Probing and Analyzing Embedded PCI designs

Applied Computing Conference
May 2000

Barbara Aichinger
FuturePlus Systems

Agilent Technologies
Innovating the HP Way

Premier Solution Partner

FuturePlus Systems

Agilent Technologies
Innovating the HP Way
Premier Solution Partner

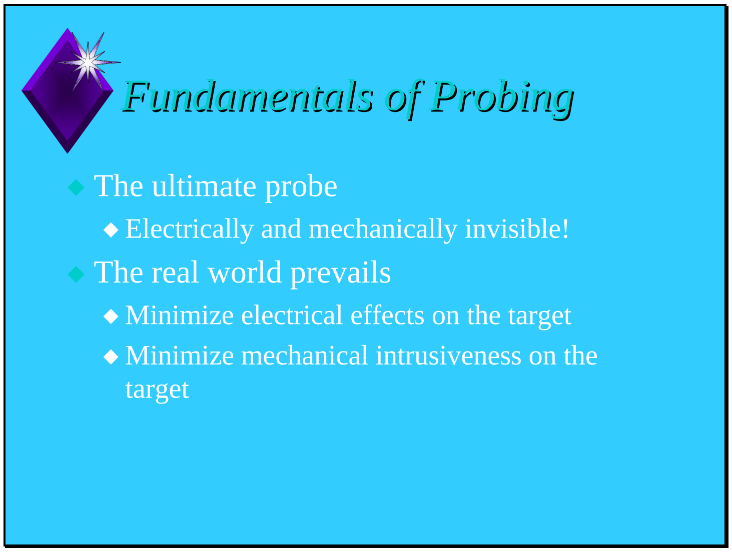
- We are a value added business to Agilent Technologies
  - A *Premier* Solutions Provider
- Our business is *only* Analysis Probes for Agilent Logic Analyzers
- All of our products have Agilent part numbers and Agilent is our world wide sales force

We are FuturePlus Systems a value added business to Agilent Technologies. We have been providing analysis probes to Agilent customers since 1991. Please visit our web site for a complete list of Analysis probes for use with Agilent logic analyzers.

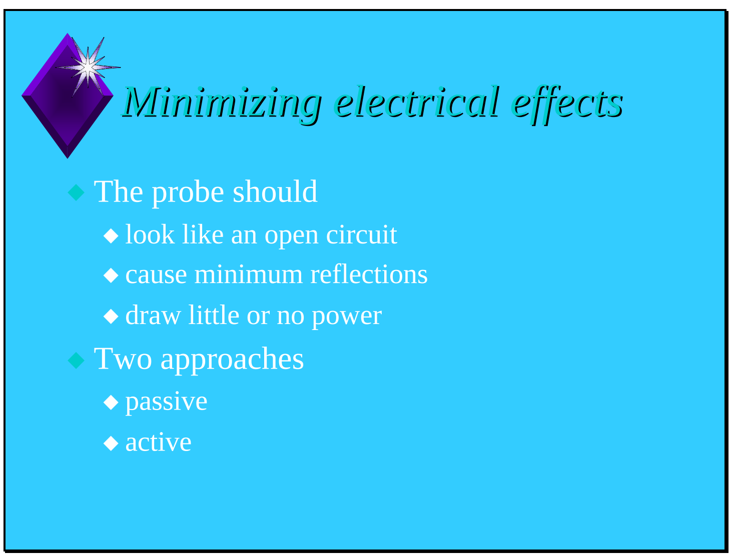
Agenda

- Fundamentals of logic analyzer probing
- Probing PCI buses that have no standardized connector
- Probing CompactPCI, PMC and other PCI technologies
- The software needed for the analysis
- Higher speed probing
- Summary

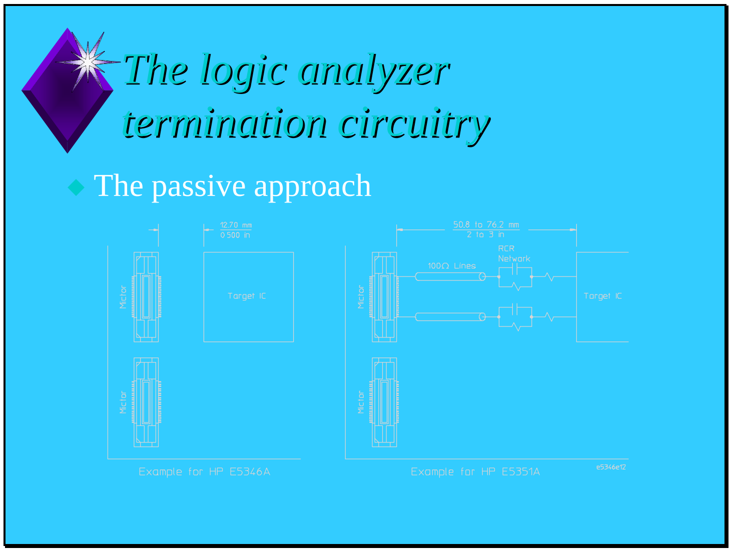
This presentation will focus on these items.



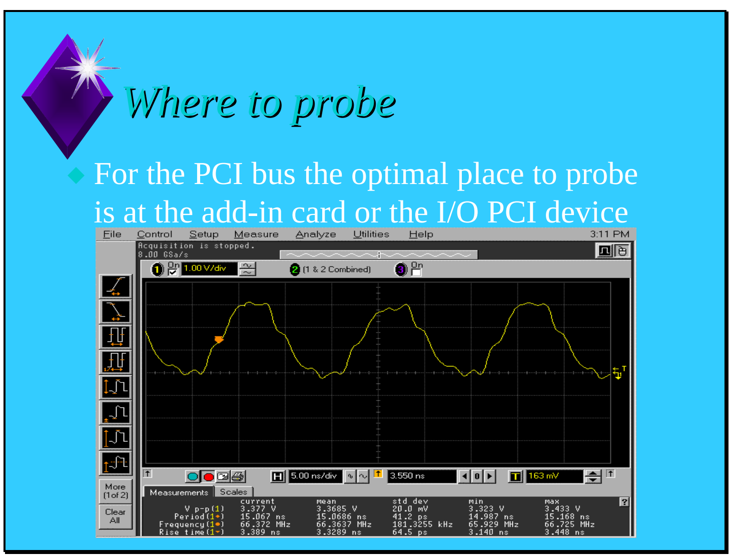
The dream of every probe designer is to make the ultimate probe. One that is electrically and mechanically invisible! However the laws of physics are still alive and well and that is impossible. So we take the next best step and that is to minimize the electrical and mechanical intrusiveness to the target.



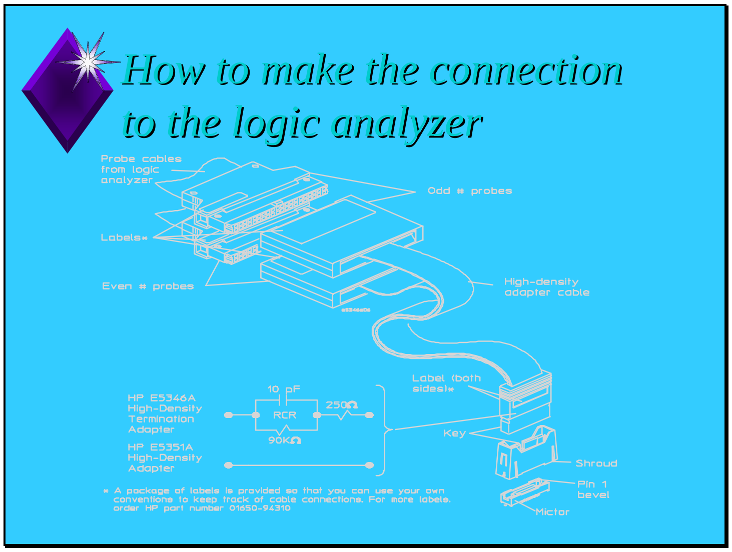
Given the various technologies that we tackle we try to design the probe so that it looks like a high impedance, causes minimal reflections and draws little or no power from the target. Currently in the logic analyzer market place there are two main ways to probe. One is passive and the other active. Many people think that the active approach is clearly superior to the passive approach because it offers higher performance. However with the ability to compensate for skew the passive approach can be used very effectively for most applications including PCI.



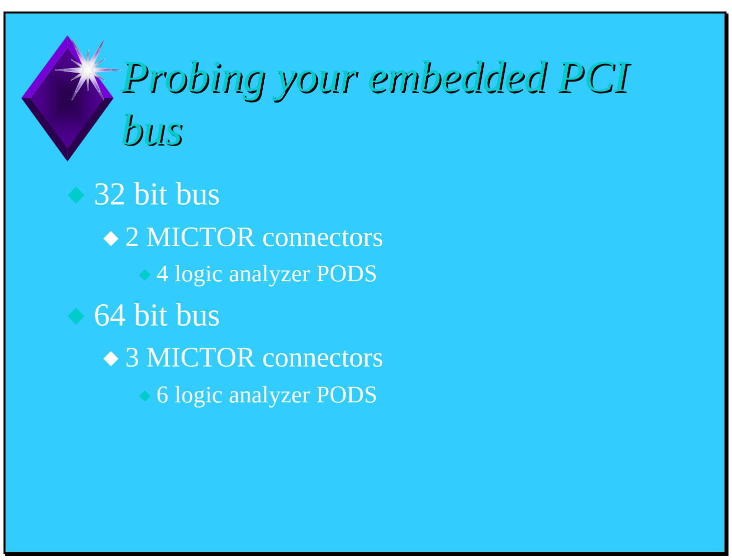
Shown here is the passive approach to logic analyzer probing of a PCI target that has no connector. The approach taken is to use the AMP mictor-38 connector. If there is enough room for the connector to get within one inch of the target IC (etch length of the signals) then the logic analyzer termination circuitry does not have to be laid down on the target board, only the Mictor connectors. If there is not enough room then the termination circuitry must be laid out on the target. The termination circuitry consists of a 249-Ohm resistor in series with a 90Kohm/8.2 pF capacitor in parallel. The termination circuitry must go as close as possible to the target (within one inch). If the Mictor connector is within one inch of the termination circuitry then the impedance of that etch can be that of the PCI bus. However if it is over one inch then the impedance of the etch from the termination to the Mictor needs to be controlled at 100 ohm.



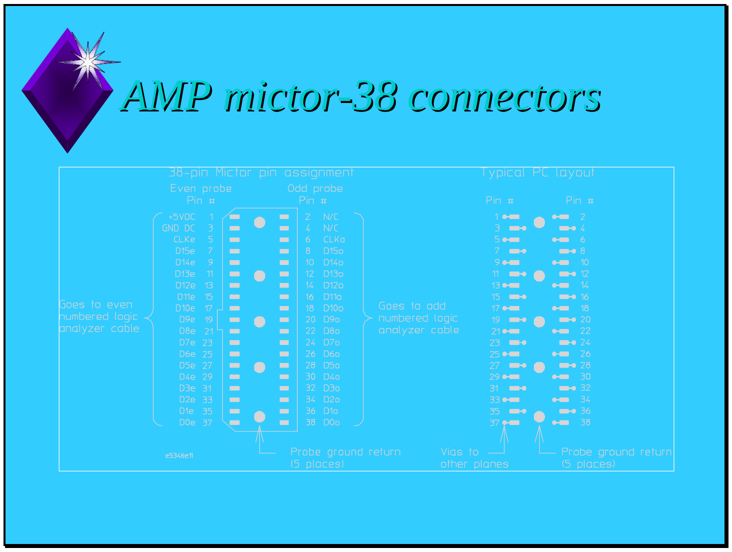
Now we need to answer the question of where in the overall etch run of the PCI bus do we place our Mictor connectors. From our experience we want to avoid probing in the middle of the run. Some of the problems that we have seen are that reflections can cause the probe to see a waveform that has “shoulders” on it. It is recommended that the Mictor connectors be placed at either end of the PCI signal run. The probe will appear as a short stub off the end of the run.



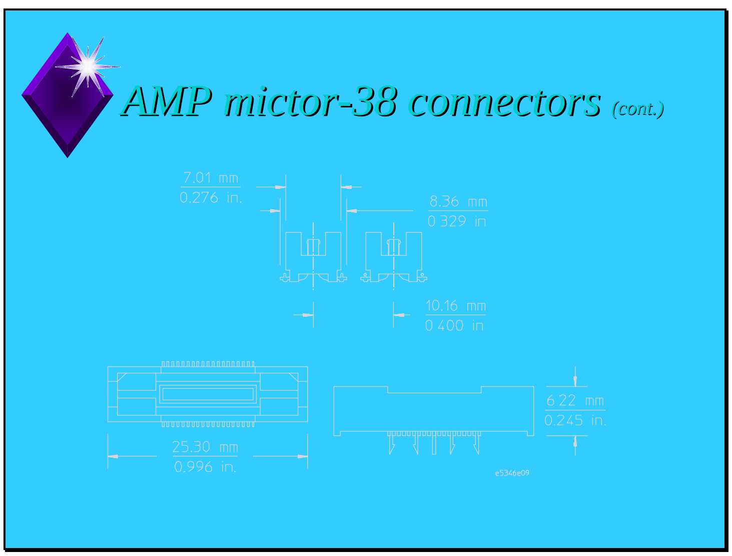
Here is a picture of the cable set that is needed to go from the Mictor connector that you have laid down on your target to the logic analyzer. If you have the termination circuitry on your target then you will need the Agilent E5351A. If you have only the Mictor connectors on your target you will need the E5346A. The E5346A has the termination circuitry built into the probe. Also note the mechanical shroud. If you have the mechanical clearance on your target it is recommended that you include the shroud. The shroud does require two mounting holes. The purpose of the shroud is to give reliable multiple insertions into the Mictor on the target. The pins of the Mictor are known to bend so care must be taken. The 40 pin headers on the E5346A/E5351A are marked EVEN and ODD. Use this nomenclature to match up to the EVEN and ODD sides of the Mictor pin out.



If your target is 32 bits you will require 2 AMP mictor-38 connectors. This will correspond to 4 logic analyzer PODS. If your target is 64 bits you will need 3 Mictor connectors and 6 logic analyzer PODS.



Here is the pinout and PCB footprint for the AMP mictor-38 connector.



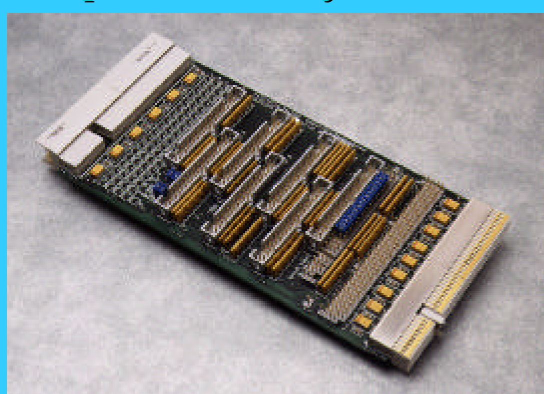
Here are the mechanical dimensions for the AMP mictor-38 connector.

Probing PCI buses that do have standardized connectors

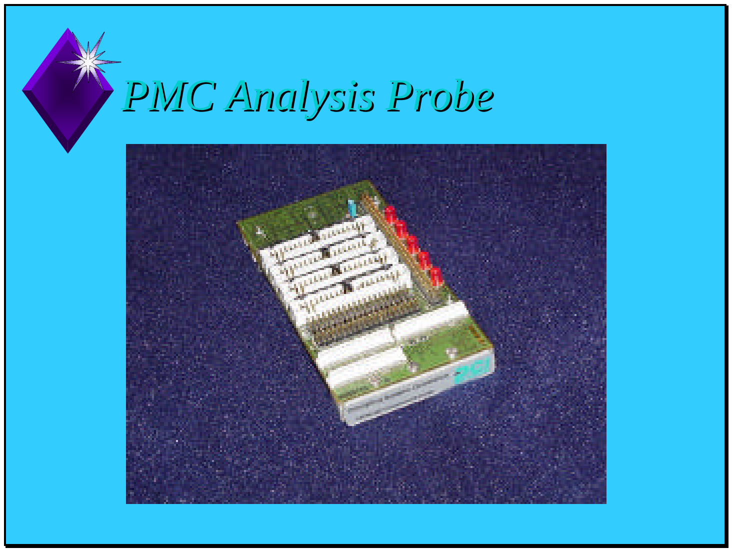
- CompactPCI
- PCI Mezzanine
- Desktop PCI
- Extended I/O PCI
- PCI-X

Now let's move on to technologies that do have standardized connectors. If you have any of these PCI technologies in your system probes already exist for your application.

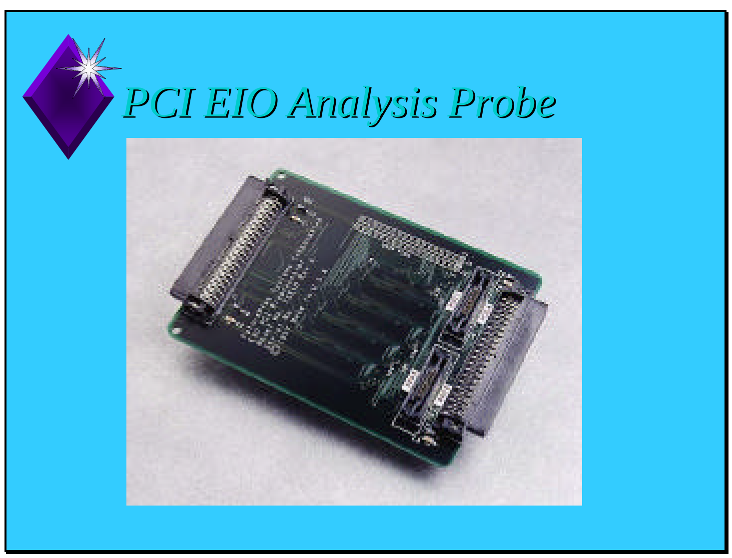
CompactPCI Analysis Probe



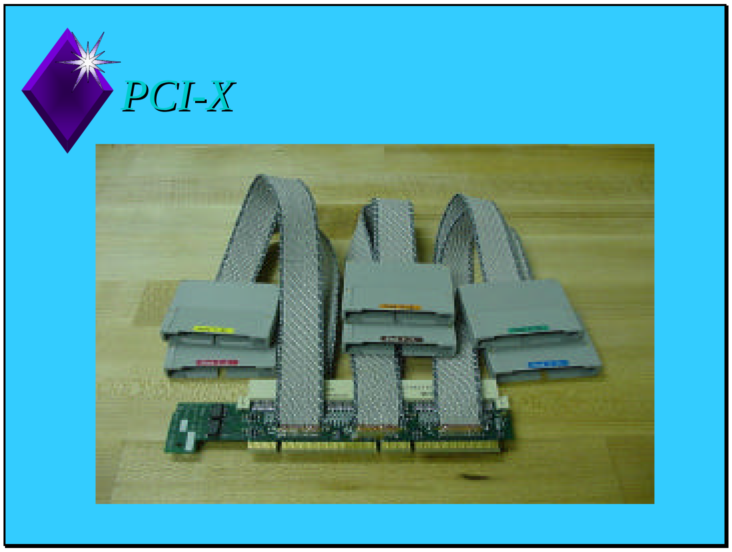
Shown here is the FS3020 CompactPCI analysis probe from FuturePlus Systems. A few things that I want to point out here are that for this application we had plenty of room. So instead of using the Mictor connectors we used 40 pin headers. Also since the etch length had to be extended so much we used clamping diodes to clamp the undershoot of the signals. This helped to prevent reflections from coming back onto the bus.



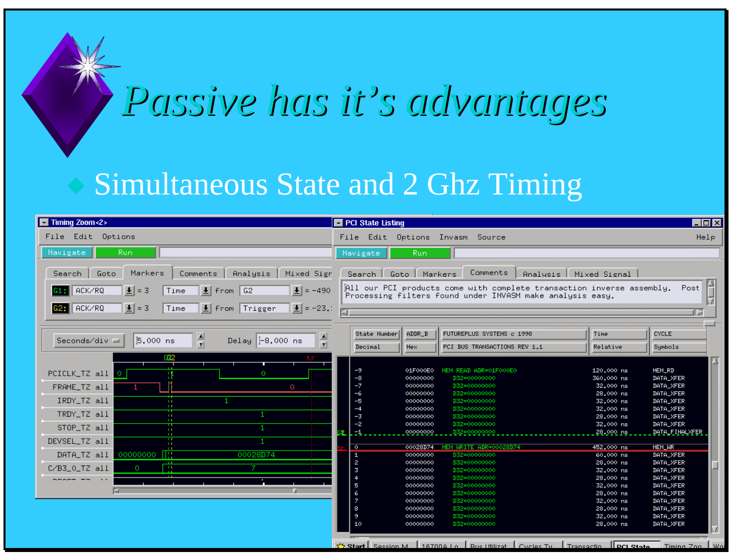
This same technique was applied to our PMC Analysis Probe shown here.



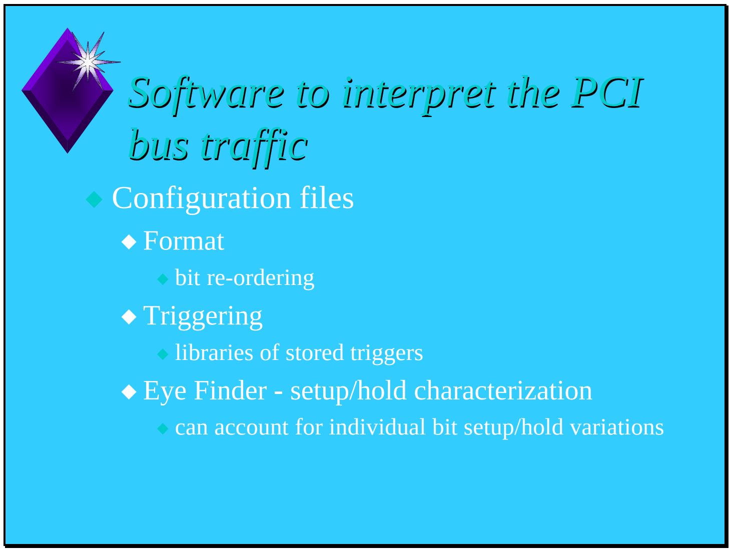
FuturePlus also has a PCI EIO Analysis probe. This probe uses the Mictor connectors and no termination circuitry is on the probe. The PCI EIO (Extended I/O) is a standard introduced by Hewlett-Packard Company as a way of allowing third parties to customize their printers.



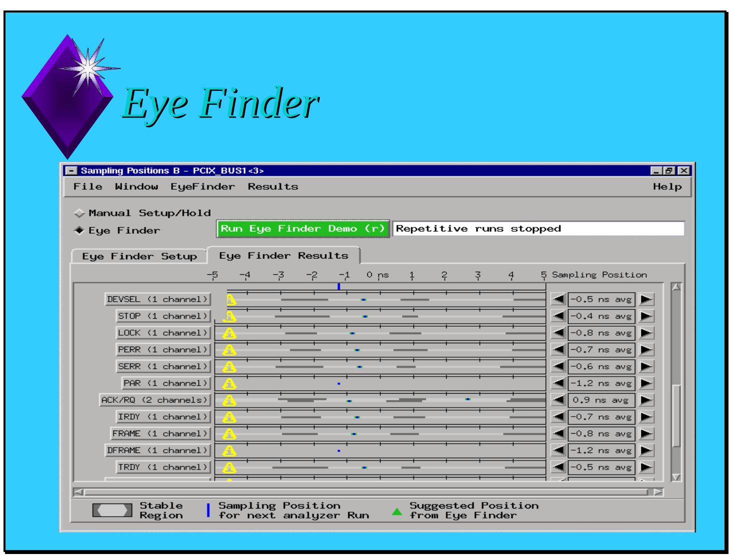
Pictured here is the latest product in the PCI Analysis Probe Family. It is the FS2007 PCI-X Analysis Probe. For the design of this probe we eliminated the Mictor connector all together and we solder the cables directly to the PCB etch. The etch extends one inch from the gold finger pins to the extender card connector and then to the termination circuitry.



Passive probing clearly has its advantages and these are shown here. With passive probing and the Agilent 16717 or above logic analyzers the designer can have simultaneous state and timing. On the right is shown a state listing (data acquired with the rising edge of the PCI clock) of the PCI bus traffic with the trigger set on a problematic address access. On the left, a 2GHz resolution timing zoom waveform around the trigger point (16K buffer) can be seen. A quick examination of the timing zoom waveform shows a glitch on FRAME#. So the user has the quick and accurate state triggering capability along side the accurate and revealing timing zoom picture.



The art of logic analysis has had a few key advances over the years. Among them the new flexibility of the configuration files. Today in the Format menu of the logic analyzer you can re-order the bits. This will help greatly the embedded PCI designer when routing the signals to the Mictor connectors. In order to keep skew in check the designer can route the signals to the connector out of order and then re-order them on the logic analyzer. There are some limitations. The clock bit cannot be re-ordered. It must be placed on the clock pin. In addition if the address bus is re-ordered the in-range triggering feature of the logic analyzer will not be available. However all other triggering features will be available. Triggering is also more flexible with the inclusion of trigger macros and the ability to store up to 10 triggers per configuration file.
The most revolutionary advancement in logic analysis today is the patented Agilent software technology called Eye Finder. The Eye Finder software performs two functions. The first is to find the data valid window of each bit probed and center the clock in that data valid window. This will allow each channel to be calibrated such that the setup and hold window can be lowered to 1.25ns. The second is that it shows the relationship of the clock to the data valid window so in a sense it characterizes the bus you are probing.



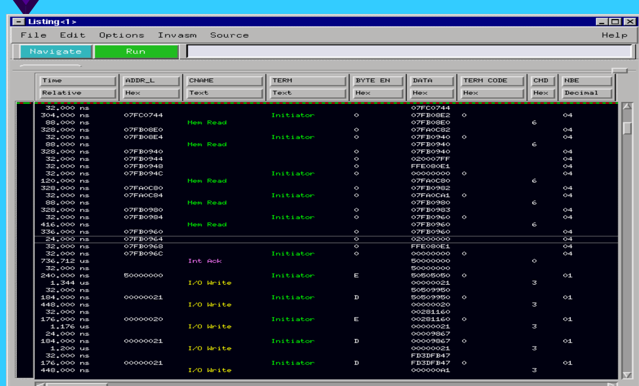
Here is a picture of Eye Finder. This software comes standard with all Agilent HP16700 systems that have version 2.0 of the operating system or better.

Post Processing Tools

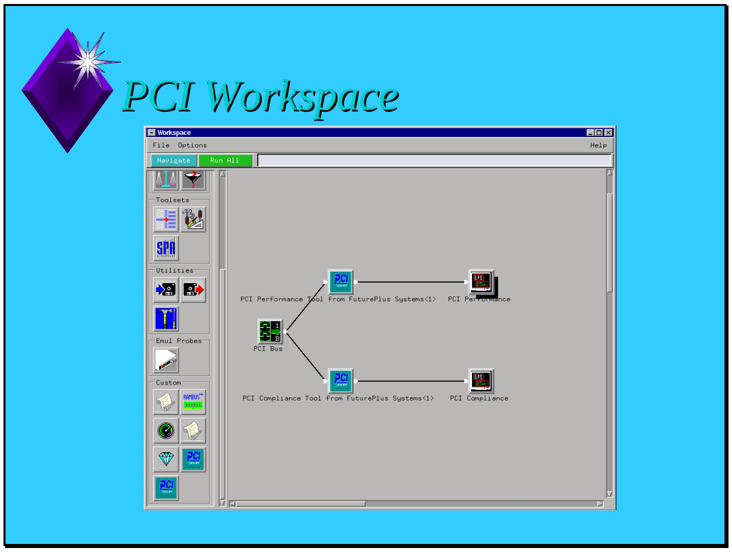
- Bus Inverse Assembly
  - Post processes the data and displays the data in easy to read PCI bus mnemonics
- Custom Tools
  - Displays performance metrics and finds compliance violations

Once the data has been acquired FuturePlus provides software that can interpret the bus transactions for PCI and PCI-X. For PCI there are also two additional tools available that measure performance and find compliance violations.

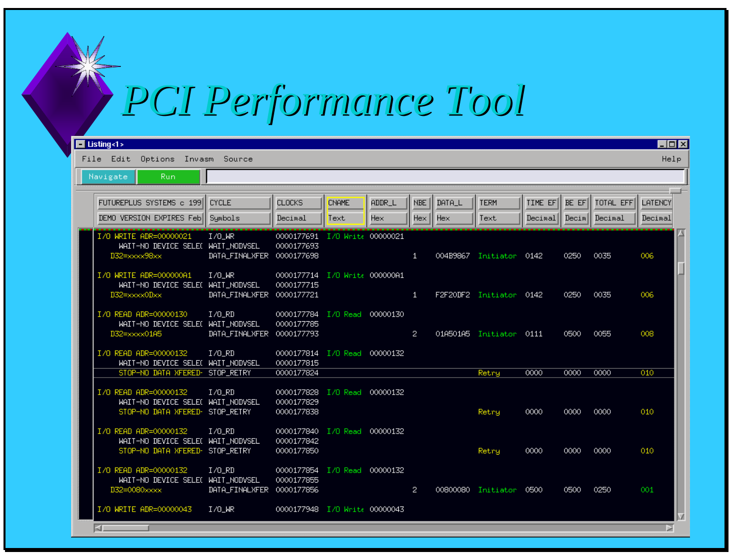
PCI Transaction Decode



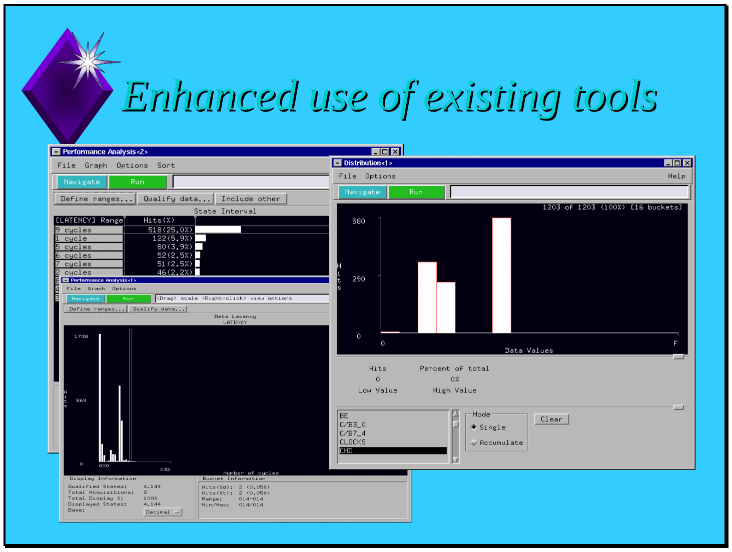
Here is a picture of the PCI bus disassembly tool. Columns are created so that the user can see the events side by side. Color has also been added so that the events are colored for easy and quick insight into any possible problems.



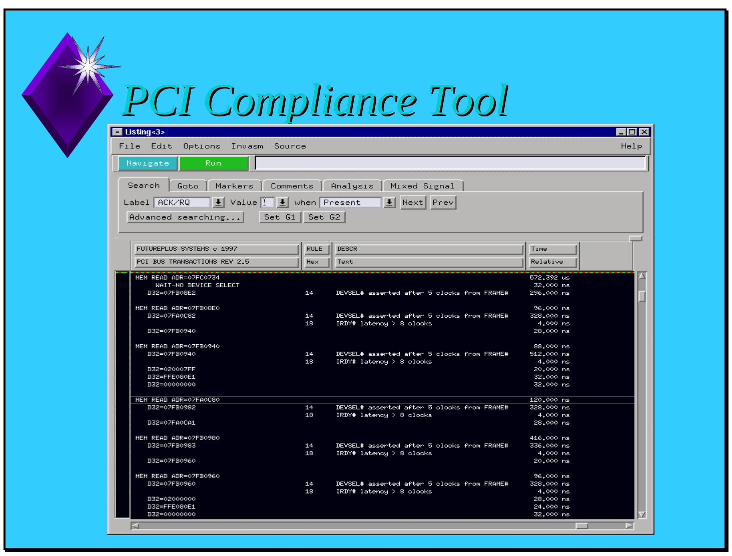
Pictured here is the 16700 workspace showing the Performance and Compliance tools from FuturePlus.



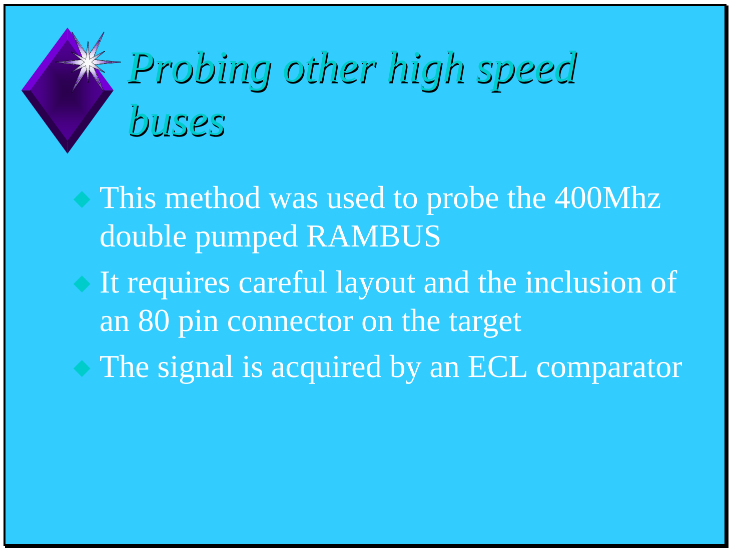
Here is the output from the performance tool. The new columns that the performance tool adds are: Time Efficiency, BE (byte enable) Efficiency, Latency and Total Efficiency. This tool also prints out a text file with summary of this information to the logic analyzer disk.



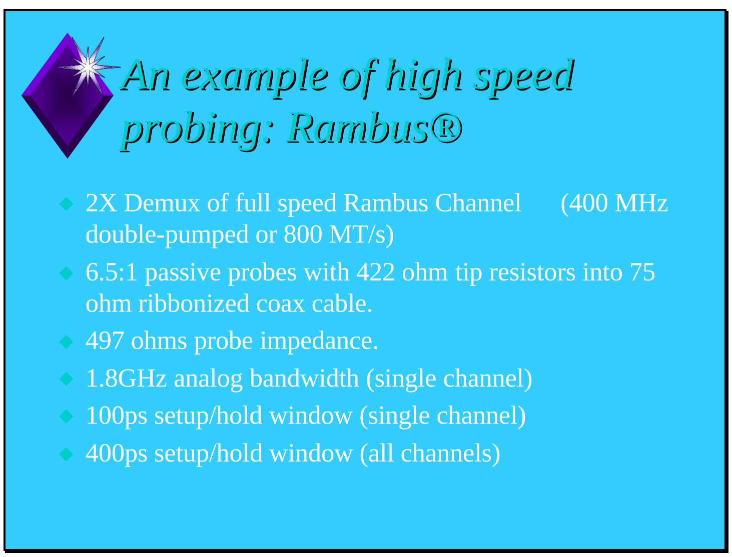
Now that the bus metrics are in demultiplexed and in column format they can easily be graphed and charted using the SPA (System Performance Analysis) tool on the 16700 logic analysis system.



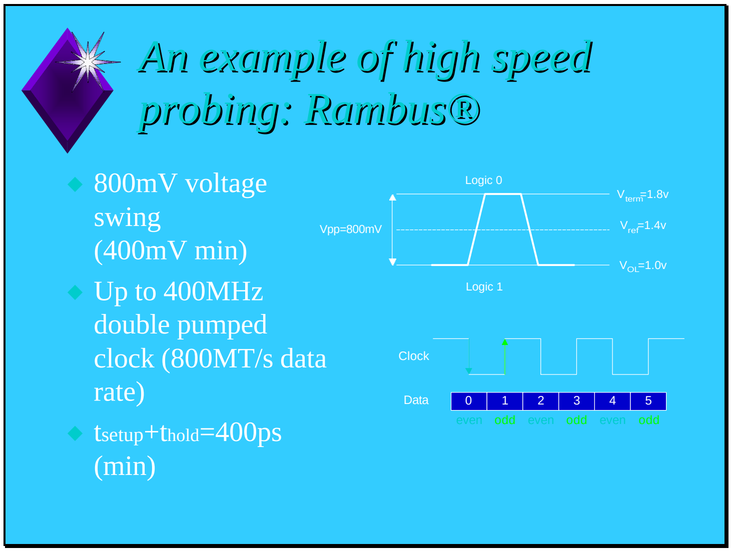
Here is a screen shot of the compliance tool. The entire acquisition buffer is searched and over 20 rule checks are done. The violation and the rule number are printed to the screen. Now the user can configure the trigger specification (triggers not supplied) for the violation and actually trigger on it if they so desire.



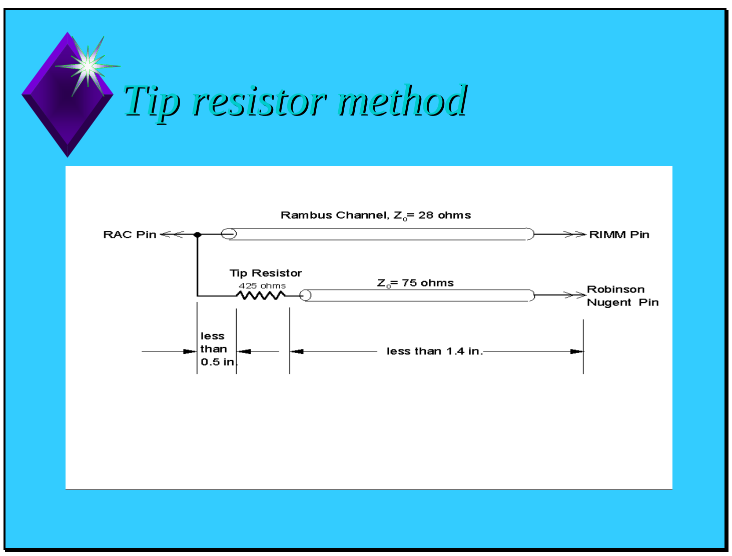
Next we have a brief introduction into some higher speed probing. This is the method we used to probe the high speed RAMBUS technology.



The “tip resistor” method used for the RAMBUS probing allows us to probe the RAMBUS at the full speed of 800 MT/s. Here are the characteristics of the probe.



Rambus has an 800mv voltage swing and is clocked on both edges of the source synchronous clock. The data valid window is a mere 400ps.



Here is a diagram showing the Rambus channel and the probe.

Rambus® General Purpose Probe

- **FS2224 Probe head plugs into an 80 pin Robinson Nugent connector**
- **No RIMM slot is needed**
- **Cable from the probe head to the Rambus Analysis box carry the 400MHz double-pumped data.**
- **An application note on our web site contains the details**

Once the signal travels up the cable it is acquired by ECL circuitry inside the box. FuturePlus offers both a general purpose version (GP RAMBUS FS2224) and a RIMM version (FS2222).

Important things to remember when it comes to probing

- Keep in mind the edge rate
  - Simulation is key
- Keep the skew low
  - passive probing will have skew issues
- Keep the stub length short
  - the closer the better
- Probe at I/O device if possible

As a summary here are some rules of thumb to keep in mind.

PCI Product Summary

from FuturePlus Systems

MODEL NUMBER	OLD MODEL NUMBER	DESCRIPTION
FS3030	*EIO*	EIO Analysis Probe & Extender
FS3010	*FSPMC32E*	32-Bit PMC Analysis Probe & Extender
FS3020	*FSCPC164E*	32/64-Bit CompactPCI Analysis Probe & Extender
FS2000	*FS16P32E*	32-Bit PCI Analysis Probe Plus & Extender, 33MHz
FS2001	*FS16P64*	64-Bit PCI Analysis Probe, 66MHz
FS2004	*FSPCB32E*	32-Bit CardBus Analysis Probe & Extender
FS2005	*N/A*	64-Bit PCI Pass. Analysis Probe & Ext., 66MHz, 3.3V
FS2006	*N/A*	64-Bit PCI Pass. Analysis Probe & Ext., 66MHz, 5V
FS2100	*FSPCI64E-3*	64-Bit PCI Act. Analysis Probe & Ext., 33MHz, 3.3V
FS2101	*FSPCI64E-3*	64-Bit PCI Act. Analysis Probe & Ext., 33MHz, 5V
FS2102	*N/A*	64-Bit PCI Act. Analysis Probe & Ext., 66MHz, 3.3v
FS2103	*N/A*	64-Bit PCI Act. Analysis Probe & Ext., 66MHz, 5V
FS1100	*FS16P32SL*	5-User, 32-Bit PCI Software License
FS1101	*FS16P64SL*	5-User, 64-Bit PCI Software License

FuturePlus Systems has been providing probes for PCI since 1993. Here is a list of our current PCI product offering.

PCI-X Product Summary

from FuturePlus Systems

- Developing 4 separate products
  - FS2104 - will work with Agilent E2929A
  - FS2105 will be the combination FS2104 and E2929A sold by FuturePlus
  - FS2007 - passive interposer FS2007 (software included)
  - FS1104 - software for embedded solutions
    - Customer lays down connectors on the target

This is a summary of our PCI-X product offering.

Product Summary

MODEL NUMBER	OLD MODEL NUMBER	DESCRIPTION
FS1000	*E5346A*	High Density Termination Adapter
FS1100	*FS16P32SL*	5-User, 32-Bit PCI Software License
FS1101	*FS16P64SL*	5-User, 64-Bit PCI Software License
FS1201	*FS90-105*	6 inch PCI Extender Cable
FS1202	*FS90-120*	12 inch PCI Extender Cable
FS2000	*FS16P32E*	32-Bit PCI Analysis Probe Plus & Extender, 33MHz
FS2001	*FS16P64*	64-Bit PCI Analysis Probe, 66MHz
FS2004	*FSPCB32E*	32-Bit CardBus Analysis Probe & Extender
FS2005	*N/A*	64-Bit PCI Pass. Analysis Probe & Ext., 66MHz, 3.3V
FS2006	*N/A*	64-Bit PCI Pass. Analysis Probe & Ext., 66MHz, 5V
FS2100	*FSPCI64E-3*	64-Bit PCI Act. Analysis Probe & Ext., 33MHz, 3.3V
FS2101	*FSPCI64E-3*	64-Bit PCI Act. Analysis Probe & Ext., 33MHz, 5V
FS2102	*N/A*	64-Bit PCI Act. Analysis Probe & Ext., 66MHz, 3.3v
FS2103	*N/A*	64-Bit PCI Act. Analysis Probe & Ext., 66MHz, 5V

If you need to analyze any other buses FuturePlus offers probes for all major computer buses. All of these products are compatible with your Agilent Logic Analyzer.

Product Summary

MODEL NUMBER	OLD MODEL NUMBER	DESCRIPTION
FS2210	FS16ISA	16-Bit ISA Analysis Probe & Extender
FS2220	FSAGP32TE	AGP 2X Analysis Probe & Interposer
FS2221	N/A	AGP 4X Analysis Probe & Interposer
FS2222	N/A	Rambus Analysis Probe for 184-pin RIMM
FS2224	N/A	Rambus Analysis Probe, General Purpose Probing
FS2230	FSSCSIA	SCSI 1,2,3 Bus Analysis Probe
FS2231	FSSCSIB	LVD SCSI Bus Analysis Probe
FS2232	N/A	SCSI Ultra 160M Analysis Probe
FS2310	FSSIMPE	SIMM Analysis Probe & Extender
FS2311	opt. 001	SIMM Analysis Probe & Extender – rear side probe
FS2320	FSDIMPEA	DIMM Analysis Probe & Extender
FS2321	N/A	PC100/133 Analysis Probe
FS3010	FSPMC32E	32-Bit PMC Analysis Probe & Extender
FS3020	FSCPC164E	32/64-Bit CompactPCI Analysis Probe & Extender