

# Agilent Standardized Core Makes Building and Supporting a Functional Test System Easier and Less Costly

LXinstruments Delivers Open Test Platform using Agilent LXI instruments

## Application Note

### Introduction

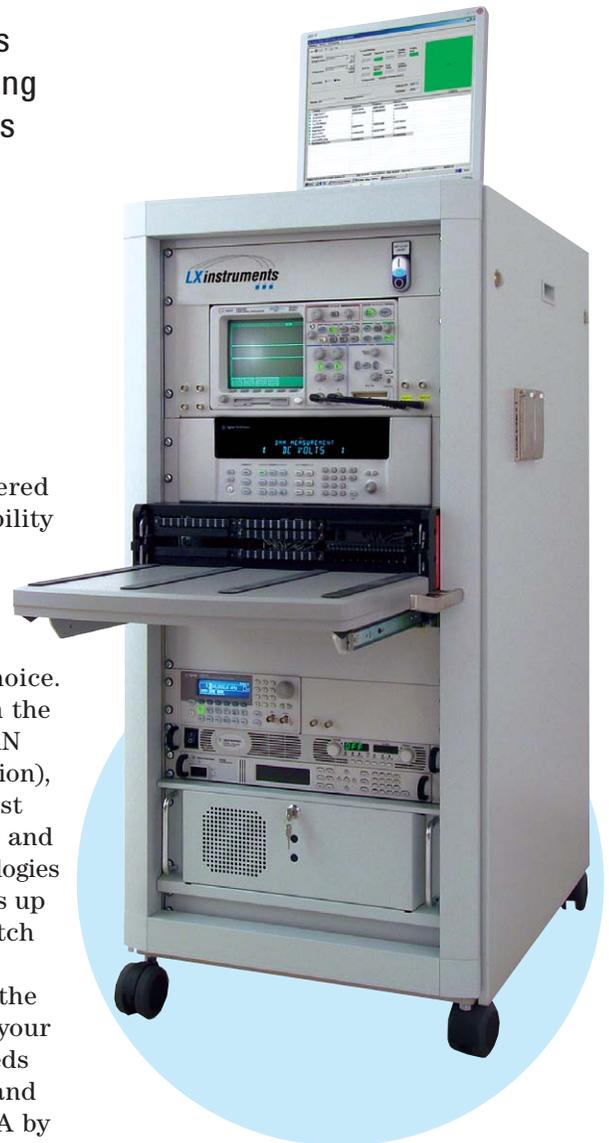
In the past, if you needed a functional test system you had to choose between a complete custom solution – typically integrated by a local system integrator – or a standard, off-the-shelf application-centered system, typically delivered by an instrument vendor. Building custom solutions often involved major engineering effort and big expenditures, and the systems were sometimes hard to support

and difficult to adapt for testing new products. The standard, application-centered systems often lacked flexibility and frequently relied on proprietary standards or software.

Today, you have another choice. With instruments based on the LXI industry standard (LAN Extensions for Instrumentation), you can create a custom test system that is easy to build and support. The Agilent Technologies 34980A mainframe supports up to 8 measurement and switch modules; you can mix and match modules to achieve the functionality you need for your application. When your needs change, you can easily expand and reconfigure the 34980A by replacing modules.

### Contents

The OTB approach	2
Hardware architecture	3
Matrix architecture	8
OTP programming interface standards	9
Fixture interface	10
Open system software	10
Business- and application-specific solutions	13
Conclusion	13



Agilent Technologies

## The OTP Approach

In this application note, we show you how one of Agilent's channel partners, LXinstruments GmbH, used the Agilent 34980A multi-function switch/measure unit and other LXI instruments to create a standardized core - the open test platform (OTP), for building test systems. The OTP makes it easier for LXinstruments to develop and support custom functional test systems for its customers. The OTP provides more than 70 percent of a system's total functionality. LXinstruments extends the functionality with custom building blocks and sub-systems to meet each customer's application-specific requirements.

Every functional test system provides three basic capabilities: sourcing, measuring and switching. "Sourcing" means providing power or stimulus to the device under test (DUT). You "measure" parameters (for example a voltage or a reaction to a stimulus) to make sure your DUT is functioning properly. "Switching" refers to moving the power and stimulus signals to the next test point, or switching to the next measurement setup on the same test point. With the right combination of modules, the 34980A provides all these capabilities. All you need to add is a power supply to power your DUT.

To build a cost-effective system architecture that would meet its customers' needs, LXinstruments needed equipment and software that is flexible and easy to use. The company used Agilent equipment and software to meet those requirements.

The LXinstruments OTP system core consists of the Agilent 34980A switch/measure unit with a digital multimeter (DMM) and at least one switch matrix module.

To demonstrate the features and functionalities of its OTP, LXinstruments built a functional test system for industrial micro programmable logic controllers (PLCs). For the micro PLC system, the software foundation is provided by the Agilent TestExec SL test executive. However, the 34980A is compatible with a wide variety of software environments, including National Instruments TestStand. LXinstruments also supports this software platform. Together, the test executive software and the LXinstruments OTP libraries provide a ready-to-run environment. LXinstruments provides test step libraries for all supported instruments. LXinstruments also relies on Virginia Panel Corporation fixtures. Combining these key elements from industry-leading partners allows LXinstruments to provide flexible, reliable and cost-effective custom systems for its customers.

## Hardware Architecture

The Agilent 34980A multi-function switch/measure unit provides a versatile system core for the OTP and a solid base for integrating additional instruments and features to meet application specific requirements.



### Requirements for testing a micro PLC

Micro PLCs are small, low-cost, programmable logic controllers used in industrial automation applications for tasks such as controlling simple machinery, or powering up individual instruments in a timed sequence. They feature a set of digital and analog inputs as well as digital outputs. The internal controller runs the industrial control application previously downloaded to non-volatile memory. In PLCs, the software application creates a state machine, and it is executed in real-time. The features of a micro PLC are a subset of larger PLCs providing more I/O ports, extended software features, field bus support (for example, Profibus) and motion controllers. They are typically used in smaller automation applications that were previously implemented with complicated relay setups.

### Functional test requirements

To test a micro PLC in a manufacturing environment, a test system must:

- Provide power to the PLC, measure inrush current, and ensure there are no shorts
- Download a test application to the PLC
- Test analog and digital inputs, preferably at the border of the specifications
- Test digital or relay outputs at nominal load (repair and QA test scenarios would also require test under different load conditions and at different temperature settings)
- Verify operator interface (test pushbuttons and verify LCD display operation)
- Test switch outputs under load
- Download PLC delivery software and data prior to packaging and shipment (optional)

The following sections outline the instruments used in the micro PLC test system, as shown in Figure 1, on the following page. Please refer to the instrument data sheets for instrument specifications.

## Industrial PC Controller

LXinstruments chose a standalone industrial PC instead of an embedded PC because a standalone PC costs less and is much easier to upgrade without interfering with the test system's backplane. In LXinstruments micro PLC test system, the industrial PC controller runs the OTP software framework and controls all instrumentation. With the exception of the Agilent 54622D oscilloscope, all instruments support the LXI Standard and

are controlled over LAN. The oscilloscope and the camera used for automated evaluation of the DUT display are controlled via the controller's USB 2.0 port, although the oscilloscope uses an Agilent 82357A USB/GPIB interface to communicate with the PC via USB.

The PC is equipped with an additional digital I/O plug-in board to control the pneumatic vents used for adapter automation as well as other auxiliary

functions that may be integrated into the test fixture. The PC plug-in board is used to separate automation functionality from test and measurement functionality. If required, LXinstruments or the customer can integrate additional serial interfaces (RS-232, CAN, Profibus etc.) into the PC.

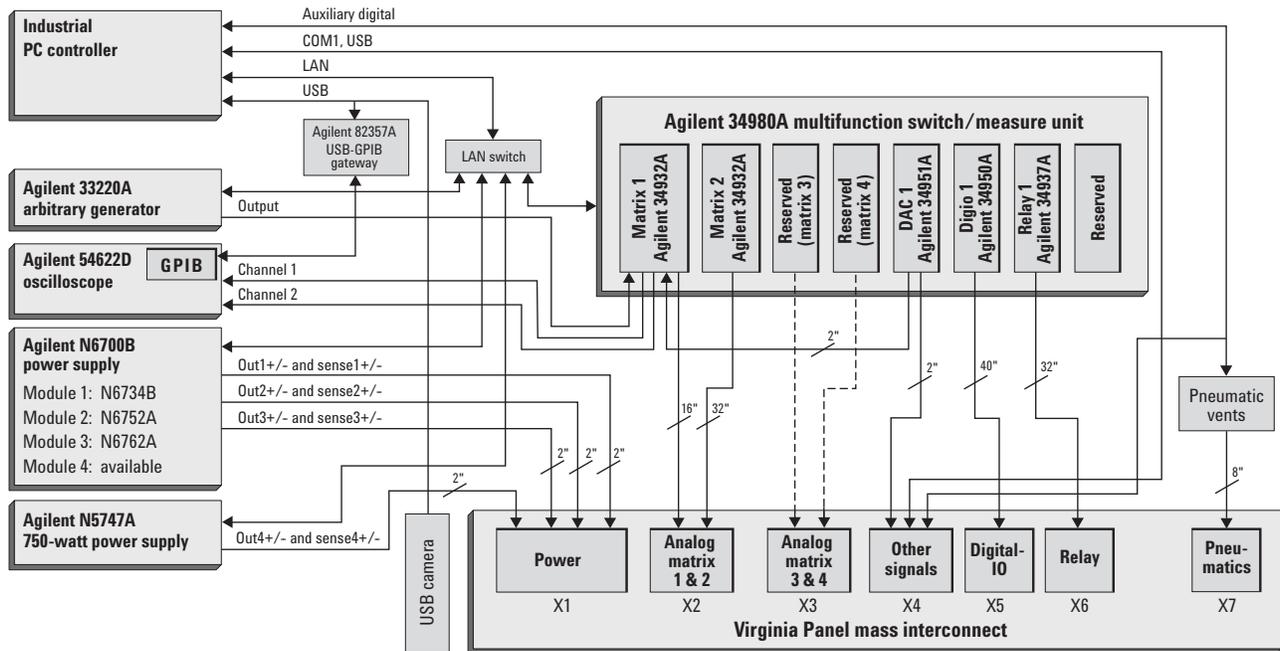


Figure 1. Example system configuration

## Agilent 34980A Multifunction Switch/Measure Unit

LXinstruments needed a way to implement the source/measure/switch functionality of the OTP in a flexible, cost effective manner. The 34980A multifunction switch/measure unit gives LXinstruments a basic core that can be configured for many different applications and changed or upgraded as required. This flexibility allows LXinstruments to satisfy a wide variety of customers' needs.

The 34980A offers versatile switching and an internal 6½-digit digital multimeter (DMM) that provides a wide range of measurement functions at scaleable speed and accuracy. The 34980A handles frequencies up to 20 GHz, higher voltages (300 V) and higher currents (generally 1 A, selected switches up to 5 A) than other switching solutions. It features LAN (LXI Class C compliant), USB and GPIB programming interfaces and hosts up to eight 349xxA switch/measurement modules. LXinstruments relies on the 34980A because it provides a flexible and cost-effective foundation for functional test systems and because its features make system debugging easy.

### Flexibility

The 34980A's modular structure makes it easy to upgrade the system and adapt it to new applications; a wide variety of plug-in modules covers much of the total functionality needed, including advanced features. In addition, when LXinstruments wants to extend the system beyond eight module slots, they can use a second mainframe (without a DMM). This method provides high pin counts and lets LXinstruments integrate complex systems cost efficiently.

### Cost efficiency

For mid-range systems, the 34980A's compact form factor and transaction speed compare favorably to other switch systems and cost significantly less than VXI and PXI systems. The universal architecture eliminates the need for costly external signal conditioning. In addition, terminal blocks or D-Sub connectors allow you to use robust, reliable and cost-efficient cabling.

### Easy debugging

Front-panel access to all module functions makes maintenance and debugging easier, since operators don't have to interact with the PC to verify functionality. When the test system is connected to a LAN, LXinstruments can further more use the

built-in Web server of any LXI instrument in the system for remote operation and maintenance. The 34980A's web server represents a superset of the functionality defined by the LXI standard and provides the ability to control and supervise switch status by means of a graphical user interface. It does not require any specific software installed on the system controller besides a web browser. The graphical representation of the switches helps operators visualize the state of individual relays and outputs connected to terminal blocks and routed to the internal DMM. LXinstruments wires four BNC connections to the test-system front panel to make it easier to verify wiring. For details, see the "Matrix architecture" section.



Figure 2. Agilent 34980A multifunction switch/measure unit

## 34980A Modules Used in the Micro PLC Test System

### For switching:

- 34932A dual 16x4 armature matrix, 300 V/1 A, 30 MHz. The micro PLC configuration is equipped with two matrices; the first 16 channels of the first matrix are reserved as instrumentation channels. All other channels are used as DUT channels.
- 34937A 28-channel Form C (1 A) and 4-channel Form A (5 A) switch module, 300 V. The Form C and Form A channels are used to switch PLC loads and provide switching resources for auxiliary hardware residing in the test fixture.

### For stimulus

- 34950A 64-bit digital I/O, programmable thresholds with programmable polarity and pattern memory. The open collector outputs of the 34950A allow for stimulus of the digital inputs of the PLC. Supply voltage is drawn from the N6762A precision power supply module residing in the N6700B mainframe. This setup gives full programming control over timing and voltage levels of the digital outputs. Using this module, the 34980A tests the micro PLC's analog and digital inputs at the specification limits.
- 34951A 4-channel isolated D/A converter  $\pm 16$  V/ $\pm 20$  mA, 16 bits resolution, 200 kHz update rate, 500 kpoints waveform memory. The D/A converters are used to stimulate the analog inputs of the DUT with static voltages as well as with defined signal

slopes stored to the waveform memory. For moderate frequencies, the D/As replace an arbitrary function generator and provide an extended voltage and current drive range at enhanced amplitude resolution.

To get the right combination of functionality for the PLC application, LXinstruments chose the above modules from the 19 different 34980A modules available. In lieu of the mainframe and module approach, LXinstruments could also use the 1U, half-rack L4400 series of LXI switch and control instruments. Contact LXinstruments for a list of additional instruments and modules they support.

## **N6700 Series Low-Profile Modular Power System (MPS)**

The Agilent N6700B MPS main-frame, with its variety of power supply modules, provides up to four independent and fully programmable voltages and currents. Each module provides up to 100 W of supply power, and autoranging ensures that the full power rating is available over a wide range of voltages and currents. This eliminates the need for multiple supplies with different voltage and current ranges. The N6700 Series also cost less than other modular power supplies. LXinstruments chose the N6700 Series for the micro PLC system because of its flexibility, size and speed:

- Compact form factor, just 1 rack unit high (1U) –the instrument’s airflow is designed so other instruments can be placed directly above and below the supply without affecting cooling.

- LAN (LXI-C compliant), USB and GPIB interfaces are standard, providing the flexibility to use whichever interface their customer requires.
- High data throughput on all interfaces and fast programming response (less than 1 ms command processing time over all interfaces).

In the micro PLC system, the N6700B supply is used to provide the following voltage sources:

- DUT supply power
- Reference voltage for open collector digital outputs
- Adapter auxiliary supply for sensors and USB camera

The N6700B also measures inrush current to confirm the DUT is drawing the right amount of current at turn on.

## **Agilent N5700 Series DC Power Supplies**

Agilent N5700 Series power supplies come in 750 W and 1500 W versions. Different models range from 6 V to 600 V, providing maximum current at the voltage level needed. LXinstruments chose the N5747A supply (60 V, 12.5 A) for its ability to meet the system’s high current needs. Other reasons LXinstruments chose the N5747A:

- Very compact form factor, just 1U high – the N5700’s airflow is designed so other instruments can be placed directly above and below the supply without affecting cooling.
- Lower cost compared to other power supplies.
- LAN (LXI-C compliant), USB and GPIB interfaces are standard, providing the flexibility to use whichever interface their customer requires.

In the micro PLC application, an N5747A power supply is used to test the PLC’s switch outputs under high load current.

## Other Instruments

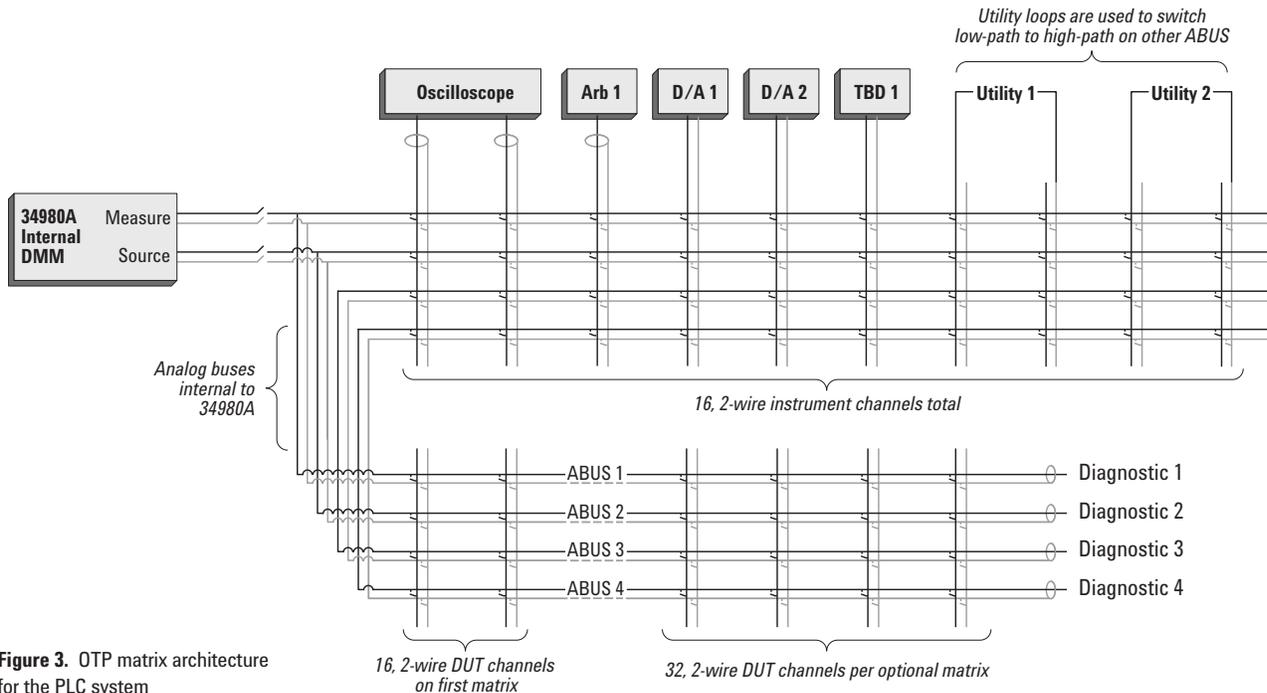
The OTP architecture and software support other instruments, including the Agilent 33250A function/arbitrary waveform generator, the Agilent 53131A universal counter and the Agilent 54642A mixed signal oscilloscope. However, none of these instruments are used in the micro PLC application.

## Matrix Architecture

When LXinstruments engineers designed the instrument matrix architecture for the OTP (see Figure 3), they included one 34932A matrix, providing 2-wire switching of 16 DUT channels to 4 analog buses. The first 16 channels of matrix 1 are reserved instrument channels, and they provide sufficient room even for complex instrumentation demands. Depending on the number of DUT channels required, the system can be expanded to include multiple matrices. The 34980A's four internal buses provide LXinstruments with the ability to route signals between the matrices and to the 34980A's internal DMM. The utility loops shown in figure 3 transfer signals

from the "Low" path of the matrix system to the "High" path. They provide a high degree of flexibility, especially for floating voltage, current and resistance measurements.

For debugging and development, you can easily access any signal present on an analog bus via the four front-mounted BNC jacks. This matrix structure provides the best compromise between cost, flexibility and ease of verification by means of a self-test application and fixture.



**Figure 3.** OTP matrix architecture for the PLC system

## OTP Programming Interface Standards

Ethernet (LAN) is the most common new standard for instrument control - and the foundation of the LXI standard. It is inexpensive and easy to implement, it provides fast throughput and it allows remote access to the system. The multi-vendor industrial standard LXI adds trigger and synchronization functionality to the LAN standard already well established in the computer industry, making it even more suited for instrument control. The OTP architecture uses LXI based instrumentation wherever possible; all core instruments are controlled through LAN. However, additional instruments may be

programmed using LAN, GPIB, USB, or RS-232 interfaces. Systems based on the LXI instruments OTP platform are future proof and will take advantage of upcoming instrumentation and associated speed enhancements. With the LAN throughput available today, the LAN based OTP is well suited for mid-scale systems and provides a very cost-effective alternative to backplane-driven architectures. Upcoming Gigabit Ethernet will further increase the throughput of LAN-based systems to a point that may meet or exceed the speeds of backplane driven architectures. Upcoming instruments implementing LXI class A or B will further increase the range of possible applications.

Agilent IO Libraries Suite 14.2, which ships with the 34980A and other Agilent instruments, provides one user interface to access all standard PC interfaces such as LAN, USB and RS-232, as well as test-and-measurement interfaces such as GPIB or VXI. The libraries provide robust interface debugging tools and the flexibility to use either drivers or native instrument commands for controlling each instrument.

See [www.agilent.com/find/iosuite](http://www.agilent.com/find/iosuite) for more information.

## Fixture Interface

The LXinstruments OTP relies on Virginia Panel Corporation (VPC) fixture interfaces, since reliable interconnections between the test system and test fixture are key to maximizing test-system uptime. The fixture interfaces are specified for more than 20,000 fixture changes without maintenance. Agilent instrument connections make it easy for LXinstruments to cable between an instrument and the interface panel. LXinstruments used the Virginia Panel G12 receiver for the sample system. It works well for table-top fixturing applications in low- to medium-volume high-mix applications. The G12 receiver provides 12 module slots, and each slot can host up to 192 pins. The VPC table assembly eliminates the need to construct custom table solutions. High-volume applications that include automated handling systems would use the Virginia Panel G18 series of interfaces. See [www.vpc.com](http://www.vpc.com) for more information about Virginia Panel mass interconnect solutions.

## Open System Software

In many cases, more than 50% of the cost of implementing a test system is related to software engineering. LXinstruments' key to reducing software development costs is to use commercially available test sequencers and a modular software approach that maximizes code reuse (see Figure 4).

LXinstruments software strategy includes:

- Choosing programming languages and instruments designed to be “open.” In other words, the software development environment and the Agilent IO Libraries Suite support any instrument.

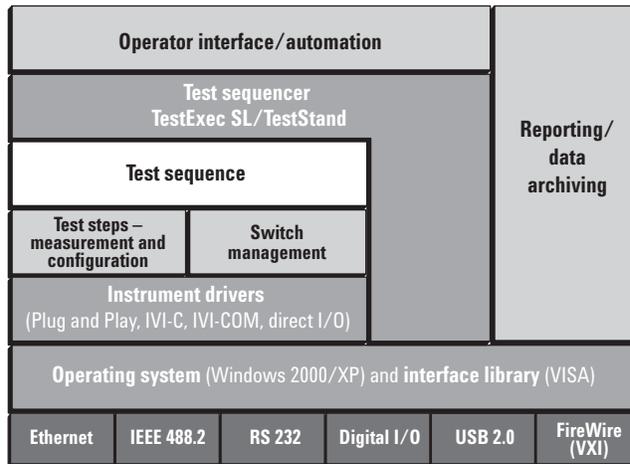


Figure 4. OTP software layers

The diagram outlines the hierarchical layer model comprising the OTP test software architecture. The values of gray represent the frequency of modification. This modular approach maximizes code reuse.

- (M) Medium gray: Standard, commercially available software; no modification by the user is required.
- (L) Light gray: Standard software modules supplied by LXinstruments. Modifications, typically done just once, adapt the modules to the customer process environment.
- (W) White: Software portions that are created or modified for every device under test (DUT).
- (D) Dark gray: Standard instrument control physical interfaces that are used by OTP and supported by the Agilent IO Libraries Suite 14.0. These are hardware dependent and typically do not change.

- Using commercial “off-the-shelf” (COTS) applications for large portions of the intended software environment.
- Separating the tasks of modifying the software framework and defining test sequences and assigning them to engineers with the appropriate skill set.
- Using defined software layers and application programming interfaces (APIs) to provide docking points for customized user interfaces, automation and reporting.
- Reusing instrument code by means of test step libraries.

Ensuring fast test-sequence execution, LXinstruments supports Agilent TestExec SL and NI TestStand, the two leading test executives. For the micro PLC system, LXinstruments chose TestExec SL.

LXinstruments adapts the standard software to meet “real world” requirements, including comprehensive user interfaces, reporting functionality and integration into automated manufacturing environments.

#### **Operator interface**

The operator interface allows users to interact with the test system in a production environment. For the micro PLC test system, LXinstruments built the following functionalities into the OTP operator interface:

- Operator login and authentication – user must enter name and password.
- Selection of test sequence (product to be tested) and variant, where variants can be product variations or different test scenarios, for example “production test,” “repair” and “margin test”.
- Start, halt, exit and abort the test sequence.
- Integration of barcode scanners and communication with handling systems.

- Display test results including measured values, test limits and judgment (pass/fail) and overall results of a test run (pass/fail).
- Display basic test statistics (number of units tested, number of units that passed/failed, time to test one DUT).
- Control of marking devices such as label printers, laser and ink marking systems.

Additional functionality for the user class “Supervisor” includes access to maintenance functions and utility sequences (control of handling system functions, access to test parameters and limits). Full access is available for the user class “Developer”.

**Test executive**

A test executive includes a runtime engine that interprets and executes test sequences and evaluates test results against the limits defined in the test sequence. It provides APIs for control by the operator interface at runtime and for the supply of status information to the operator interface. The test executive also provides a test sequence development environment that is used to define and modify sequences. As mentioned earlier, LXinstruments used Agilent TestExec SL for the micro PLC system, but the OTP platform also supports NI TestStand.

**Test sequences**

Test sequences define the individual tests used to evaluate a DUT and include test parameters, limits and the order of execution of test steps. Test sequences are typically defined by test engineers based on test requirement specifications provided by R&D and QA departments or, in the case of contract manufacturing,

by the customer of the contract manufacturer. The integrated test sequence development environment allows test engineers to focus on defining test sequence content and test methodologies rather than developing instrument-control code, data handling and other low-level programming tasks. Test sequences are defined simply by arranging test steps and setting parameters and limits for test execution.

**Test steps**

Test steps are the fundamental building blocks of test sequences. They are written in programming languages such as C, Visual Basic, NI LabVIEW or Agilent VEE Pro. LXinstruments delivers comprehensive test step libraries with each OTP-based system. The libraries focus on instrument functionality rather than on specific test applications and thus are reusable for different applications. As the test step libraries are delivered in source code, the user may start from the existing libraries in order to add individual test steps for specific applications.

**Switch management**

Switch management can be seen as a specific form of test steps. In the micro PLC system, switch handlers control complex topologies that are defined using the TestExec SL switching topology editor. The user defines the switch route to be used for a given test. At runtime, TestExec SL closes all relays on the switch path prior to execution of the test and opens them after execution of the test automatically. OTP-based systems are delivered with switch control software and predefined switch topologies to make it easier to develop test sequences.

**Instrument drivers**

Instrument drivers are used to encapsulate instrument complexity and to provide programmatic access to the instruments without having to learn the underlying SCPI (Standard Commands for Programmable Instrument) syntax. IVI and/or Plug and Play drivers for all instruments supported by the OTP platform are provided by Agilent and shipped with the system. Because the OTP platform uses Agilent IO Libraries Suite 14.2, its open architecture makes it easy to integrate instruments from different vendors into the system. It supports all major driver and interface standards.

## Business- and Application-Specific Solutions

### Data reporting and archiving

The OTP software architecture separates data reporting and archiving from the individual test sequences and utilizes the APIs provided by the test sequencer. This arrangement makes test-sequence development easier, because when you write the test sequence, you do not need to be concerned with reporting and archiving. The test executive takes care of collecting data, displaying results and storing them. The OTP approach enforces consistent data handling for all sequences and helps to standardize test data formats throughout your test floor and throughout your company.

### Operating system and interface library

The OTP software foundation is built on Microsoft Windows XP. All instruments are programmed using the VISA interface driver framework, which is part of the IO Libraries Suite. The IO Libraries also support interfaces such as FireWire (VXI), USB, RS-232 and GPIB (IEEE 488.2).

The LXinstruments standard system core can be extended to provide test capability for a variety of other industries and applications. A few examples:

- **RF and microwave measurements and switching** (aerospace/defense, telecommunications, automotive and other industries)
- **Serial communication interfaces** (industrial automation, automotive and other industries)
- **Higher voltages and currents** (white goods, automotive and industrial automation industries)
- **Optical inspection and mechanical stimulus** (applications in all industries)

## Conclusion

LXinstruments used the Agilent 34980A multi-function switch/measure unit and open software standards to create a standardized open test platform. The 34980A-based OTP makes it easier to develop and support custom functional test systems. Using a matrix switch architecture, reliable fixtures, and a modular software approach all contribute to system flexibility and reliability and, ultimately, to lower test costs. The test system described in this application note is just one example of what is possible. Whether you are developing your test system in house or using a system integrator like LXinstruments, you can use the basic principles outlined here to create a test system to meet your needs. Agilent can provide all of the instruments and most of the other components you need.



### About LXinstruments

LXinstruments, located in Böblingen, Germany is a leader in the development and deployment of customer-specific functional test solutions. The partnership between Agilent Technologies and LXinstruments combines the global presence of a leading instrument manufacturer with the flexibility and application knowledge of a mid size system integrator. For more information about LXinstruments see [www.lxinstruments.com](http://www.lxinstruments.com).



### Agilent Email Updates

[www.agilent.com/find/emailupdates](http://www.agilent.com/find/emailupdates)

Get the latest information on the products and applications you select.



### Agilent Direct

[www.agilent.com/find/quick](http://www.agilent.com/find/quick)

Quickly choose and use your test equipment solutions with confidence.



[www.agilent.com/find/open](http://www.agilent.com/find/open)

Agilent Open simplifies the process of connecting and programming test systems to help engineers design, validate and manufacture electronic products. Agilent offers open connectivity for a broad range of system-ready instruments, open industry software, PC-standard I/O and global support, which are combined to more easily integrate test system development.

**LXI** is the U.S. registered trademark of the LXI Consortium.

### Related Agilent Literature

Publication title	Publication type	Publication number	Web address
Agilent 34980A Multifunction Switch/Measure Unit	Data sheet	5989-1437EN	<a href="http://www.agilent.com/find/34980A">www.agilent.com/find/34980A</a>
Agilent N6700 Series Low-Profile Modular Power System	Data sheet	5989-1411EN	<a href="http://www.agilent.com/find/n6700">www.agilent.com/find/n6700</a>
Agilent N5700 Series System DC Power Supplies	Data sheet	5989-1330EN	<a href="http://www.agilent.com/find/n5700">www.agilent.com/find/n5700</a>
Agilent I/O Hardware for PC-to-Instrument Connection	Data sheet	5989-1889EN	<a href="http://www.agilent.com/find/gpib">www.agilent.com/find/gpib</a>
Agilent E2094N IO Libraries Suite 14.0	Data sheet	5989-1439EN	<a href="http://www.agilent.com/find/io">www.agilent.com/find/io</a>
Agilent VEE Pro 7.0 (W1140A-VEE)	Data sheet	5989-6302EN	<a href="http://www.agilent.com/find/vee">www.agilent.com/find/vee</a>

You'll find comprehensive information on test-system development at [www.agilent.com/find/syscontent](http://www.agilent.com/find/syscontent)

## Remove all doubt

Our repair and calibration services will get your equipment back to you, performing like new, when promised. You will get full value out of your Agilent equipment throughout its lifetime. Your equipment will be serviced by Agilent-trained technicians using the latest factory calibration procedures, automated repair diagnostics and genuine parts. You will always have the utmost confidence in your measurements.

Agilent offers a wide range of additional expert test and measurement services for your equipment, including initial start-up assistance onsite education and training, as well as design, system integration, and project management.

For more information on repair and calibration services, go to

[www.agilent.com/find/removealldoubt](http://www.agilent.com/find/removealldoubt)

## www.agilent.com

For more information on Agilent Technologies' products, applications or services, please contact your local Agilent office. The complete list is available at:

[www.agilent.com/find/contactus](http://www.agilent.com/find/contactus)

### Phone or Fax

#### United States:

(tel) 800 829 4444  
(fax) 800 829 4433

#### Canada:

(tel) 877 894 4414  
(fax) 800 746 4866

#### China:

(tel) 800 810 0189  
(fax) 800 820 2816

#### Europe:

(tel) 31 20 547 2111

#### Japan:

(tel) (81) 426 56 7832  
(fax) (81) 426 56 7840

#### Korea:

(tel) (080) 769 0800  
(fax) (080) 769 0900

#### Latin America:

(tel) (305) 269 7500

#### Taiwan:

(tel) 0800 047 866  
(fax) 0800 286 331

#### Other Asia Pacific Countries:

(tel) (65) 6375 8100  
(fax) (65) 6755 0042

Email: [tm\\_ap@agilent.com](mailto:tm_ap@agilent.com)

Revised: 09/14/06

Product specifications and descriptions in this document subject to change without notice.

© Agilent Technologies, Inc. 2007  
Printed in USA, February 23, 2007  
5989-1873EN



Agilent Technologies