Keysight Technologies
TS-8989 System Integration Guide

Application Note
**Introduction**

In today’s manufacturing environment, floor space is an increasingly invaluable variable in the cost of test equation. One way to optimize space is to do more with the existing workstations and rack space. Keysight’s TS-8989 PXI functional test system is designed as an integrated all-in-one measurement and high current switching box solution, providing flexibility for manufacturers to optimize the latter. In this application note, an example of integrating the TS-8989 in a typical rack is shown as a guidance on key considerations when determining rack type, power distribution, mass interconnect and cabling.

Figure 1a shows the front view for instrumentation connectivity, and rear view for DUT connectivity. Figure 1b shows the side view of the TS-8989 system with dimension in millimeters for user reference when designing custom structures to enclose the system.

Keysight recommends a minimum of 100mm of clearance from the front and 100mm of clearance from the rear if customized enclosure is installed, to prevent overheating to the TS-8989 and stress on the cables.
Integration into a standard rack

A typical functional test system setup may consist of equipment other than TS-8989, for example a test application may require not only the TS-8989 and power supply, but also other equipment such as industrial controllers, electronic loads or custom load boxes for passive components. Hence, the rack size is an important consideration to ensure the chosen rack provides sufficient space for all equipment, from 12U to 52U height depending on the complexity of test configuration. In the case of a high-mix manufacturing environment, a test system may even be shared for multiple products to maximize efficiency. In this case, the user must also allocate additional empty rack space for any future expansion with additional equipment for higher complexity products.

Next, space allocation for accessories such as the keyboard, LCD monitor, power distribution unit and mass interconnect must be part of consideration too. Last but not least, although the TS-8989 provides sufficient ventilation with its cooling fan, additional rack fans may still be required to dissipate heat captured within the rack. As we all know, hot air rises toward the ceiling, hence these fans should be installed on top of the rack to rapidly remove heated air. TS-8989 is designed to fit in a 19-inch (width) EIA rack cabinet, occupying 8U height space with full standard rack width. Every TS-8989 comes installed with rack mount kit so that the customer can mount it onto the rack easily. It should be positioned opposite of the mass interconnect to reduce cable length.

Figure 2a illustrates a typical rack layout design with the TS-8989 integrated in a standard 15U height 42-inch depth rack. Notice the empty space allocation for future additional instrument such as standalone load or communication box.

Figure 2a – Layout design with evenly distributed equipments and empty space
Figure 2b shows an actual system layout use for a compact Electronic Control Unit (ECU) test. The designer positioned the power distribution unit (PDU) and power supply at the bottom, the TS-8989 in the middle and the fan assembly at the top of the rack.

This is important to maintain the balance of the system for maximum stability. An unbalanced system may present safety issues, especially if it is a tall rack with equipment concentrated at the top of the rack. Monitor, keyboard and mouse are not integrated into the rack layout due to compact rack size and are placed on top of the system rack in this particular example.

Power supplies are usually installed at the bottom due to their heavy weight, whereas the TS-8989 are integrated as near as possible to the mass interconnect for minimum cabling length. The fans are installed at the top for maximum heat dissipation. What may not be more apparent is that the equipment weights are distributed evenly throughout the system.
Power Distribution Unit

Power distribution unit (PDU) provides multiple system power outputs for the purpose of distributing electric power to equipments within a rack. In a typical system, every instrument in a rack is connected to a terminal output of the PDU. Each power inlet has a fuse for surge protection and power fluctuations. Some PDUs are incorporated with circuit breaker as well.

Before choosing a PDU, the user must first determine the total power needed by adding the total watts of equipment connected to the terminal output of the PDU. Then, the user selects a PDU with power rating that is higher than the total equipment load.

The TS-8989 is designed for use with a single-phase AC voltage of 100 - 240 VAC at maximum electrical specification of 675W. In this example, a 1.2kW power supply N6702A and a 30 W rack fan are used for the test application, hence the total maximum load is 1905 W. On PDU selection, the Keysight E3858B PDU at 100-240V single phase 15A rating is chosen, with 240V AC input from the wall outlet. Using a simple mathematic formula, Power (W) = Voltage (V) x Current (I), the PDU power rating is 3600W, which is sufficient while providing additional 47% of buffer. Figure 3 shows the cable distribution from PDU to the TS-8989 and power supply.

A good rule of thumb is choosing a PDU with at least 30% of its power capacity free from loading, to keep a buffer for power-on inrush current and future system growth.
Mass Interconnect & Cabling

As a one box solution with integrated power/load switching and instrument switching channels, almost every signal to DUT will be routed through the TS-8989. User can choose either to connect the DUT directly to rear of TS-8989, or use a mass interconnect between for DUT connection.

Direct connection of DUT to TS-8989 is applicable especially if a system is dedicated for only one DUT type testing. However, in a high mix manufacturing environment, most systems are setup with a mass interconnect, so that users can exchange a DUT quickly to avoid downtime and still maintain test integrity. The mass interconnect acts as the connector interface between the system and DUT. Routing all signals from the system through a mass interconnect not only helps users quickly change DUTs, it also protects the mating connections from repeated connect/disconnect cycles.

There are a few widely used mass interconnect suppliers out in the market that are capable to support high power (50A) contact pins. The most important key is that users must search for a solution that best fits their test needs. The example in Figure 4 shows the setup using Express Connect type of mass interconnect, using two type of Zero Insertion Force connectors to support signal pin and power pin. User must always consider I/O requirements when determining components that necessary to complete a mass interconnect design. In order to choose a suitable mass interconnect, one must first consolidate the number of signal points (<5A), power points (>5A) or any other type of contacts points (coaxial, pneumatic etc...). The number of signal points and power points can be determined by TS-8989 connectors output (shown in Table 1 map between TS-8989 with signal/power points for mass interconnect) to help you determine the selection on mass interconnect modules type. Depending on requirements, the user may choose not to connect all pins from the TS-8989 to the mass interconnect. For more information, kindly refer to manual “TS-8989 Wiring Guide and Hardware Reference” for pin-out population of TS-8989.

![Power Connector](image)

![Signal Connector](image)

Figure 4 – Express Connect type of mass interconnect by Keysight
When building cables for TS-8989, select cables and contact pins with suitable AWG/rating to support TS-8989 connectors current handling capacity as shown in Table 1. For identifying the type of mating connectors to TS-8989 cards, please refer to Table 2.

Some cables may require shielding that provides high insulation to avoid signal interference (crosstalk). This is especially true for higher frequency signals from digitizers or CAN communication channels. Take note that for the E6176A, N9377A and U7179A connectors, the three pins in a row are connected together for current sharing as shown in Figure 5. When making connections to a channel, all the three pins in the row must be wired to ensure current sharing and prevents premature pin failure from excessive current flow.

<table>
<thead>
<tr>
<th>TS-8989 Connectors</th>
<th>Mass Interconnect Current handling per point</th>
<th>Point Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility</td>
<td>1A – 3.5A</td>
<td>63 signal points</td>
</tr>
<tr>
<td>Universal Instrument Routing</td>
<td>1A</td>
<td>160 signal points</td>
</tr>
<tr>
<td>E8792A</td>
<td>1A</td>
<td>96 signal points</td>
</tr>
<tr>
<td>E8793A</td>
<td>1A</td>
<td>96 signal points</td>
</tr>
<tr>
<td>E8782A</td>
<td>1A</td>
<td>112 signal points</td>
</tr>
<tr>
<td>E8783A</td>
<td>1A</td>
<td>160 signal points</td>
</tr>
<tr>
<td>N9379A</td>
<td>2A</td>
<td>96 signal points</td>
</tr>
<tr>
<td>E6175A</td>
<td>7.5A</td>
<td>8 power points</td>
</tr>
<tr>
<td>E6176A</td>
<td>7.5A</td>
<td>16 power points</td>
</tr>
<tr>
<td>E6177A</td>
<td>2A</td>
<td>48 signal points</td>
</tr>
<tr>
<td>N9377A</td>
<td>7.5A</td>
<td>16 power points</td>
</tr>
<tr>
<td>N9378A</td>
<td>2A</td>
<td>48 signal points</td>
</tr>
<tr>
<td>U7177A</td>
<td>2A</td>
<td>48 signal points</td>
</tr>
<tr>
<td>E6178B</td>
<td>30A</td>
<td>10 power points</td>
</tr>
<tr>
<td>U7178A</td>
<td>40A</td>
<td>10 power points</td>
</tr>
<tr>
<td>U7179A</td>
<td>15A</td>
<td>16 power points</td>
</tr>
</tbody>
</table>

Table 1 – TS-8989 connector output with mass interconnect type

<table>
<thead>
<tr>
<th>TS-8989 Connector Type</th>
<th>Mating Connector</th>
<th>Mating Pin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility 78-pin D-Sub</td>
<td>1658674-1 (AMP)</td>
<td>1658670-1 (AMP)</td>
</tr>
<tr>
<td>E8792A, E8793A, N9379A</td>
<td>96-position DIN</td>
<td>925486-1 (AMP)</td>
</tr>
<tr>
<td>E6178B, U7178A</td>
<td>10-position Heavy Duty</td>
<td>594176 (ERNI)</td>
</tr>
</tbody>
</table>

Table 2 – Recommended mating connector (part number and manufacturer) for TS-8989
Keysight recommends the following best practices during self integration:

1. First, cables routed to the TS-8989 should be secured to a strain relief bar or bracket. Strain relief is always strongly advised to eliminate possible intermittent pulling and disconnection between cables and its respective cards. In addition, it will prevent any damage to the TS-8989 mating connectors.

2. Secondly, it is advisable to keep the distance between TS-8989 and mass interconnect as short as possible to minimize signal losses. However, do allow for bends in the cable for proper cable routing with extra length. It is important to ensure sufficient space to prevent tight bends when enclosure is closed.

Therefore, when determining proper cable length, after measuring the horizontal distance between the mass interconnect and the TS-8989 with the enclosure fully extended (open all doors, panels etc.), users must then take include the extra length required to accommodate the strain reliefs and unexpected bends when closed.

Figure 6 shows a well-planned system cabling:

Figure 6a - Applying strain relief bar between the TS-8989 to Mass interconnect.

Figure 6b - Placing TS-8989 at the same height level to the mass interconnect in order to minimize the distance between them when fully extended.
Final Setup

In order to facilitate the best system rack integration, the TS-8989 is designed with rear interface for DUT access, while the front interface is used for instrumentation. Figure 7a shows the front view of complete system setup, with well organized cable assemblies between TS-8989 and mass interconnect. Cables are routed directly from the TS-8989 DUT interface to the mass interconnect, without any additional cables routing to the TS-8989 instrument interface. In this setup, the user can access all PXI instrumentation cards, switching cards, as well as power buses from system rear, without blockage from the bulky cabling as shown in Figure 7b - system rear view. This provides better access to the system during debugging or troubleshooting. It also enables quicker card swap overs while changing to other products that requires a re-configuration of the system.

At this stage, the core of the system rack integration is almost complete. This core will determine the quality of the final system when other equipment are integrated.
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