Configuring Your LXI-based Test System for Easy Maintainability

Assigning IP addresses to specific switch ports minimizes risks to system and DUT

Application Note

When creating instrument connections in any automated test system, several common issues are likely to arise. While it’s relatively easy to connect and verify LXI instruments, a few extra steps may be necessary before you can begin programming the instruments. For example, issues such as address conflicts are a common occurrence when setting up addresses for each device.

Once an automated test system is deployed, any type of troubleshooting, maintenance or repair requires well-defined procedures that ensure a stable system configuration and predictable testing. One common example: If an instrument is swapped with another of the same type, the absence of a well-documented procedure may leave the system in a state that causes it to operate in unexpected or unwanted ways. In the worst-case scenario, improper operation may result in damage to either the test equipment or the device under test (DUT).

With LXI-based systems, one of the initial hurdles is deciding how to allocate or assign Internet Protocol (IP) addresses to the individual instruments. This note focuses on three possible solutions that range from simple to robust:

• Use Dynamic Host Configuration Protocol (DHCP) to assign addresses at power up
• Set static IP addresses
• Assign IP addresses to specific ports on the LAN switch

The latter approach is an emerging solution that is also the most robust. It requires an Ethernet switch that supports a DHCP relay information option called RFC 3046 Option 82. Option 82, as we’ll call it, has two important advantages; it simplifies system troubleshooting, maintenance and repair, and it helps minimize the risks to the system and the DUT.

The remainder of this application note provides an overview of all three approaches. Each overview describes the recommended use case for each approach, presents the pros and cons of each, and concludes with tips for successful implementation.

1 There are usually software issues, too. On that topic, please see Agilent application notes 1465-3, Understanding Drivers and Direct I/O (publication 5989-0110) and 1465-4, Choosing Your Test System Software Architecture (publication 5988-9619)
Letting DHCP assign addresses at instrument power-up is the simple, hands-off approach. This is usually sufficient for simple test systems or ad hoc tests that will be created once, used for a short period and then disassembled. Similarly, this works well when there is no need for long-term maintenance or support.

DHCP will work well in usage scenarios such as the following:
- Lab bench setups that are frequently rearranged
- Instruments that are frequently shared among users
- One-time or static configurations in which IP addresses won’t change
- Neither the system nor the DUT is likely to be damaged by unexpected changes to instrument settings

The best-case scenario for DHCP is when the system is under the control of a single person. This limits the chances that the configuration will experience unknown changes: DHCP will reassign addresses only when the system is somehow changed. If there is just one user, they should know—and control—any system changes.

In contrast, DHCP alone is not predictable enough for long-lived ATE systems that must provide high availability. Fixed IP addresses or port-specific IP addresses are better choices.

**Pros**
DHCP is the fastest and easiest way to configure a system and start using it. As noted above, it is good for one-off or well-controlled systems. It is also sufficient when connecting to just one of each type of instrument—one scope, one function generator, one DMM, one power supply, etc.

Tools such as the ACE utilities within the Agilent IO Libraries can simplify the set-up process (Figure 1).

**Cons**
Within the acronym DHCP the word “dynamic” says it all: An unexpected address change is always a possibility with DHCP. Substituting a replacement instrument during system troubleshooting, calibration, maintenance or repair can cause address changes. This makes it necessary to check and verify all addresses after any configuration change. If any addresses have changed, test program configurations will need to be revised to reflect the new address assignments.
The simple case: Set fixed IP addresses

Selecting and assigning fixed IP addresses is an effective choice for medium-sized, moderately complex test systems because it is the most straightforward to implement. As with simple DHCP addressing, it can be made more reliable by adding programmatic checks (see page 6).

To simplify system programming, it is possible to assign a device name to each IP address. For example, device names can be assigned in either the IVI driver declarations or by using the “alias” capability in the Agilent IO Libraries’ ACE utilities. Accessing the alias capability is as simple as right-clicking on the device in the map (Figure 2).

At this level of system complexity, it’s likely that more than one person will have access to the system. As a safeguard, written procedures will be needed to guide users through any type of change to the system’s complement of instrumentation. This will help prevent problems when, for example, calibration or repair personnel need to change any IP addresses to run their test routines.

**Pros**

Simplicity is the main advantage. This makes it easy to document all IP addresses—and the change procedures—in case an instrument must be removed. Standard tools such as the Agilent ACE utilities can easily find each instrument within the system.

**Cons**

Assigning fixed IP addresses doesn’t automatically accommodate the use of spares or remote calibration strategies in which substitute instruments might be installed. As a result, it is important to check the IP address any time an instrument is removed from the rack for troubleshooting, maintenance, repair or temporary use elsewhere. It’s important to note that the procedures for changing the IP address vary by instrument, adding some complexity to configuration and maintenance.
The robust case: Assign port-specific IP addresses

When creating a large, complex, highly-available test system, the decision to use port-specific IP addresses will be useful during system development and after system deployment. Making it work requires the use of a LAN switch and DHCP server that are both compatible with Option 82.2

Here’s how the addressing process works with Option 82:

1. The switch requests a block of addresses from the DHCP server
2. The DHCP server uses a predefined lookup table, which is created during system development
3. The switch assigns a predefined fixed address to each of its ports

As long as an instrument is connected to a specific port its address will remain fixed. Further, any instrument connected to a specific port will receive the predefined IP address.

This approach works with all LXI-compliant instruments—no modifications are required. The instruments will use DHCP to obtain their address, and Option 82 will always assign the same address to the instrument connected to a given port.

The modest additional cost of an Option 82-capable switch—compared to a consumer-grade switch—is inexpensive insurance for a high-availability test system. Fortunately, this capability is increasingly being used as a security measure so it’s reasonable to expect widespread adoption. Currently, Option 82-capable switches are available from vendors such as Cisco (Catalyst series), Juniper (EX series) and Alcatel/Lucent (Omniswitch 9000 family). This capability is still somewhat rare in consumer-grade devices.

Pros

Port-specific addressing ensures that the test system has fixed IP addresses associated with each switch port. One key benefit: This provides stable addresses when coding the test-system software. During development and after deployment, an equivalent-model substitute instrument will receive the proper address when connected to the same switch port. This ensures predictable behavior from the instrument and the system.

The use of port-specific addressing also solves the problem of instrument substitution during troubleshooting, maintenance or repair. For example, a calibration station can assign its own block of addresses and the instruments will automatically adjust their addresses accordingly.

Cons

This type of advanced capability is probably under the control of the corporate IT department, which may need to approve the use of Option 82. However, an internal networking specialist may be able to help enable Option 82 for the test system.

As noted earlier, Option 82-compatible devices carry a slight price premium. On the plus side, this capability will save time and money during system development, troubleshooting, maintenance and repair.

One final note: This capability does not provide protection from human error. If a non-equivalent instrument is substituted it will receive the “proper” IP address; however, it may have different functionality and programming codes. Unfortunately, this type of error could cause problems in the system and potentially damage the system or DUT.

2 Consider contacting a networking specialist in your company’s IT department: If your local DHCP server already supports Option 82, they may be able to identify an existing switch you can use
Comparing the three approaches

All three approaches have pluses and minuses, and have preferred use cases. Table 1 provides a quick side-by-side comparison of the respective pros and cons.

<table>
<thead>
<tr>
<th>Method &amp; Use Case</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Let DHCP assign IP addresses in small ad hoc systems</td>
<td>• Quick and simple</td>
<td>• Dynamic, unpredictable</td>
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<td></td>
<td>• Low-cost consumer-grade LAN hardware</td>
<td>• Possible damage to system or DUT</td>
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<tr>
<td></td>
<td></td>
<td>• Time needed to decipher unexpected changes</td>
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<tr>
<td>Set static IP addresses in medium-sized, moderately complex systems</td>
<td>• Simple</td>
<td>• Possible damage to system or DUT</td>
</tr>
<tr>
<td></td>
<td>• Low-cost consumer-grade LAN hardware</td>
<td>• Time needed to define and set addresses</td>
</tr>
<tr>
<td></td>
<td>• Stable configuration</td>
<td>• Must set/check address when changing any</td>
</tr>
<tr>
<td></td>
<td>• Simplifies programming</td>
<td>instrument</td>
</tr>
<tr>
<td>Assign port-specific IP addresses in large, complex, highly available systems</td>
<td>• Stable, predictable configuration</td>
<td>• Higher cost for Option 82-capable switch</td>
</tr>
<tr>
<td></td>
<td>• Simplifies programming</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lower likelihood of damage to system or DUT</td>
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</table>
**Tips for successful implementation**

With any of the three methods, two tips will help ensure successful implementation. One is to perform manual or programmatic address checks. The other is to isolate the system from company networks.

**Check addresses manually**

Manual address checks can be performed in two ways: with the ACE utility mentioned in the DHCP and static-address cases; and through the Web browser interface of every LXI instrument. Either approach should be used after any configuration change and before running an automated test program.

With the ACE utility, icons associated with each affected instrument will change from green to red if any changes have been made (Figure 3). ACE provides tools for checking and changing instrument addresses.

When working from a remote location, it may be easier to use the instrument Web pages. These can be used to verify and, if necessary, change the IP address (Figure 4).
Add programmatic checks
The core idea is to use ID queries: Any negative response to an ID query will return an error to the test program. These queries can be created using either the SCPI “*IDN?” command or a check in the IVI declaration. With IVI, simply use a parameter in the initialize command. Here is how it could be implemented for a DMM at address 169.254.4.10:

DMM.Initialize “TCPIP1::169.254.4.10::inst0::INSTR”,True,True, “QueryInstrStatus = True”

The “True” and “True” arguments check the identity of the instrument then check for the return of any errors.

Isolate the system
For added system stability, it will be useful to separate the cluster of test equipment from the broader company network. The easiest way to do this is with a router or switch. A switch will isolate network traffic while a router will also block any unauthorized users from accessing the test network. When choosing Option 82, use a switch: a router will provide DHCP addresses, most likely overriding the port-specific address assignments.

One final tip: It’s best to turn on critical system components after checking the configuration. Of course, this is a good habit with any type of test system.

Conclusion
When creating an LXI-based system, one of the key challenges is deciding how to allocate IP addresses to the individual instruments. For large, complex, highly available test systems, the most robust solution is to assign specific IP addresses to individual ports of the LAN switch.

This approach requires the use of a switch and DHCP server that support the DHCP relay information option called RFC 3046 Option 82. The use of an Option 82-capable switch has three major advantages:

• It provides a stable, predictable system configuration
• It lowers the likelihood of damage to the system or DUT
• It simplifies system programming

The use of programmatic address checks will further ensure proper system configuration. Thorough documentation of assigned addresses, instrument models and change procedures will also reduce the chances that human error will cause unexpected system behavior.

Related Agilent Literature

<table>
<thead>
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<tr>
<td>Application Note 1465-3, <em>Understanding Drivers and Direct I/O</em></td>
<td>5989-0110</td>
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<tr>
<td>Application Note 1465-3, <em>Understanding Drivers and Direct I/O</em></td>
<td>5988-9819</td>
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For a detailed description, please refer to application note 1465-10, *Using LAN in Test Systems: Network Configuration* (publication 5989-1413)
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