Instructions For Use of PCI Extender Cards (EV9323A)

Revision 1.3

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1 Specifications

The extender card is a tool for engineering analysis, experimentation, and hardware design qualification. It is designed to generally conform to PCI 2.1 specification mechanically, and to produce as little electrical signal degradation as possible while still performing its function. Refer to the provided schematics, drawings, and user manual for complete details and specifications.

2 Extender Card Features

All PCI signals are routed through the card, with most bus control signals able to be disconnected with the installed individual signal isolation switches.

Weak (10K) pullups are provided for the PCI control signals FRAME#, STOP#, IRDY#, TRDY#, DEVSEL#, RESET#, and CLK, so that they are deasserted on the extender card's top receptacle if the signals are disconnected from the bus with the switches. The peripheral under test can be hard reset by opening the switch and grounding its RESET# input (accessible at the RESET# switch).

Weak (10K) pulldown is provided on the IDSEL signal so it is deasserted when disconnected.

Test pin dimension and spacing accommodate all standard logic analyzer probes.

Plenty of ground points are provided for grounding logic analyzer pods and scope probes.

Signals are clearly labeled on the silkscreen on both sides of the board.

Extender cards can be stuffed with components on the A-side **or** the B-side, so that test points are oriented "outward" regardless of physical constraints of motherboard component orientation or arrangement of other installed peripheral cards.

20-pin sockets connected to +5V (pin 20) and GND (pin 10) are provided for prototyping such as with 16V8 GALs or other logic.

Fuses are installed on the 3V and 5V supply rails for isolation testing and to help prevent accidental shorts from causing board or component damage. Test points are provided for easy access to drive the peripheral under test with external supplies (with the fuse removed).

Components on the card are not sensitive to ESD.

3 Applications

3.1 Timing Analysis and Probing

Your extender card can be used to perform certain types of timing analysis and measurements on PCI signals by attaching an oscilloscope or logic analyzer to the exposed test points. After connecting the probes to the correct location, create or modify software to transition the output signals being measured. With this technique it is possible to easily measure delay and setup and hold times[1]. It's very easy to change boards under test, and because the test equipment is connected to the extender card rather than the board under test, it takes very little time to measure differences in timing or delay across multiple boards.

Signals can also be easily multi-probed with analog equipment or an oscilloscope module in a logic analyzer, so that a normal logic analyzer display (digital waveforms) can be shown time-correlated to the analog signal. Set the analyzer to trigger on the logic condition and then trigger the other module. A PCI interface card (such as Future Plus Systems FS16P32E) in another PCI slot is useful for this.

Shorted AD lines on a board needing repair can usually be quickly found by searching the labeled AD[31..0] test points with an oscilloscope and looking for degraded signal quality.

3.2 Logic Analyzer Triggering

The extender card can be used to trigger a logic analyzer at a specific location in software (such as an application or device driver) by a simple modification to the software and only a few test points. This is very effective when most of the logic analyzer probes are consumed monitoring non-PCI signals on the peripheral card and not available for a complex trigger, or at any time that software is capable of detecting the anomaly (either just before or just after it happens).

Simply connect FRAME#, CBE[3..0], and IDSEL to the logic analyzer, set it to trigger on a configuration space read or write[2], and modify the software to generate that access at the proper time. If triggering is unreliable due to these patterns occurring in the data phases in the normal course of events, modify the extender card to produce a delayed FRAME# signal ("DFRAME#") by installing and programming a 16V8 in one of the provided prototype slots, and include that signal in the trigger to differentiate the address phase from the data phase.

3.3 Current Consumption Measurements

Current consumption of a peripheral card can be easily measured by removing the 3.3V and/or 5V supply fuses and substituting an ammeter. By measuring the supply voltage on the provided test points, board power consumption can be calculated. The extender card rarely interferes with operation of the peripheral under test, so these measurements can be taken under a variety of operating conditions and also quickly checked across multiple boards.

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[1] Exercise care in taking these measurements that you are in fact observing outputs from the device under test, rather than outputs from another source (such as motherboard when attempting to measure signals on a peripheral card).
Delay is the time from an input clock edge that causes a transition to the actual transition of a given output. It is defined for output signals and is usually the only temporally oriented parameter for characterizing outputs. Due to asymmetry in rising and falling signals, it's typical to separately measure delay for clk ↑ (for rising-edge synchronous circuits) to output ↑ and also clk ↑ to output ↓. *Setup* and *hold* are defined only for input signals; this is the time before and after the input clock edge which latches the input to the most recent transition of the input being latched before or after the clock edge; equivalently, the time before and after the clock where the input is stable. They are usually the only temporally oriented parameters for characterizing inputs. Setup and hold should also be separately checked for both rising and falling input signal transitions.
In both cases, it is vital to record the threshold voltage used to take the measurement.

[2] FRAME#==0, CBE[3..0]==1010 (read) or 1011 (write), IDSEL==1.

To measure current consumption when the device is uninitialized or in hardware reset, simply open the RESET# switch, take the reset-state measurement, then close the switch and take the uninitialized measurement. RESET# is automatically asserted when the switch is open.

3.4 Supply Voltage Variation

Power supply voltage variation (and resulting current consumption differences) testing is a natural extension of the current consumption measurements suggested previously. Instead of using an ammeter, remove the fuse(s) and substitute adjustable power supplies connected at the test point. Be sure to connect the power supply correctly so it sources the peripheral and not the motherboard!

Typically, when doing this test, it will be necessary to power up the device under test (using the supply) and the motherboard (using its supply) approximately simultaneously to avoid component damage. It is highly recommended to power them up, then reset the motherboard with the hardware reset button (even if it doesn't seem necessary to do so). This will duplicate the condition of having the device installed in the motherboard slot, and will insure the motherboard BIOS initializes the peripheral under test correctly. After boot-up, measure the effect of varying the supply voltage (and the corresponding current consumption if desired) in the various states of operation (such as in reset, uninitialized, initialized but not operating, and operating). This can be used to establish the operational supply voltage range and maximum power.

If the peripheral under test includes power supply regulation on the board, it will be necessary to defeat it in order to get any useful results from this test.

3.5 Experimentation and Prototyping

Because the extender card features easy access to the PCI signals and provides sockets for programmable logic, it is easy to prototype some very useful analytical circuits or make modifications to the bus signals such as might be necessary to correct PCI protocol violations on new chip or board designs. 5V and GND and proper decoupling capacitors are provided for the 20-pin sockets, which are ideally suited for Lattice GAL16V8-5LP (or similar). If you intend to create registered equations, be sure to connect CLK to pin 1 and ground pin 11 (OE#). It is recommended to install a 20-pin socket (on the component side of the extender card) to accommodate the programmable logic.

By using this method and routing a few PCI control signals through the 16V8, it is possible to make many modifications to the signals generated by the peripheral under test or to the signals visible to the peripheral under test. Useful modifications might include protocol corrections, delaying some signals such as to test the effect of a slower DEVSEL# timing, or splitting shared signals from two cards to look at their behavior independently and recombining them so it looks identical to the motherboard (and therefore not interfering with proper system operation).

3.6 Debugging Hardware Problems

The isolation switches on the extender card make it very easy to identify the specific location of connection faults on a peripheral card. This is very useful if you put a peripheral you just built or modified into a motherboard and it doesn't boot.

There are typically only two tests to run:

1. Isolate the FRAME# signal by opening the switch. If it boots now, there probably aren't any shorted AD or control signals; rather, some other problem exists (such as a protocol violation).
2. Disconnect all the control signals from the bus by opening all the switches. If it boots, there is a good chance there is a short on the control signals. Disconnect FRAME# and binary search for the signal short. If it doesn't boot, it's probably a short in the AD lines. Unfortunately these can't be isolated so you probably need to perform a visual inspection after identifying which signals appear to be shorted as suggested earlier (end of section 3.1).

3.7 Slot Wearout Prevention

When performing experiments and design qualifications with prototype cards, there is usually a great deal of insertion and removal. This can lead to destruction of the motherboard. In cases where the motherboards are difficult to obtain or are very expensive, slot wearout can be avoided by using the extender card. If the extender card's top receptacle wears out, it can be easily replaced.

If desired, modify the extender card by installing a standard VGA connector on the board. Then attach a PCI slot retaining bracket to the VGA connector. A slot screw can then be used to secure the extender card into the computer case. This doesn't work of course, if you have an exposed motherboard not in a case.

Depending on the application, an alternative board such as Adex Electronics PCIX32 Bus Isolation Extender may be preferred. This card can completely isolate the upper receptacle (including power and ground) by one switch (or control line). This is very useful when testing many boards at a manufacturing facility where the time saved by swapping boards under test without rebooting the test station is important. However, the Adex cards are much less useful for hardware development, design qualification, and general engineering debugging or analysis. [www.adexelec.com]

3.8 Environmental Testing

Because the extender card moves the peripheral under test physically away from the motherboard, it is possible to construct a small environmental test chamber which encloses the peripheral card. The enclosure can rest on the system case and then the peripheral card can be heated or cooled in the chamber without affecting the motherboard or other installed peripherals. Sometimes, two extender cards (or a taller extender card) must be used (depending on the system case and the test chamber design). This arrangement is particularly useful to establish the operational temperature range of a peripheral card, as well as the effect of temperature on supply current or operating voltage range.

3.9 Miscellaneous Uses

Because the card provides easy access to power and ground, prototype PCI cards can be placed in the extender card's top receptacle and quickly checked with a meter for supply shorts prior to installing the prototype cards in a motherboard. The power points are well-labeled and therefore usually easier to identify than probing the prototype card directly.

There are many circumstances where it might be desirable to isolate a PCI signal (such as a peripheral card's INTA# output) from the motherboard by disconnecting it with the switch at the proper time while it is operating in the system. While this often interferes with the system operation, this sort of experiment should work once, and in many cases provides useful information such as to identify which PCI card in a system asserted a certain signal that's shared across multiple cards.

Disconnect the FRAME# signal with the switch to make the peripheral card never respond to a PCI access (until FRAME# is reconnected).

Disconnect the RESET# signal and ground the peripheral card's RESET# input to hold it in reset. Doing this in a temporary manner is very useful when writing diagnostic software which is capable of completely reinitializing the peripheral, including the registers that are normally set only by the motherboard BIOS when the system boots up.

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