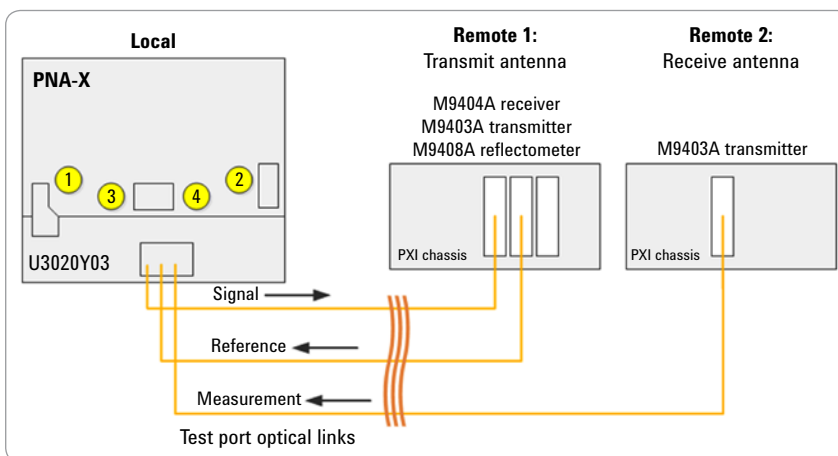


Figure 4. This example solution for testing on an antenna range illustrates the flexibility that becomes possible when the PXI-based OXI products are placed in two remote locations.



Figure 5. Performance of a 1.5-km optical link without preamplification.



Figure 6. Performance of the same 1.5-km optical link when using the M9405A preamplifier.

Enabling remote connectivity and control

The complete PNA measurement environment—including display and control—can be operated via USB devices at the remote end of the optical link by adding a one-port (M9406A) or four-port (M9407A) optical-to-USB hub. The hubs provide connections to keyboard, mouse, power sensor and electronic calibration (E-Cal) modules as well as the instrument display (with the optional USB-to-VGA converter).

Calibration can be performed from the remote location, as can the power measurements necessary to verify RF power levels at the DUT. A two-pair optical cable supports the transmit and receive paths from the remote and the modules.

The M9405A preamplifier covers the same operating frequency range as the converters and delivers 30 dB of gain to overcome conversion loss and improve noise figure. Its noise figure performance is 8.5 dB to 26.5 GHz and 6 dB up to 35 GHz. This capability also is available as an integrated part of the M9403A and M9404A modules.

The amplifier can be a useful addition to any remote system because a certain amount of noise is associated with the link in typical electro-optical and opto-electrical pairs. As shown in Figure 5, there is about 34 dB of loss and a loss slope of about 0.23 dB/GHz and an additional 5 dB above 22 GHz in a 1.5-km run. Noise figure is about 40 dB. Using the M9405A preamplifier in the link, noise figure drops to 10 or 15 dB and loss varies between 0 and 10 dB (Figure 6).

When the VNA has a configurable test set, adding the M9408A reflectometer module enables full port extension over a full 1-km span. Even at shorter distances, the reflectometer extends the measurement plane and delivers more power to the device—and this allows full two-port characterization that isn't practical using coaxial cables. The M9408A has a frequency range of 300 kHz to 50 GHz and can also be used as an independent dual coupler.

Conclusion

In applications that include a remote SUT, Agilent's PXIe-based OXI modules eliminate problems such as signal loss and poor noise figure associated with long runs of coaxial cables. These easy-to-configure modules also reduce the number of elements required in the measurement system. In addition, they provide capabilities such as the ability to control the network analyzer from the remote end of the optical connection. If you believe these products have value for your application, please call your Agilent sales representative to discuss the requirements and implementation strategy.

Related information

- Brochure: *PNA-X Series microwave network analyzers*, publication 5990-4592EN
- Brochure: *PXI Optical Extenders for Instruments*, publication 5990-9069EN
- Data sheet: *PXI Optical Extenders for Instruments*, publication 5991-0383EN



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