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Mass Interconnect for VXIbus Systems

The HP 75000 family of VXIbus products includes a set of interconnect hardware that enables automatic test system developers to mount DUTs easily to HP's VXIbus mainframe.

by Calvin L. Erickson

The interconnect hardware in an automatic test system consists of the components that connect the device under test (DUT) to the test system mainframe. Typically, automatic test equipment (ATE) product development has focused on instrumentation, controllers, and software. The result is that the interconnect hardware in a test system has become a major component of system cost. In most test systems, interconnects consist of discrete wire and connector harnesses, and their fabrication is custom and labor intensive. Many systems also require a mass interconnect for interfacing with multiple devices under test DUTs.

The development of the VXIbus has brought these issues into sharper focus. Greater density requires that more signal lines must be packed into less space. Higher speeds require shorter lead lengths and better connectors. Finally, economics and time-to-market constraints demand standard parts suitable for many applications.

This paper discusses the development of mass interconnect products specifically for VXIbus systems. Based on the HP ATS 2000 system resource interface, these products mount directly on the front of the HP VXIbus mainframe. This paper also discusses the trade-offs involved in incorporating a mass interconnect into a VXIbus test system.

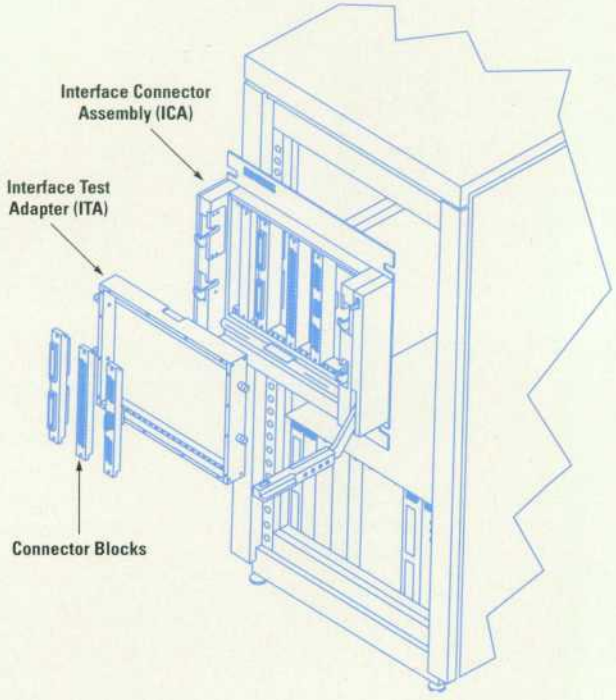


Fig. 1. The kinds of interconnect products in the HP 75000 system resource interface.

HP Interconnect Components

As part of the HP 75000 family of VXIbus instruments, a number of mass interconnect products are available for use in VXIbus test systems. These products, known as the HP 75000 system resource interface, allow a single test system to service a large variety of units under test. Fig. 1 shows the products included in the HP 75000 system resource interface.

The interface connector assembly (ICA) is the heart of the system. It serves as the primary interface between the test system and the DUT. The ICA is typically rack-mounted and wired directly to test system resources such as switching, sensors, and sources. The ICA provides locations for mounting ICA connector blocks and aligning connector blocks and their mating halves, and a mechanism for overcoming the connector mating forces. The HP 75000 system resource interface connector assemblies include:

- The HP 9420A ICA. This is the standard rack-mount version shown in Fig. 1.
- The HP E3720A VXIbus ICA. This ICA mounts directly on the front of a VXIbus mainframe. It also allows direct access to VXIbus modules and provides the greatest opportunity for short lead length.
- The HP E3722A hinged ICA. This ICA also mounts directly on the front of a mainframe and hinges down to allow access to VXIbus modules.

The interface test adapter (ITA) is the frame that mates with the ICA. It provides locations for mounting connector blocks. Typically, several ITAs are purchased, one for each type of DUT. A frame or fixture is often built on the ITA, customizing it to the particular DUT. Fig. 2 shows an ITA customized for functional testing of a printed circuit board. The HP 75000 system resource interface includes two different ITAs:

- The HP 9421A. This ITA is used with the HP 9420A ICA and the HP E3722A hinged ICA.
- The HP E3721A VXIbus ITA. This ITA is used with the HP E3720A VXIbus ICA.

Different kinds of connector blocks are available for use with the ICAs and ITAs (see Fig. 3). These blocks are wired and then installed in the appropriate location

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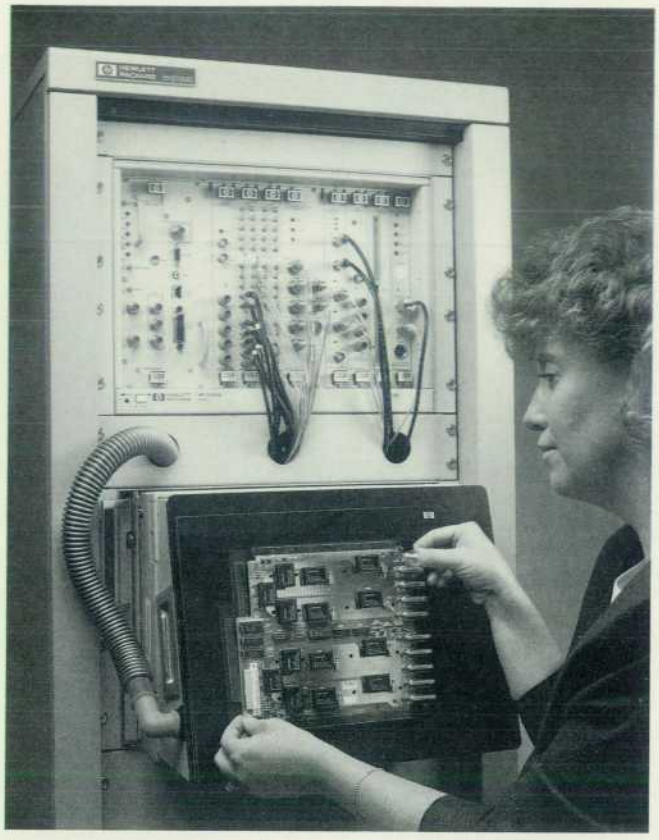


Fig. 2. A typical automatic test application in which an interface test adapter (ITA) is customized for the functional testing of a printed circuit board.

within the ICA or ITA. The three primary choices are 192-pin general-purpose, 36-contact coaxial, and 24-contact power. These connector blocks are compatible with each ICA and ITA choice listed above.

Customer Requirements

The list of customer requirements for mass interconnect in a VXIbus test system is extensive. Most of these requirements derive from the need to test a large variety of DUTs. The mass interconnect must have a variety of connectors that can handle different types of signals. These include low-level precision signals, high-frequency signals, and high-power signals. Sometimes, it is necessary to keep lead lengths as short as possible to maintain signal integrity. The connectors must have a long life to allow frequent changes of the ITA. The ITA must have a rugged and versatile construction to allow the addition of a variety of fixtures suitable for testing everything from printed circuit assemblies to automobiles.

Most test systems require many modes of wire routing. For the VXIbus, these modes include:

- VXI-to-ICA. For example, a VXIbus relay module can have many connections directly to an ICA connector block.
- VXI-to-VXI. The same relay module can have an analog bus connection to a neighboring module in the same mainframe.
- VXI-to-System. A VXIbus slot 0 module may require an HP-IB connection to the controller.
- ICA-to-System. A non-VXIbus signal generator may require connection to an ICA connector block.

Test systems must be easy to configure and reconfigure. This requires that VXIbus modules must be easy to install and remove. Wiring should be accessible. Standard cable assemblies should be available that satisfy most of the wiring requirements. Different ICA configurations should be available for mounting in front of VXIbus or standard rack mounting.

Finally, some customers require that the mass interconnect conform to industry standards such as ARINC 608 and MATE.

Product Development

The project definition dictated that we rely on existing products to satisfy customer requirements. From a practical standpoint, a lack of resources prevented us from designing a new product from scratch. Therefore, one of our major decisions concerned the selection of a vendor. There were two viable choices. One vendor had already modified their existing interconnect product line (connector block, ICA, and ITA) to fit on the VXIbus. Their design was generally sound, and contained only a few minor problems. Another vendor had a different product line that conformed to the recently emerging industry standard ARINC 608, which has become increasingly important in some segments of the marketplace. Although this product line had not been adapted to VXIbus, it was already established within HP. Both products were similar in cost, quality, and density. In the end, the decision to use the second vendor was based on two primary criteria: leverage and industry standards.

We gained leverage from previous HP engineering experience in test systems, the willingness of the vendor to provide engineering expertise, and the use of the same connector blocks across the entire family of ICAs and ITAs. HP's Advanced Manufacturing Systems Operation (AMSO) had the products set up on the HP ATS 2000 product line. This allowed us to adopt the HP 9420A ICA, the HP 9421A ITA, and the connector blocks without

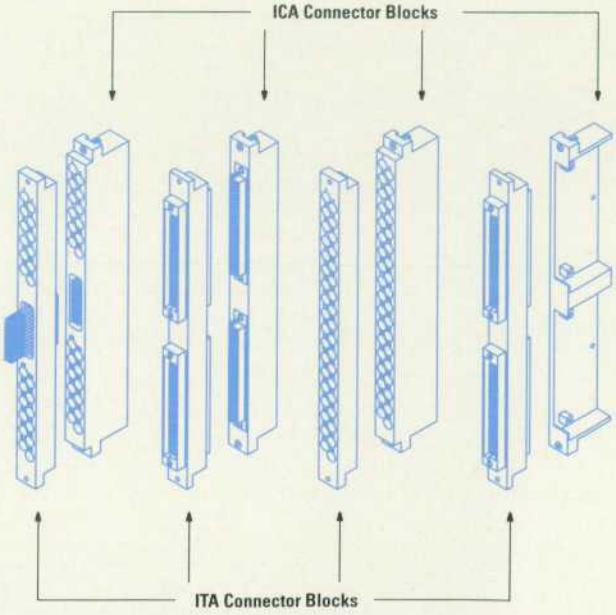


Fig. 3. ITA and ICA connector blocks.

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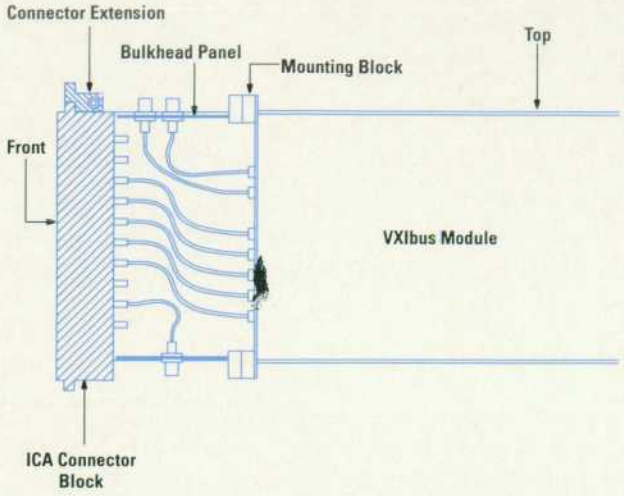


Fig. 4. An HP E3730A interface terminal module (ITM) with the cover removed.

going through full qualification testing. We still had to solve the problem that these interconnect components did not mount on the front of a VXIbus mainframe. The vendor solved this problem for us by agreeing to make modifications to the standard ICA based on our design concepts. Finally, we made the decision to use the same connector blocks across the entire family. This prevented duplicate documentation and qualification efforts.

Modifications to the standard ICA for use on the front of a VXIbus mainframe faced several design challenges. A primary design goal was to minimize the wire length between the VXIbus module and the ICA connector block. This meant that the connector block had to be assembled directly to the VXIbus module. An interface terminal module (ITM) similar to those already used in the HP VXIbus switch products was a logical choice. This interface terminal module attaches to a VXIbus module on one side and includes an ICA connector block on the other (see Fig. 4). The two ends are wired together, minimizing wire length. Note that a better solution would have been to include the ICA connector block as part of the VXIbus module. This was not practical because VXIbus does not specify the type and location of front-panel connectors. Most systems include modules from various vendors. Thus, there is no way to control all the connectors and their locations.

The next challenge was providing easy installation and removal of VXIbus modules past an ICA mounted on the front of the mainframe. The first vendor demonstrated one solution to this problem. Their ICA simply hinged down and out of the way. Although this provided excellent module access, it had two problems. The first was the requirement for very tight alignment tolerances between the mainframe and the ICA. The second was that the VXIbus module, and not the sturdy ICA frame, supported the interconnect mating forces. We decided that installing the ITM-to-VXIbus assembly directly through a stationary VXIbus ICA was a better solution (see Fig. 5). If the connector block were allowed to float within the interface terminal module, tolerances between the mainframe and the ICA could be kept loose. Also, if the connector block could be screwed into the ICA as originally designed, mating forces would be properly supported. There was only one problem: the standard ICA was not tall enough to allow a VXIbus module to pass through the opening. Increasing the height of the opening just enough to allow passage of a VXIbus module solved this problem. A connector extender was designed to increase the height of the standard connector blocks to fit in the new stretched VXIbus ICA. This modification did not affect the ICA alignment and closure mechanisms because only the top member was changed. These mechanisms reside in the bottom and sides.

Another challenge was that the standard connector blocks are on 19.05-mm (0.75-in) centers. C-size VXIbus modules are on 30.48-mm (1.2-in) centers. This was handled by simply adjusting the hole patterns in the VXIbus ICA and VXIbus ITA, making the interface terminal module 30.48 mm (1.2 in) wide, and supplying appropriate filler panels

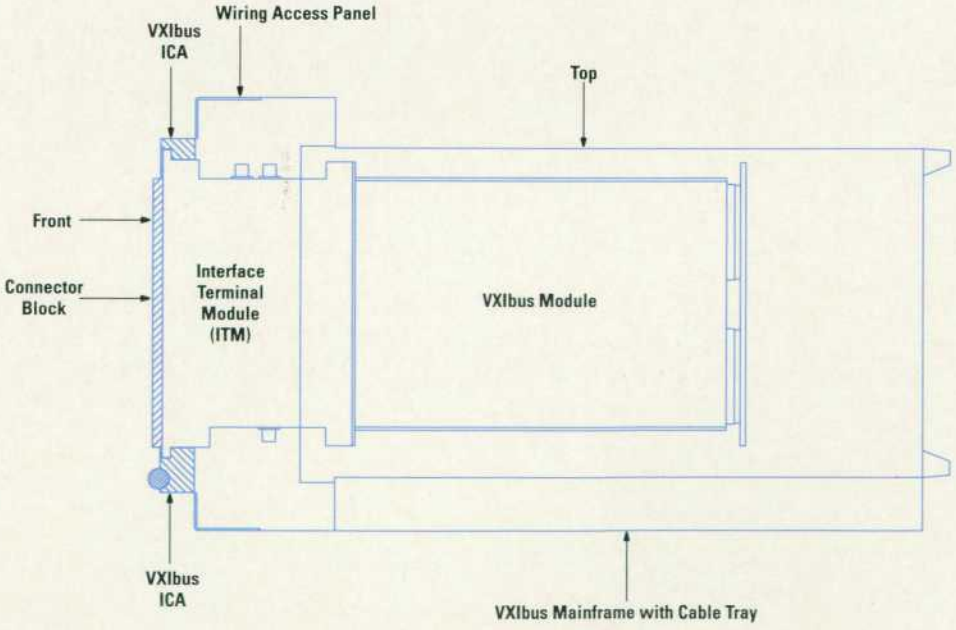


Fig. 5. An HP E3720A VXIbus ICA with an interface terminal module.

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for use with the narrower connector blocks. A side effect of this is that the HP E3720A VXIbus ICA is no longer truly compatible with ARINC 608. We decided that this was an acceptable compromise if all the connector blocks were the same.

Other challenges included the need to maintain easy access to modules and to facilitate all modes of system wiring. These needs were satisfied with careful placement of the VXIbus ICA relative to the rack mounting surface and the inclusion of access panels for wiring and a special tool for the module mounting screws.

The development of the HP E3722A hinged ICA was much more opportunistic. A customer requested that we supply an ICA hinged to the front of a mainframe. For this product, interface terminal modules are not used and all wires between the VXIbus module and the ICA connector block are flexible, so that opening the hinged ICA allows access to the VXIbus modules. The vendor developed the changes based on one of their previous designs. Customer interest has remained strong and the E3722A is now a standard product (see Fig. 6).

Product Description

The three ICAs and their associated ITAs and connectors described above meet system wiring requirements in different ways. The following sections describe and illustrate these differences by showing the ICAs installed in a typical rack-mounted test system.

HP 9420A Interface Connector Assembly. The HP 9420A interconnect products are identical to those used in the HP ATS 2000 product. These include the HP 9420A ICA, the HP 9421A ITA, and three sets of connector blocks (general-purpose, coax, and power). These products are not specific to VXIbus and can be useful in any rack-mount application.

The HP 9420A ICA can be rack-mounted in any location in a test system. It conforms to ARINC 608, and provides

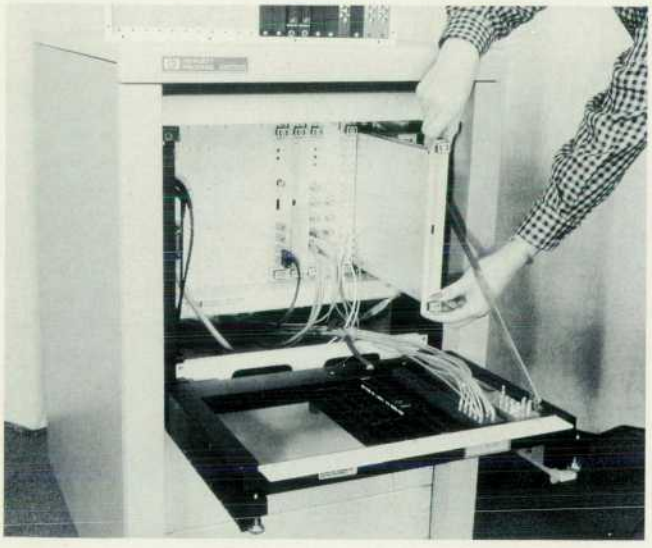


Fig. 6. An HP E3722A hinged ICA.

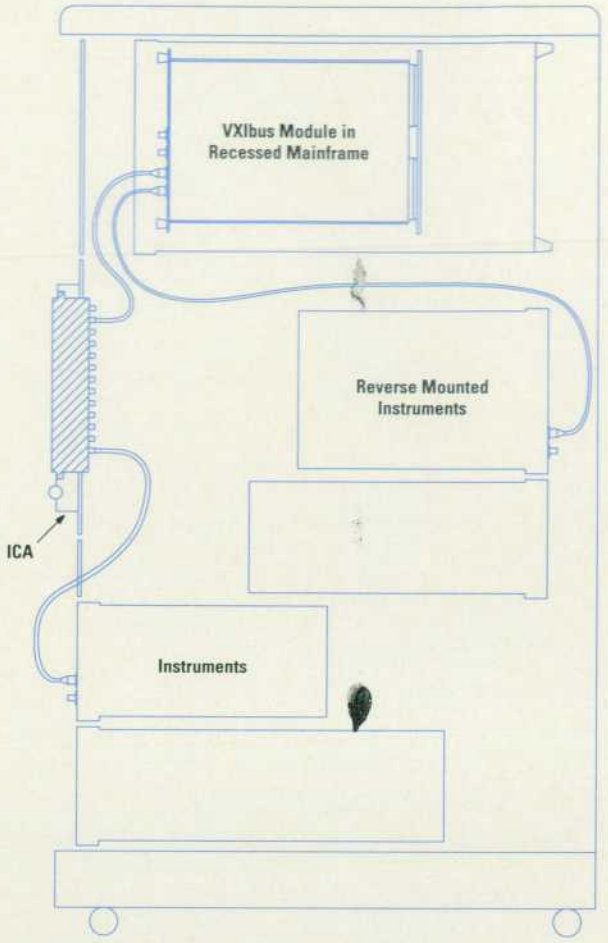


Fig. 7. Typical system wiring for an HP 9420A ICA.

21 slots on 19.05-mm (0.75-in) centers. Although it is the most versatile ICA, it may use more rack space and require longer lead lengths than desired (see Fig. 7).

The HP 9421A ITA is designed to mate with the HP 9420A ICA. It has a frame with 21 slots. Tapped holes are provided for attaching additional framework specific to each DUT. This framework and associated wiring must be provided by the customer.

The general-purpose connector blocks (ICA and ITA) include two 96-pin connectors. The coax connector blocks include positions for 36 contacts, purchased separately. The power connector blocks include 24 sense contacts and positions for 24 30-A contacts, purchased separately. All the contacts have a life of 25,000 cycles.

HP E3720A VXIbus Interface Connector Assembly (VXIbus ICA). The HP E3720A is an ICA modified to fit on the front of a VXIbus mainframe. It provides 13 positions on 30.48-mm (1.2-in) centers. Each position is aligned with the corresponding slot in the mainframe. The main differences between the HP E3720A and the standard HP 9420A ICA include:

- Flanges to position the VXIbus ICA relative to the VXIbus mainframe (these flanges also allow rack mounting anywhere in the test system)

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- Access panels above and below the VXIbus ICA (removal of these panels provides access to system wiring and eases the task of module installation and removal)
- The top horizontal bar shifted up a sufficient distance to allow VXIbus modules to be inserted through the VXIbus ICA
- The bottom horizontal bar cut out to allow greater access to system wiring
- Support by both horizontal bars for 13 connector blocks instead of the standard 21
- A special tool to gain easier access to the VXIbus module mounting screws.

Fig. 8 shows wire routing in a slot that does not require an interface terminal module.

The HP E3730A interface terminal module (ITM) is a housing that mounts on the front of a VXIbus module (see Fig. 9). It is designed for use only with the HP 3720A VXIbus ICA. Features of this product include:

- Mounting blocks for mounting the ITM onto most VXIbus modules (This is accomplished by removing the handles from a module and replacing them with the blocks.)
- Standard connector blocks that mechanically float relative to the ITM (This accommodates tolerance buildup between the mainframe and the VXIbus ICA.)
- Bulkhead panels for connections to other parts of the system
- Provisions for installing terminal boards (see Fig. 10) supplied with many HP VXIbus switch products (These boards supply functions such as matrices, thermocouple reference, and so on.)
- A "funnel" for tool guidance when installing a module in the mainframe
- A pull ring to ease the task of removing modules.

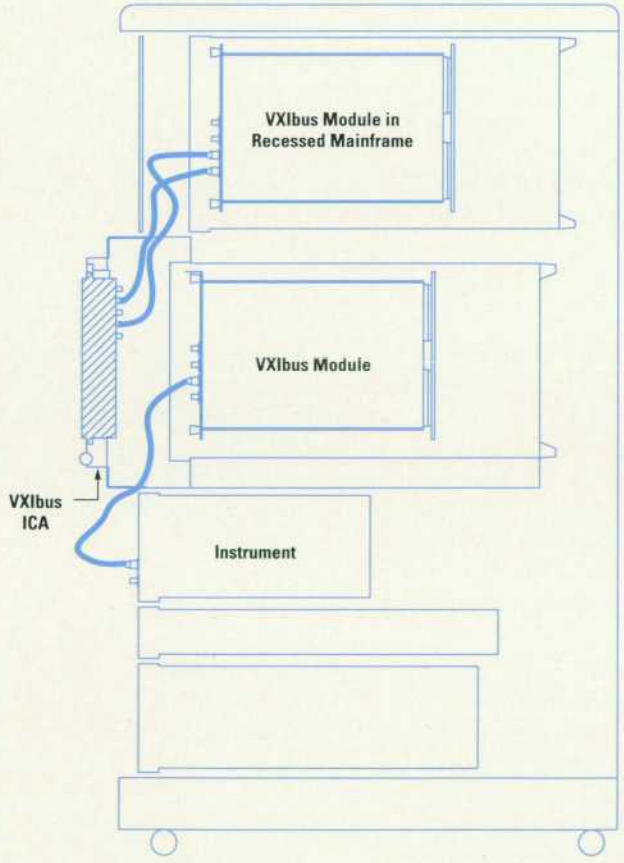


Fig. 8. Typical system wiring for an HP E3720A VXIbus ICA without an interface terminal module.

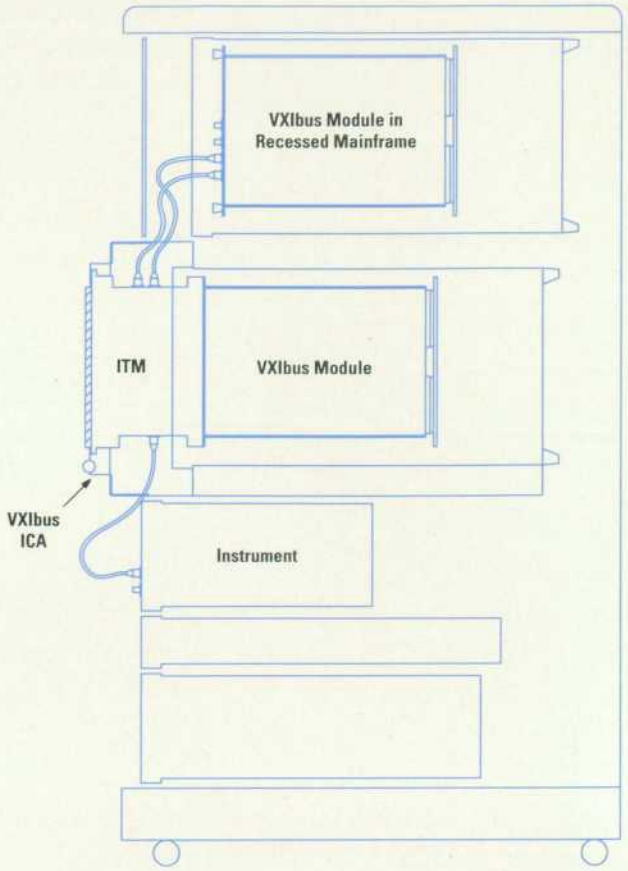


Fig. 9. Typical system wiring for an HP E3720A VXIbus ICA with an HP E3730A interface terminal module.

The E3721A VXIbus interface test adapter (VXIbus ITA) is designed to mate with the E3720A VXIbus ICA. It is identical to the HP 9421A ITA except that it supports 13 connector blocks instead of 21.

HP E3722A Hinged Interface Connector Assembly (Hinged ICA). The HP E3722A is another ICA that has been modified to fit on the front of a VXIbus mainframe. Like the HP 9420A ICA, it conforms to ARINC 608 and provides 21 slots on 19.05-mm (0.75-in) centers. The main differences between the HP E3722A hinged ICA and the standard HP 9420A ICA include:

- Flanges to position the hinged ICA relative to the VXIbus mainframe, which include hinges on the bottom and knurled screw tiedowns on top
- Tapped holes across the bottom for cable tie points.

Fig. 11 shows the wire routing with a hinged ICA.

System Integration Process

The process of including a mass interconnect in test system development is very complex. The following simplified procedure may help the system integrator through many of the issues.

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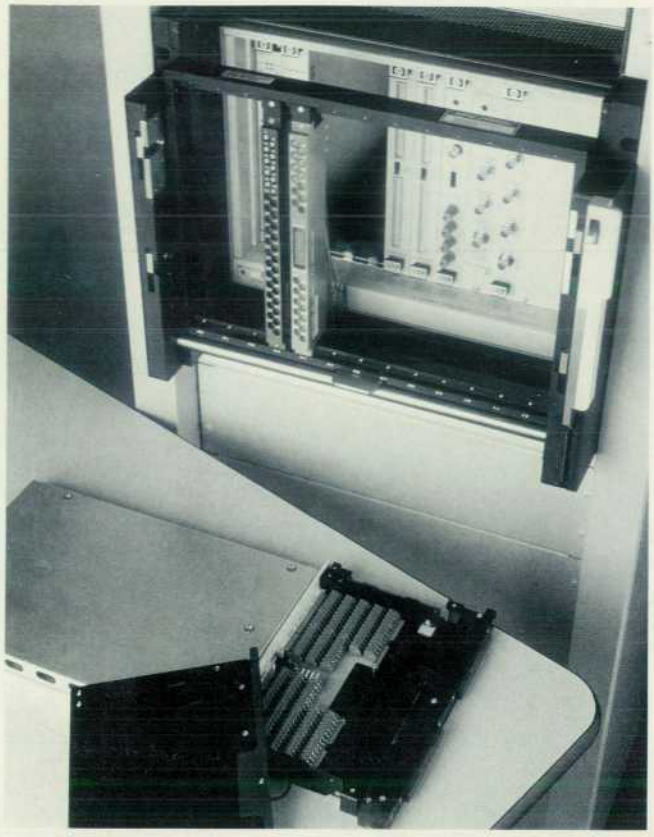


Fig. 10. In the foreground is an HP E3730A interface terminal module terminal board with the cover removed. In the background is an HP E3720 VXIbus interface connector assembly attached to an HP 75000 Series C cardcage.

1. The first step is to identify the number and type of DUTs that will be tested by the system. Usually, a different ITA will be built for each DUT, with one more for system self-test. A list of necessary system resources should be created for each ITA. Each list should include sources such as power supplies, sensors such as voltmeters and counters, and components for switching and communication. The different ITA lists can be combined into a single list of system resources required for all tests. Each item on the list will translate into a single line on the ICA.

2. The second step is to determine if a mass interconnect is necessary. The following questions should help in this decision.

- How many different DUTs will be tested? More than two or three may indicate a need for mass interconnect.
- How often will ITAs be changed? More than 400 to 500 times through the life of the system may indicate a need for mass interconnect.
- How many lines must be fed through the mass interconnect: more than 200 to 400 general-purpose lines, or more than 20 to 50 coax or power lines? If so, mass interconnect may be appropriate.
- What type of signals must be connected?
- Do appropriate mass interconnect connectors exist?

In many cases, a mass interconnect is not appropriate. A high-quality, military-style circular connector may be adequate.

3. The next step is to refine the list made in step 1. Trade-offs must be made between maximizing system flexibility, minimizing complexity and cost, and maintaining critical performance specifications. Particular attention should be given to switching networks. Consider the following:

- Custom configurations behind the ICA limit system flexibility, but they also reduce ITA complexity and cost.
- Switch networks are essential for minimizing resources and providing system flexibility, but switches have limited life. They add complexity and reduce system performance.

Add lines to the list to account for switching networks, ITA identification, and so on. To each line, attach any important performance specifications such as frequency, voltage, and current.

4. The next step is to make a preliminary layout of the entire system. In most cases, it is best to start with a block diagram. The diagram can then be used to make a sketch of a rack showing all system components. This sketch should include all sources, sensors, switches, mass interconnects, controllers, and so on. Now is the time to think about wiring issues such as grounding and critical lead lengths. Remember to leave room for growth and flexibility.

Selection of the appropriate ICA occurs at this time. This decision should be based on the above considerations and the following:

- Is compatibility required with other ITAs? These ITAs may already exist or they may be planned as part of a large project.
- Is compatibility required with an industry standard such as ARINC 608? This would limit the choice to the HP 9420A or the HP E3722A.
- What type of signals will be connected? How many lines will be connected? What is the required cycle life of the connectors? The answers to these questions may indicate the use of less-expensive interconnect products such as the HP 34592A quick interconnect.

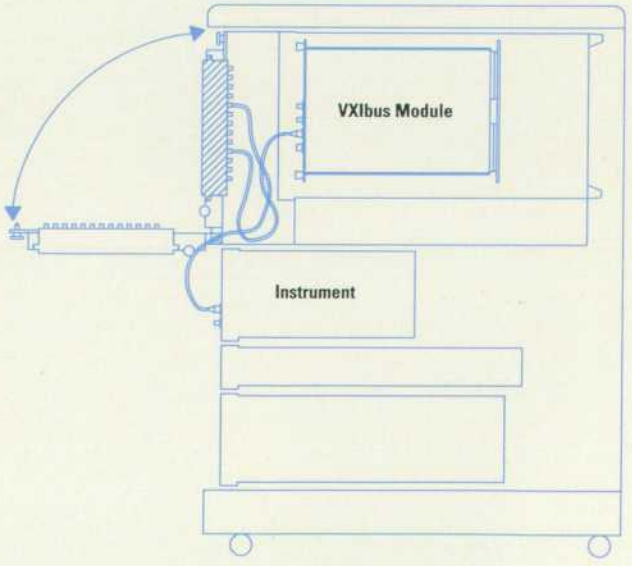


Fig. 11. Typical system wiring for an HP E3722A hinged ICA.

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- Is rack space limited? If so, the HP E3720A or HP E3722A may be the best choice. Both ICAs mount on the front of the VXIbus mainframe. Remember, however, that other system components may be reverse mounted behind the HP 9420A without sacrificing rack space.
- Is a reduction in access to VXIbus front panels acceptable? Any ICA mounted in front of the VXIbus mainframe will limit access to VXIbus modules. Front-panel indicators will not be visible and modifying modules and wiring will be more difficult.
- Is short lead length between the VXIbus modules and the ICA connector important? If so, the HP E3720A may be the best choice.
- Do most of the ICA wires (at least 60 to 75 percent) connect to VXIbus modules directly in a single mainframe? If so, the HP E3720A may be the best choice. If there are many wires that connect elsewhere in the system, the HP 9420A could be a better choice.
- Are the limitations of the HP E3722A hinged ICA acceptable? A practical limitation in density is imposed by the requirement that all wires must bend every time the ICA is hinged down. Because the hinge is at the bottom, all wires must be tied at that point. This impedes wiring that must connect to resources above the VXIbus mainframe.

5. The fifth step is to refine the system layout and interconnect list. In particular, add detail on the layout of connector blocks in the ICA, including pinout definitions for each block. It is usually a good idea to retain a generic functional grouping. In other words, dedicate some blocks to sources, some to sensors, some to power, some to high frequency, some to switching networks, and some for growth. This functional grouping is particularly important for systems that will be testing many different DUTs. Remember that many of the custom connections can be made inside the ITA.

6. Finally, it is time to compile a list of all parts and products. For the system side, this should include the ICA, interface terminal modules (for the E3720A), ICA connector blocks and blanks, cable assemblies, and contacts. For the DUT side, this should include ITAs, ITA connector blocks and blanks, cable assemblies, contacts, and all parts necessary to customize the ITA for a particular DUT.

Conclusion

The integration of mass interconnect into a test system adds significant, but often essential, complexity. The system integrator is required to consider many factors. These factors include DUT quantity and type, signal characteristics and density, system components, available rack space, diagnostics, reconfiguration, and so on. One of the most important factors is the availability of appropriate mass interconnect products. The HP 75000 system resource interface provides an excellent set of tools for use with VXIbus-based test systems. Appropriate use of these products can greatly influence system cost, development time, and performance.

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