PCI Express™ Form Factors: Card, Mini Card and ExpressCard*

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Agenda

- Add-in Card
  - Review of add-in card basics
  - What’s new since the CEM 1.0a spec was released?
- PCI Express Mini Card
  - Review of basics
  - What’s new
- ExpressCard*
- Summary
- Call to Action

* Other names and brands may be claimed as the property of others.
Add-in Card
Simple Add-in Card Design

Follows PCI Card form factors

Standard Height Cards, 4.20” (106.7mm)

Low Profile Cards, 2.536” (64.4mm)

Half Length Cards, 6.6” (167.65mm)

Full Length Cards, 12.283” (312mm)

Uses PCI I/O Bracket

PCI Express Is Optimized for Cost
Add-in Card Size Exceptions

- Standard height x1 cards are limited to half-length (6.6”) for desktop applications
  - Push towards small form factor systems
  - 10W power limit
- For server I/O needs there is allowance for a 25W, standard height x1 card that MUST be greater or equal to 7.0” but less than or equal to full length
**Low Cost Edge Card Connector**

- x1 connector 36 pins vs. PCI 120 pins
- Simple Single Level Contacts
- 1mm Contact Spacing
- Low Cost Connector Assembly
Scalable Connector Design

Scalable Design allows connectors from x1 to x16 to be easily designed.

Smaller link-width cards can plug into larger link-width connectors.

- Use same contacts
- Modular body design
- Use same connector manufacturing process
Slot Placement Strategy

X1 PCI Express

I/O Connectors

x16 PCI Express Graphics

PCI
Routing in 4-Layer Motherboards

PCI Connectors

PCI Express x1 connector
(4 times PCI performance)

PCI Express x16 connector
(64 times PCI performance)

PCI Express layout and connectors can be routed in 4 Layers

Flexibility in routing PCI Express and PCI connectors on the same board

Smaller connectors provide more room for routing and components

µATX 4 Layer, P4 Motherboard
## Power Delivery

<table>
<thead>
<tr>
<th>Power Rail</th>
<th>10W slot</th>
<th>25W slot</th>
<th>75W slot</th>
</tr>
</thead>
<tbody>
<tr>
<td>+3.3V ±9%</td>
<td>3A max</td>
<td>3A max</td>
<td>3A max</td>
</tr>
<tr>
<td>+12V ±8%</td>
<td>0.5A max</td>
<td>2.1A max</td>
<td>5.5A max</td>
</tr>
<tr>
<td>+3.3Vaux ±9%</td>
<td>375mA max</td>
<td>375mA max</td>
<td>375mA max</td>
</tr>
</tbody>
</table>

**Notes:**
- 3.3Vaux max current is 375mA when the add-in card is Wake enabled and 20mA when Wake disabled.
- An ECR to the CEM 1.0 spec changed the maximum slot power from 60W to 75W

**Compared to PCI and AGP:**
- Additional power from 12v rail
- +5V, -12V requirements are eliminated
Power Rules

- System MUST provide +12V and +3.3V rails to ALL PCI Express slots in a chassis
- Systems may optionally provide +3.3Vaux but if supplied it MUST be provided to all PCI Express slots in a chassis
- If the platform supports the WAKE# signal then it MUST provide it and +3.3Vaux to all PCI Express slots in chassis
- Capacitive load rules:
  - +12V rail: 300µF @ 10W; 1000µF @ 25W; 2000µF @ 75W
  - +3.3V rail: 1000µF
  - +3.3Vaux rail: 150µF
Power Rules (Continued)

- Current slew rate: 0.1A/µs
- All x1 add-in cards must power up at a maximum of 10W; once configured as a High Power device, if applicable, a card can consume up to 25W
- All x16 add-in cards must power up at a maximum of 25W; once configured as a High Power device, if applicable, a graphics card can consume up to 75W
Power & Card Summary

- 10W: x1 cards (= 6.6” length)
- 25W: x1 cards (> 7.0” length), x4 cards, x8 cards, x16 low-profile graphics cards, x16 server I/O cards
- 75W: x16 full-height graphics cards
Add-in Card Interoperability

<table>
<thead>
<tr>
<th>Slot Card</th>
<th>x1</th>
<th>x4</th>
<th>x8</th>
<th>x16</th>
</tr>
</thead>
<tbody>
<tr>
<td>x1</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>x4</td>
<td>No</td>
<td>Required</td>
<td>Allowed</td>
<td>Allowed</td>
</tr>
<tr>
<td>x8</td>
<td>No</td>
<td>No</td>
<td>Required</td>
<td>Allowed</td>
</tr>
<tr>
<td>x16</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Required</td>
</tr>
</tbody>
</table>

- Up-plugging: Plugging a smaller link card into a larger link connector is fully allowed.
- Down-plugging: Plugging a larger link card into a smaller link connector is not allowed and is physically prevented.
- Down-shifting: Plugging a card into a connector that is not fully routed for all of the lanes. In general, this is not allowed. The exception is the x8 connector which the system designer may choose to route only the first four lanes. A x8 card functions as a x4 card in this scenario.
Reference Clock (REFCLK+, REFCLK-)

- Differential pair
- Nominal frequency of 100MHz (±300ppm)
- Point-to-point connection between each PCI Express connector and the clock source
- Within each differential pair the PCB trace lengths must be within 0.005”
- Spread Spectrum support is optional but likely needed to pass emissions testing!
- Termination resistors located at the clock source
Lane Reversal, Polarity Inversion

- The plus and minus connections from the system board’s transmit differential pair (PETp/PETn) may be reversed
  - Simplification for board routing
  - Receiver is required to support Lane Polarity Inversion
- If a component does NOT support lane reversal then the board (system or add-in card) must adhere to strict connection ordering (i.e. Lane 0 to Lane 0, Lane 1 to Lane 1, etc) to the add-in card connector
- If a component DOES support lane reversal then the same lane ordering must be used for both the transmit and receive pair
CEM spec updates since Revision 1.0a

- Card Presence Detect
- REFCLK clarification
- Slot Power Limit Implementation Note
- Connector color
- Card retention
- PERST# clarification
Card Presence Detect

- Supports the hot plug solution; ALL add-in cards must implement both gold fingers, PRSNT1# and the “furthest” PRSNT2#
- System use is optional for non-hot plug solutions
- There are multiple PRSNT2# pins on the connector – this is needed to support up-plugging
  - System buses them together
  - Add-in card connects PRSNT1# to the FURTHEST PRSNT2# pin on its connector

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![Diagram showing Card Presence Detect](image-url)
**REFCLK clarification**

- The timing budget allows for approximately 4” of add-in card trace length
- Termination resistors on the add-in card **ARE** allowed but…
  - ✓ Not covered by the CEM spec!
  - ✓ The nominal voltage swing, and rise & fall times will be reduced in half!
- Consider shutting off the clock to empty slots!
- Additional details on REFCLK measurement configurations and data are being provided in the CEM 1.0a Errata document
Software Update of the Slot Power Limit -
System firmware must update the slot power limit to the system's allocated value for the PCI Express add-in card (e.g. Graphics) and ensure the completion of this update prior to invoking the option ROM for that add-in card's PCI Express function. If the initial slot power limit value is set by hardware initialization then any attempt by software to change that value must be verified by that software prior to initializing the add-in card. Subsequent updates by the system firmware or operating system software, if any, may only increase the slot power limit value. However, after a card is reset the initial slot power limit value may be lower than the previous value. The maximum power level for an add-in card must be assigned by the system firmware during PCI Express bus configuration. For graphics the power level assigned will be dependent on the platforms support of the PCI Express Graphics High-End Specification (including the supplemental power cable).
Connector Color

- CEM 1.0 did not suggest or specify a color for the add-in card connector
- Approved ECN addresses this
- By default the recommended color should be black
  - This color hasn’t been used for an add-in card connector since ISA was around
  - Avoids any confusion with PCI connectors even though PCI and PCI Express cards are mechanically incompatible
- Other colors ARE allowed if a system OEM requires a particular color coding scheme
Card Retention

- ECN defines additional component keepout areas on add-in cards to support system-level card retention
- Focus is on full-height, x16 cards for Graphics
PERST# Clarification

- ECN defines threshold windows for PERST# activation
- Voltage monitoring circuitry will be able to reliably detect a power rail condition requiring the assertion of PERST#
Add-in Card Summary

- PCI Express is Optimized for Cost
  - Cost-effective for migration into commodity infrastructure
  - Replaces PCI over time with 15+ years of life

- PCI Express is Easy to Implement
  - Leverages existing form factors and standards
  - Transition with existing PCI form factors
PCI Express Mini Card
What is PCI Express Mini Card

- Replacement for Mini PCI
  - Targeted for BTO/CTO solutions

- PCI Express and USB 2.0 enabled
  - Optimized for communication add-ins

- Card envelope: 30mm x 56mm x 5mm
  - Equal to ½ width of Mini PCI Type IIIa card
Communications Centric

Mini PCI Express Add-in Card

- PCI Express
- USB
- LEDS
- Mini PCI Express COMMUNICATION CENTRIC FUNCTION
- FUNCTION-SPECIFIC CONNECTOR
- Modem
- Ethernet
- Wireless

SYSTEM BUSSES

SYSTEM INTERFACE

FUNCTION

I/O INTERFACE
Targeted Applications

- **Wireless-Personal Area Network (W-PAN)**
  - Bluetooth / Ultra wideband

- **Local Area Network (LAN)**
  - 10/100/1G/10G Ethernet

- **Wireless-LAN (W-LAN)**
  - 802.11b/g/a, etc.

- **Wide Area Network (WAN)**
  - V.90/V.92 modem / xDSL / cable modem

- **Wireless-WAN (W-WAN)**
  - GSM/GPRS / UMTS / CDMA
Half the Size of Mini PCI

PCI Express Mini Card (Type IIIa)
Upgradeability / Serviceability

- Angled insertion and removal
- OEM optimized retention
  - Internal clips / screws / door attached clip
- BTO / CTO
  - Single connector
  - Multiple technologies
- Field replacement by service technicians
  - Reduce TCO / services costs
Mechanical Summary (1)

Cross-section

Card outline dimensioning
Mechanical Summary (2)

I/O connector zone

Keep out zones
Mechanical Summary (3)

Two socket arrangement defined

System board footprint

Component keep out area for card hold down solution
## Signal Summary

<table>
<thead>
<tr>
<th>Signal Group</th>
<th>Signal</th>
<th>Direction</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power</strong></td>
<td>+3.3V (2 pins)</td>
<td></td>
<td>Primary 3.3V source</td>
</tr>
<tr>
<td></td>
<td>+3.3VAUX (1 pin)</td>
<td></td>
<td>Auxiliary 3.3V source</td>
</tr>
<tr>
<td></td>
<td>+1.5V (3 pins)</td>
<td></td>
<td>Primary 1.5V source</td>
</tr>
<tr>
<td></td>
<td>GND (12 pins)</td>
<td></td>
<td>Return current path</td>
</tr>
<tr>
<td><strong>PCI Express</strong></td>
<td>PETp0, PETn0</td>
<td>Input/Output</td>
<td>PCI Express x1 data interface: 1 differential transmit pair and 1 differential receive pair</td>
</tr>
<tr>
<td></td>
<td>PERp0, PERn0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>REFCLK+, REFCLK−</td>
<td>Input</td>
<td>PCI Express differential reference clock (100 MHz)</td>
</tr>
<tr>
<td></td>
<td>CLKREQ#</td>
<td>Output</td>
<td>Reference clock request</td>
</tr>
<tr>
<td><strong>Universal Serial Bus</strong></td>
<td>USB_D+, USB_D−</td>
<td>Input/Output</td>
<td>USB serial data interface – USB2.0 Specifications</td>
</tr>
<tr>
<td><strong>Auxiliary Signals</strong></td>
<td>PER$T#</td>
<td>Input</td>
<td>Functional reset to the card</td>
</tr>
<tr>
<td></td>
<td>WAKE#</td>
<td>Output</td>
<td>Open Drain active Low signal</td>
</tr>
<tr>
<td></td>
<td>SMB_DATA</td>
<td>Input/Output</td>
<td>SMBus data signal – SMBUS 2.0 Specifications</td>
</tr>
<tr>
<td></td>
<td>SMB_CLK</td>
<td>Input</td>
<td>SMBus clock signal – SMBUS 2.0 Specifications</td>
</tr>
<tr>
<td><strong>Communications Specific Signals</strong></td>
<td>LED_WPAN#, LED_WLAN#, LED_WWAN#</td>
<td>Output</td>
<td>Active Low signals – connection status indicators</td>
</tr>
</tbody>
</table>
# Pin Arrangement

## 52 pin solution
Arranged to assure isolation

## Table 3-4: System Connector Pin-Out

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Name</th>
<th>Pin #</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>Reserved*</td>
<td>52</td>
<td>+3.3V</td>
</tr>
<tr>
<td>49</td>
<td>Reserved*</td>
<td>50</td>
<td>GND</td>
</tr>
<tr>
<td>47</td>
<td>Reserved*</td>
<td>48</td>
<td>+1.5V</td>
</tr>
<tr>
<td>45</td>
<td>Reserved*</td>
<td>46</td>
<td>LED_WPAN#</td>
</tr>
<tr>
<td>43</td>
<td>Reserved*</td>
<td>44</td>
<td>LED_WLAN#</td>
</tr>
<tr>
<td>41</td>
<td>Reserved*</td>
<td>42</td>
<td>LEDWWAN#</td>
</tr>
<tr>
<td>39</td>
<td>Reserved*</td>
<td>40</td>
<td>GND</td>
</tr>
<tr>
<td>37</td>
<td>Reserved*</td>
<td>38</td>
<td>USB_D+</td>
</tr>
<tr>
<td>35</td>
<td>GND</td>
<td>36</td>
<td>USB_D-</td>
</tr>
<tr>
<td>33</td>
<td>PETp0</td>
<td>34</td>
<td>GND</td>
</tr>
<tr>
<td>31</td>
<td>PETn0</td>
<td>32</td>
<td>SMB_DATA</td>
</tr>
<tr>
<td>29</td>
<td>GND</td>
<td>30</td>
<td>SMB_CLK</td>
</tr>
<tr>
<td>27</td>
<td>GND</td>
<td>28</td>
<td>+1.5V</td>
</tr>
<tr>
<td>26</td>
<td>PERp0</td>
<td>25</td>
<td>GND</td>
</tr>
<tr>
<td>23</td>
<td>PERn0</td>
<td>24</td>
<td>+3.3V_AUX</td>
</tr>
<tr>
<td>21</td>
<td>GND</td>
<td>22</td>
<td>PERST#</td>
</tr>
<tr>
<td>19</td>
<td>Reserved</td>
<td>20</td>
<td>Reserved***</td>
</tr>
<tr>
<td>17</td>
<td>Reserved</td>
<td>18</td>
<td>GND</td>
</tr>
</tbody>
</table>

### Mechanical Key

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Name</th>
<th>Pin #</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>GND</td>
<td>16</td>
<td>Reserved**</td>
</tr>
<tr>
<td>13</td>
<td>REFCLK-</td>
<td>14</td>
<td>Reserved**</td>
</tr>
<tr>
<td>11</td>
<td>REFCLK+</td>
<td>12</td>
<td>Reserved**</td>
</tr>
<tr>
<td>9</td>
<td>GND</td>
<td>10</td>
<td>Reserved**</td>
</tr>
<tr>
<td>7</td>
<td>CLKREQ#</td>
<td>8</td>
<td>Reserved**</td>
</tr>
<tr>
<td>5</td>
<td>Reserved****</td>
<td>6</td>
<td>1.5V</td>
</tr>
<tr>
<td>3</td>
<td>Reserved****</td>
<td>4</td>
<td>GND</td>
</tr>
<tr>
<td>1</td>
<td>WAKE#</td>
<td>2</td>
<td>3.3V</td>
</tr>
</tbody>
</table>
### Power and Thermals

#### Table 3-6: Power Ratings

<table>
<thead>
<tr>
<th>Voltage Tolerance</th>
<th>Primary power</th>
<th>Auxiliary power*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peak (max) mA</td>
<td>Normal (max) mA</td>
</tr>
<tr>
<td>+3.3V (AUX)</td>
<td>±9%</td>
<td>1,000</td>
</tr>
<tr>
<td>+1.5V</td>
<td>±5%</td>
<td>500</td>
</tr>
</tbody>
</table>

**3W MAX power consumption**

**2.3W MAX thermal dissipation**

![Power Density Uniform Loading](PowerDensity.png)

- **Power Density Uniform Loading @80% coverage**
Robust power management features
- ACPI and PCI PM supported
- In-band wake mechanisms supported
- Wake# – enables lowest system power solution
- SMBus – available for advanced features

Dual power planes
- 3.3V – nominal voltage required for I/O drive requirements
- 1.5V – reduces need for on-card regulation

Two power states
- PRIMARY – 3.3V and 1.5V fully ON
- AUXILIARY – 3.3VAUX available in D3HOT
### Status Indicators

#### Table 3-2: Defined LED states

<table>
<thead>
<tr>
<th>State</th>
<th>Definition</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>The LED is emitting no light.</td>
<td></td>
</tr>
<tr>
<td>ON</td>
<td>The LED is emitting light in a stable non-flashing state.</td>
<td></td>
</tr>
<tr>
<td>Slow Blink</td>
<td>The LED is flashing at a steady but slow rate.</td>
<td>250 ± 25% milliseconds ON period 0.2 ± 25% Hz blink rate</td>
</tr>
<tr>
<td>Intermittent Blink</td>
<td>The LED is flashing intermittently proportional to activity on the interface.</td>
<td>50% duty cycle 3 Hz minimum blink rate 20 Hz maximum blink rate</td>
</tr>
</tbody>
</table>

#### Table 3-3: Recommended use for LED indicators by wireless classes

<table>
<thead>
<tr>
<th>State</th>
<th>W-PAN</th>
<th>W-LAN</th>
<th>W-WAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>Not powered</td>
<td>Not powered</td>
<td>Not powered</td>
</tr>
<tr>
<td>ON</td>
<td>Powered; ready to transmit or receive</td>
<td>Powered, associated and authenticated but not transmitting or receiving</td>
<td>Powered, associated and authenticated but not transmitting or receiving</td>
</tr>
<tr>
<td>Slow Blink</td>
<td>N/A</td>
<td>Powered but not associated or authenticated; searching</td>
<td>Powered but not associated or authenticated; searching</td>
</tr>
<tr>
<td>Intermittent Blink</td>
<td>Activity proportional to transmitting &amp; receiving speed</td>
<td>Activity proportional to transmitting &amp; receiving speed</td>
<td>Activity proportional to transmitting &amp; receiving speed For voice applications, turning off and on the intermittent blink based on the ring pulse cycle can indicate a ring event.</td>
</tr>
</tbody>
</table>

- Three LEDs
  - ✓ W-PAN
  - ✓ W-LAN
  - ✓ W-WAN

- Single-ended, 9 mA sink capable

- LED support via I/O connector
  - ✓ Still an option
Ease of Design

- Digital / Analog physical separation
  - RF is not as near to digital
    - High speed digital on host connector
    - Analog on I/O connectors

- Spread Spectrum Reference clock supports
  - Reduced EMI emissions

- Software compatibility
  - Per native bus definitions
    - PCI Express
    - USB 2.0
    - SMBus 2.0
Mini Card Summary

- Higher performance and smaller F/F replacement for Mini PCI
- Optimized for communications applications
  - IHVs can select the serial interface appropriate for their device
  - Support for LED status indicators
- Outstanding power management features
ExpressCard*

* Other names and brands may be claimed as the property of others.
Agenda

- The motivation behind ExpressCard technology
- Key characteristic details of ExpressCard technology
- Key design considerations
- ExpressCard applications opportunities
The *ExpressCard* Standard

PCMCIA’s next generation PC Card technology specification

- Major step to align with platform trends
- Retains the best characteristics of CardBus
- Leverages advanced serial bus technologies

* Other names and brands may be claimed as the property of others.
Platform shifts present opportunities, drive requirements

I/O interconnect
- fast serial links
- native hot-plug

Notebook PCs
- thinner and lighter

Desktop PCs
- smaller, modular form factors

Establishing module product compatibility across desktop & mobile

smaller yet higher performance
lower cost by design

smaller yet flexible

technology reuse
lower cost by volume
address growing SFF market
Desktop View on ExpressCard

- Significant ease-of-use benefit over traditional add-in cards
  - Closed box I/O expansion without clutter and complexity
  - Lower support costs compared to traditional add-in cards

- Uses native interfaces
  - I/O plumbing is “standard feature” of the base platform
  - No external I/O controller or bridge is required

- Advanced serial interfaces vs. existing parallel interfaces
  - Fewer pins and more bandwidth
  - Lower cost interconnects (connector, cables, silicon)

- Leverage a larger combined desktop / mobile market
  - Draw on mobile platform proven usage model

SFF desktop market growing – estimates range from 20% - 40% market share by 2005
Architectural Overview

- System design based on a modular, extensible slot model
  - Assumes multiple slot solutions, single slots allowed

- Relies on native bus operation
  - PCI Express Base Specification 1.0a
  - USB 2.0 (low / full / high speeds)

Compliant systems must support both in slots

- Compatible with existing operating system
  - Future OS may offer non-essential enhancements
ExpressCard/34 Module Form-Factor

- **34 mm**
- **75 mm**
- **5 mm thick**

**Features:**
- Security notch
- Finger grip
- Connector alignment feature
ExpressCard/54 Module Form-Factor

- 54 mm
- 75 mm
- 53 mm
- 34 mm
- 5 mm thick
Building a Slot

Slot for 34mm modules only

- Top Cover
- Host Connector
- Left Guide Rail
- Right Guide Rail
- Host/Daughter Card

Universal slot for both modules

- Top Cover
- Host Connector
- Left Guide Rail
- Right Guide Rail
- PCB Insulator
- Host/Daughter Card
ExpressCard Connectors

- Beam-on-blade, single in-line configuration, 1mm pitch
  - Low-cost yet reliable and durable
    - 5K / 10K cycle rating for module connectors
    - 5K cycle rating for host connectors
  - Two-levels of contacts in module
ExpressCard module using PCI Express
System Diagram

ExpressCard™ module using USB

Power Switch

Clock Request
Ref CLK
Wake Request
System Reset

PETp0
PETn0
PERp0
PERn0

USBD+
USBD-
CPUSB#
RESERVED
SMB_CLK
SMB_DATA
+1.5V
+3.3V
+3.3V_AUX
12
11
10
9
8
7
6
5
4
3
2
1

ExpressCard™ module using USB
Power & Thermal Requirements

- Solution balances the needs of applications with thermal constraints of size
  - Thermal limits defined for “inside the slot” dissipation

1.3W thermal

<table>
<thead>
<tr>
<th>Supply</th>
<th>Limits</th>
<th>Notes</th>
</tr>
</thead>
</table>
| +3.3V  | 1000 mA – Average
1300 mA – Max | OFF in D3 |
| +3.3VAUX | 250 mA – Average
325 mA – Max | ON in D0 – D3 (with wake enabled) |
|        | 5 mA – Average | D3 limit when wake disabled |
| +1.5V  | 500 mA – Average
650 mA – Max | OFF in D3 |

1. Sum of +3.3V & +3.3VAUX averages may not exceed 1A
2. Sum of +3.3V & +3.3VAUX maximums may not exceed 1.75A
System Configurations

- Location of slots vary for desktop & mobile
  - Based on application and accessibility needs

- Platform-independent recommendations
  - Support multiple slots in a platform
    - Single slot solutions seriously limit usage flexibility
  - Provide at least one slot for ExpressCard/54 modules
    - Supports CF adapters, Smart Card adapters, larger rotating-media drives
System Desktop Concepts

OEM-specific riser card

Cabled daughter cards

Power from system PSU

PCI Express Cable

USB Cable
Power to the Slot

- Slot is cold when un-occupied
  - Module presence pins dictate when power is needed
    - No software needed
  - System in sleep state (S3/S4)
    - *Special case* – after insertion, power to module held off until after system returns to S0

- No 5V USB bus power
  - Replaced with regulated 3.3V (& 1.5V)
  - 3.3V auxiliary current on a separate pin
  - Replace regulator with rail switching in designs

<table>
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<tr>
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<td>REFCLK+</td>
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<td>GROUND</td>
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</table>

Simpler solution – no controller / software connection
Thermals

- Smaller cards mean less thermal capacity
  - *a matter of physics*
- Use PM aggressively to reduce thermal contribution

- High source power provided for short-term application needs
  - *Duty-cycle/usage profile determines long-term contribution to the thermal average*

*65°C still air environment assumed*

Thermal modeling module

ExpressCard/34 Power Limit*

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</tbody>
</table>

*HEATER, 25.4mmX50.8mm*
Power Management

- Support for PM in modules is mandatory
  - Active State PM (PCI Express – L0s & L1)
  - D3 support (PCI Express & USB 2.0)

- Wakeup mechanisms
  - PCI Express
    - WAKE# – sideband to wake system power
    - PME in-band messaging
  - USB
    - USB in-band wake signaling
Modules using both PCI Express and USB in a single instance

- Current bus driver stacks: no knowledge of physical dependency
  - When a request is made to remove or stop a function: *one function will be knowingly removed, the other function will suffer surprise removal*

- Use ACPI – *legacy solution*
  - _EJD (Eject Dependencies) – cross declarations in port descriptions_

- Updated driver stacks – *future solution*
  - Require serial numbers be implemented in the PCI Express Extended Configuration Space
  - Reflect the PCI Express serial number in USB device configuration space under a new string descriptor
Ease-of-Use Considerations

- Surprise insertion and removal
  - HW/SW tolerant of user actions
- Module extraction from the slot
  - Spec targeted at manual removal over need for ejector systems
- Module installation is independent of which interface used by the application
- Proper marking and labeling techniques aids in module insertion
ExpressCard Compliance

- Will be tied to ExpressCard logo usage for registered products

- Proposed compliance program
  - Combination of checklist & interop testing
    - Requires use of silicon that meets PCI-SIG and USB-IF silicon compliance programs
  - Co-sponsored SIG events to ease participation costs
Application Opportunities

- Transition existing applications from CardBus to ExpressCard technology
  - Leverage the broad range of existing USB silicon
- Introduce new applications
  - Enabled by PCI Express and USB
  - New desktop platform and consumer opportunities

Designed for adapters, rotating media, higher power applications

1.8” HD app

Designed as long term form factor, fit for smaller next generation systems
# Target Applications

<table>
<thead>
<tr>
<th>Interface</th>
<th>Performance¹</th>
<th>Target Applications</th>
</tr>
</thead>
</table>
| PCI Express     | 2.0 Gbps (full-duplex) | Wired & Wireless LAN  
|                 |              | Broadband modems  
|                 |              | Audio/Video Steaming  
|                 |              | TV Tuners/Decoders  
|                 |              | I/O Adapters (e.g. 1394a/b)  
|                 |              | Magnetic Disk Drives |
| USB 2.0         | 1 Mbps to 480 Mbps (half-duplex) | Wired & Wireless WAN  
|                 |              | Wireless PAN  
|                 |              | Flash Memory  
|                 |              | SFF Flash Card Adapters  
|                 |              | Security  
|                 |              | Legacy I/O (PS2, serial, parallel)  
|                 |              | Optical Disk Drives  
|                 |              | GPS Receiver  |
| SMBus²          | 100 Kbps (half-duplex) | Sideband system management |

¹ *nominal data throughput*  
² *optional host feature*
ExpressCard Timeline

Planned for 2003-2004 …

- Formal specification release – complete!
- Publish design collaterals – in progress!
- Compliance program begins – in progress!

PCMCIA participation = developer support and compliance program access
ExpressCard Summary

- The *ExpressCard Standard* enables modular card solutions for *PCI Express* and *USB*

- *ExpressCard* technology is targeted for a wide range of platforms including mobile and desktop PCs

- *ExpressCard* solutions will provide the best end-user experience for PC upgrades
ExpressCard Next Steps

- Module and system developers: join and participate in the PCMCIA
  www.expresscard.org

- Silicon developers: design ingredients for ExpressCard applications emphasizing low power and power management features

- Get ExpressCard technology included on your 2004 product roadmaps
Summary

- PCI Express functions will be available in a wide variety of form factors serving multiple market segments.
- Each form factor addresses the specific physical, power, thermal and performance needs of the markets they are intended to serve.
- Each form factor has a solid transition strategy for end-users/customers.
Call to Action

- Prepare your product roadmaps to intercept the first launch of systems, cards, and modules

- Utilize the PCI-SIG (and other industry groups, as appropriate) for specifications and support
Thank you for attending the 2004 PCI-SIG Asia-Pacific Developers Conference.

For more information please go to www.pcisig.com