



# **"Polaris 10" Databook**

Technical Reference Manual - AMD Confidential

Part Number: 55765\_3.00

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# Revision History

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**Note:** The release states are defined as:

**Preliminary Releases:**

Revision numbers 0.xx are rough works.

Revision numbers 1.xx are documents with substantial info

Revision numbers 2.xx are documents with complete information.

**Full Release**

Revision numbers 3.xx are for production.

## Revision History

Rev 3.00 (June 26, 2017)

- Removed references to preliminary data across the document.
- Updated DisplayPort version to 1.4 across the document.
- Added 20keV part information to [Part Identification \(p. 1\)](#).
- Updated contents of [Thermal Diode \(p. 16\)](#).
- Revised tables in [DDC I22C Mode Electrical Characteristics \(p. 56\)](#).
- Revised Transmitter Electrical Specification in [SMBus Electrical Characteristics \(p. 58\)](#).
- Updated contents of [Physical Dimensions \(p. 65\)](#).

Rev 1.03 (January 24, 2017)

- Updated DisplayPort information in [Display Features \(p. 7\)](#).

Rev 1.02 (January 18, 2017)

- Updated DisplayPort information in [Display Features \(p. 7\)](#).

Rev 1.01 (July 21, 2016)

- Updated [Display Features \(p. 7\)](#) number of DisplayPort and HDMI™ supported displays.
- Updated feature list in [Video Acceleration Features \(p. 13\)](#) and [Video Codec Engine \(VCE\) Features \(p. 14\)](#).

- Updated PCIE\_ZVSS resistor type from 200  $\Omega$  to 180  $\Omega$  in [Table 3-3 \(p. 22\)](#).
- Updated VDDC, VDDCI, VDD\_08, and VMEMIO voltages in [Table 3-22 \(p. 37\)](#). Also removed note 1 from the table.
- Updated nominal voltage, AC tolerance values and VMEMIO TDC in [Table 5-2 \(p. 54\)](#). Also updated notes 3 and 7 and added [Figure 5-1 \(p. 55\)](#).
- Updated [Table 6-2 \(p. 62\)](#).
- Updated [Thermal Diode Characteristics \(p. 62\)](#).
- Added note 3 which specifies the solder ball diameter in [Physical Dimensions \(p. 65\)](#).

Rev 1.00 (April 6, 2016)

- Preliminary release.

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# Introduction

**The databook is updated as necessary following qualification to convert this document to a formal specification.**

**Please review any errata and advisories as they identify amendments to the specifications in this databook.**

**Contact your local AMD support person for the software support schedules of GPU features.**

## 1.1 Part Identification

### 1.1.1 Packaging Types and Device IDs

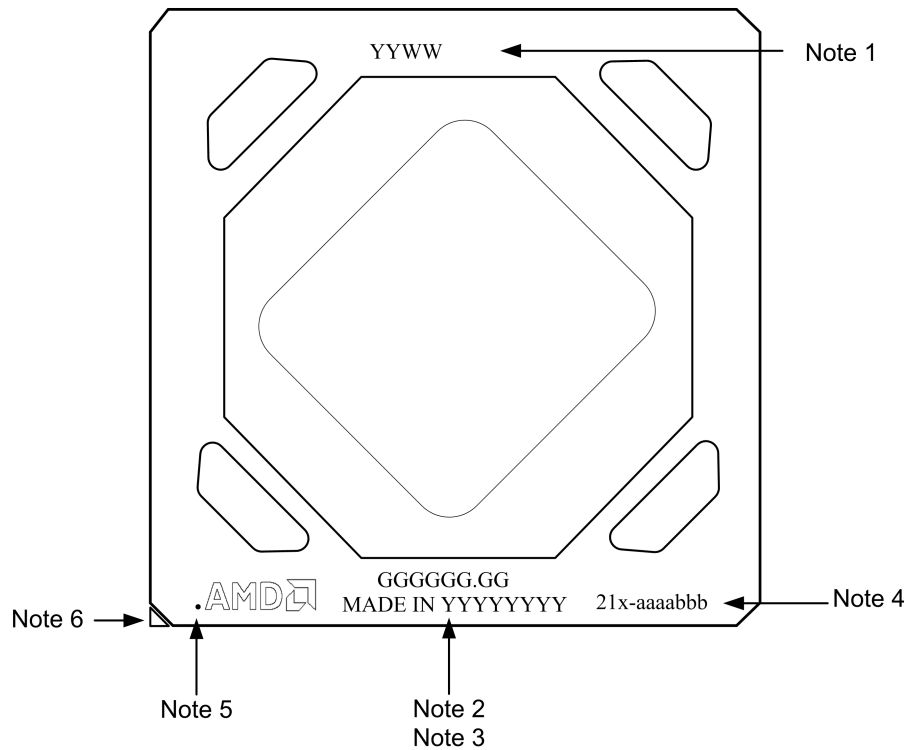
The vendor ID is 0x1002.

Table 1–1 Package Information

Part	Device ID / Revision ID	Part Number	HD Audio Controller ID	HD Audio Codec ID	Package
"Polaris 10 PRO"	67DF/CF	215-0876204 <sup>1</sup> 215-0876406 <sup>2</sup>	AAF0	AA01	1401 HFCBGA
"Polaris 10 XT"	67DF/C7	215-0876184 <sup>1</sup> 215-0876392 <sup>2</sup>			
<b>Note:</b> 1. 10keV part 2. 20keV part Refer to AMD Product Advisory, order #56068 for the details on the part difference.					

### 1.1.2 Branding Format

Figure 1-1 "Polaris 10" Branding



**Note:**

1. The date code where YY is the assembly start year and WW is the assembly start week. Special markings that help differentiate the GPU from others may also appear on this line. For example, ES is found after the date code for engineering samples.
2. Country of origin YYYYYYYY (The assembly site; such as USA, SINGAPORE, TAIWAN, and CHINA).
3. The wafer foundry's lot number.
4. The part number. Refer to [Table 1-1 \(p. 1\)](#) for the appropriate part number.
5. Pin 1 dot.
6. GPU pin A1.

The branding format can be in laser, ink, or mixed laser and ink marking.

# Functional Overview

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This section describes the major subsystems and interfaces of "Polaris 10". To go to a topic of interest, use the following list of linked cross-references:

- [Memory Interface \(p. 3\)](#)
- [Acceleration Features \(p. 5\)](#)
- [Display System \(p. 6\)](#)
- [Video Codec Engine \(VCE\) Features \(p. 14\)](#)
- [PCI Express® Bus Support Features \(p. 14\)](#)
- [Power Management Features \(p. 15\)](#)
- [Spread-spectrum Support \(p. 15\)](#)
- [Internal Thermal Sensor \(p. 15\)](#)
- [Thermal Diode \(p. 16\)](#)
- [Logo Compliance \(p. 16\)](#)
- [Test Capability Features \(p. 16\)](#)
- [Other Features \(p. 16\)](#)
- [Export Control Classification \(p. 17\)](#)

## 2.1 Memory Interface

### 2.1.1 Memory Configurations Support

"Polaris 10" has eight (256-bit) DRAM sequencers. Each DRAM channel is 32-bit wide. All DRAM devices must be of the same type, have the same size on each channel and must run at the same voltage.

"Polaris 10" supports only GDDR5 DRAM.

**Supported DRAM Component Organizations:**

- 8 or 16 banks (3 or 4 bank bits). Single rank.
- Rows: 1024, 2048, 4096, 8192, 16384, 32768, or 65536 (10, 11, 12, 13, 14, 15, or 16 bits).
- Columns: 256, 512, 1024, 2048 (8, 9, 10 bits).
- CS (chip select): 1.

### 2.1.2 Memory Aperture Size

The memory-aperture size can be set up through either pin straps for designs that do not have dedicated ROM for the video BIOS, or ROM straps for designs that have dedicated ROM. Refer to the descriptions of the ROM\_CONFIG[2:0] and MEM\_AP\_SIZE [2:0] straps in [Configuration Straps \(p. 37\)](#) for more information.

The memory aperture defines the address range that the CPU can access. The memory-aperture size assigned to the GPU by the system BIOS is different from the physical-memory size that the AMD display driver reports to the operating system and control panel. It does not limit the GPU's ability to use the entire frame-buffer memory at any time. Modern graphics and multimedia applications use drivers to alter the frame-buffer contents—direct manipulation of the frame buffer by the CPU is limited. Therefore, having a memory-aperture size that is smaller than the physical frame-buffer size does not limit performance. The AMD display driver reports the memory size based on the amount of physical VRAM installed on the card rather than the memory-aperture size.

Due to memory-management constraints, the memory-aperture size should be the same as the frame-buffer size for 64 MB, 128 MB, and 256 MB. For frame-buffer sizes larger than 256 MB, the memory-aperture size should be 256 MB. For designs requiring larger than 256 MB aperture size, consult with AMD.

### 2.1.3 Examples of Possible Memory Configurations

The following are examples of possible single-rank memory configurations using different memory types.

**Note:** Not all memories are qualified. Check with your local AMD support person for the latest qualified memory list.

#### 2.1.3.1 GDDR5 SGRAM (Graphics Double Data Rate Synchronous Graphics RAM)

Table 2–1 GDDR5 SGRAM

Size per Part	Configuration	Row × Col × Bank Bits	Total Memory Size (256-bit Interface)
<b>512 Mbit</b>	2 M × 32 × 8	12 × 6 × 3	512 MB
<b>1024 Mbit</b>	2 M × 32 × 16	12 × 6 × 4	1024 MB
<b>2048 Mbit</b>	4 M × 32 × 16	13 × 6 × 4	2048 MB
<b>4096 Mbit</b>	8 M × 32 × 16	14 × 6 × 4	4096 MB
<b>8192 Mbit</b>	16 M × 32 × 16	14 × 7 × 4	8192 MB



## 2.2 Acceleration Features

- Support for DirectX® 12 (Feature Level 12\_0) features, including the full-speed 32-bit floating point per component operation:
  - Shader Model 5.0 geometry and pixel support in a unified shader architecture:
    - Vertex, pixel, geometry, compute, domain, and hull shaders.
    - 32- and 64-bit floating-point processing per component.
    - New advanced shader instructions, including flexible flow control with CPU-level flexibility on branching.
    - A nearly unlimited shader-instruction store, using an advanced caching system.
    - An advanced shader design, with an ultra-threading sequencer for high-efficiency operations.
    - Graphics Core Next supporting native scalar instructions.
    - Advanced, high-performance branching support, including static and dynamic branching.
    - High dynamic-range rendering with floating-point blending, texture filtering, and anti-aliasing support.
    - 16- and 32-bit floating-point components for high dynamic-range computations.
    - Full anti-aliasing on renderable surfaces up to and including 128-bit floating-point formats.
    - A new read/write caching system, replacing texture cache with a unified read-write two-level cache.
- Support for OpenGL 4.5.
- Support for OpenCL™ 2.0.
- Support for Mantle
- Support for AMD LiquidVR™
- Anti-aliasing filtering:
  - 2×/4×/8× MSAA (multi-sample anti-aliasing) modes are supported.
  - A multi-sample algorithm with gamma correction, programmable sample patterns, and centroid sampling.
  - Custom filter anti-aliasing with up to 12-samples per pixel.
  - An adaptive anti-aliasing mode.
  - Lossless color compression (up to 16:1).

- Anisotropic filtering:
  - Continuous anisotropic with 1× through 16× taps.
  - Up to 128-tap texture filtering.
  - Anisotropic biasing to allow trading quality for performance.
  - Improved anisotropic filtering with unified non-power of two-tap distribution and higher precision filter computations.
  - Advanced texture compression (3Dc+™).
  - High quality 4:1 compression for normal and luminance maps.
  - Angle-invariant algorithm for improved quality.
  - Single- or two-channel data format compatibility.
- 3D resources virtualized to a 40-bit virtual addressing space, for support of large numbers of render targets and textures.
- Up to 16k × 16k textures, including 128-bit/pixel texture are supported.
- Programmable arbitration logic maximizes memory efficiency and is software upgradeable.
- Fully associative texture, color, and z-cache design.
- Hierarchical z- and stencil-buffers with early z-test.
- Lossless z-buffer compression for both z and stencil.
- Fast z-buffer clear.
- Fast color-buffer clear.
- Z-cache optimized for real-time shadow rendering.
- Z- and color-compression resources virtualized to a 32-bit addressing space, for support of multiple render targets and textures simultaneously.

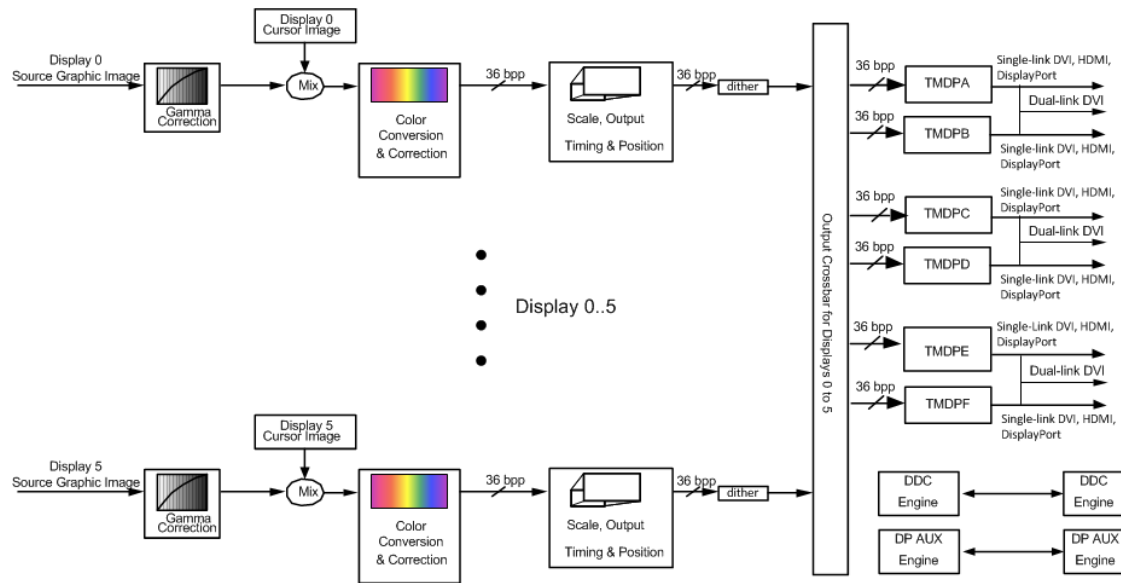
## 2.3 Display System

The display system supports accelerated display modes on up to six independent display controllers.

The full features of the display system are outlined in the following sections.

## 2.3.1 Display Features

Figure 2–1 "Polaris 10" Display Top-level Data-flow Diagram



- Up to six independent display controllers that support up to true 36-bpp (bits per pixel) throughout the display pipe.
- Support for each display output type up to the following display timings:
  - DisplayPort 1.4 (HBR 3):
    - Up to three 5120 × 2880 pixel resolution displays @ 60 Hz refresh rates with dual-cable configuration, or
    - One 5120 × 2880 pixel resolution display @ 60 Hz refresh rates with single-cable configuration, or
    - Up to six 3840 × 2160 @ 60 Hz or six 4096 × 2160 @ 60 Hz displays.
  - HDMI™ 2.0b (6 Gbit/s) up to six 3840 × 2160 @ 60 Hz or six 4096 × 2160 @ 60 Hz outputs
  - Dual-link DVI up to three 2560 × 1600 @ 60 Hz or 1920 × 1200 @ 60 Hz
  - Single-link DVI up to six 1920 × 1200 @ 60 Hz
- Support for up to six independent display timings on DisplayPort, HDMI, or DVI interfaces
- Advanced video capabilities, including high-fidelity gamma, color correction, and scaling for High Dynamic Range (HDR) or Standard Dynamic Range (SDR)
- A high-precision color pipe with the support of sRGB, Rec. 709 and Rec. 2020 color spaces with up to 12 bits/component
- HDR 10 with HDMI 2.0b and DP 1.4 HDR protocol support

- Each display pipe includes a high quality scaler for upscaling lower resolution desktop modes to available display resolutions (RMX) or underscanning for the HDMI output (if needed)
  - All desktop sources up to 4096 pixels/line may be upscaled (RMX)
  - Desktops up to 1920 wide may be underscanned for HDMI
- Support for Virtual Super Resolution (VSR) modes with surface size up to 5120 × 2880 downscaled to 3840 × 2160 @ 60 Hz
- HDCP supported independently and simultaneously on all HDMI, DVI, and DisplayPort outputs

**Note:** HDCP is available only to licensed HDCP licensees and can only be enabled when connected to an HDCP-capable receiver

- Supports HDCP version 1.4/2.2 protection for the HDMI interface
- Supports HDCP version 1.1/2.2 protection for the DisplayPort interface
- Supports HDCP version 1.4 protection for the DVI interface
- Support for Stereo 3D displays through HDMI, DisplayPort, and DVI. Includes frame-sequential and frame-packed full Stereo 3D modes. Also 2D frame-compatible modes including side-by-side, top-and-bottom, line interleaved, and pixel interleaved
- Line or pixel interleave Stereo 3D mixing supported without the use of graphics shaders by using two display pipes for left and right and blending together immediately before the display output; this improves the Stereo 3D performance.

### 2.3.2 DVI/HDMI™/DisplayPort Features

- All TMDP links can be independently configured to any of single-link DVI, HDMI, or DisplayPort (DP)
- TMDPA and TMDPB (links A and B) may be combined to support dual-link DVI
- TMDPC and TMDPD (links C and D) may be combined to support dual-link DVI
- TMDPE and TMDPF (links E and F) may be combined to support dual-link DVI
- See [Table 3-6 \(p. 25\)](#) for more information on the supported display interface combinations
- Optional dithering or frame modulation from the 36-bpp internal display pipeline to 24-bit or 30-bit outputs on the DVI, HDMI, and DisplayPort if not using a 36-bpp output mode

### 2.3.2.1 DVI/HDMI™ Features

- Supports industry-standard CEA-861 video modes including 480p, 720p, 1080i, 1080p, and 2160p. For a full list of currently supported modes, contact your local AMD support representative
- Supports AMD FreeSync™ technology on HDMI using AMD's vendor specific extension:
  - Fully HDMI compliant
  - Requires at least one display that is capable of AMD HDMI FreeSync™ technology
- Maximum pixel rates for 24-bpp outputs are:
  - DVI—165 MP/s (megapixels per second) for single-link DVI
  - DVI—330 MP/s for dual-link DVI
  - HDMI—594 MP/s

Table 2–2 HDMI™ Features

HDMI Feature	Support
<b>Link Capabilities</b>	
<b>Maximum Signal Bandwidth (MHz)</b>	594*
<b>Maximum HDMI Data Bandwidth (Gbit/s)</b>	$3 \times 5.94 = 17.82$
<b>Video Capabilities</b>	
<b>Maximum 2D Resolution</b>	1920 × 1080p @ 144 Hz, 36 bpp 2560 × 1440 @ 100 Hz, 30 bpp 2560 × 1440 @ 144 Hz, 24 bpp 3840 × 2160 @ 60 Hz, 24 bpp 4096 × 2160 @ 60 Hz, 24 bpp 3840 × 2160 @ 30 Hz, 36 bpp 4096 × 2160 @ 30 Hz, 36 bpp
<b>RGB</b>	Yes
<b>YCbCr 4:4:4 / YCbCr 4:2:2 / YCbCr 4:2:0</b>	Yes
<b>xvYCC</b>	Yes
<b>HDMI Deep Color</b>	Yes
<b>Maximum 4:4:4/4:2:2/4:2:0 Color Depth (bits per component)</b>	12
<b>PCM (Pulse-code Modulation) Audio Capabilities</b>	
<b>PCM Audio Rates Supported (kHz)</b>	192, 96, 48, 176.4, 88.2, 44.1, 32
<b>PCM Audio Bits per Sample</b>	24, 20, 16
<b>Maximum PCM Audio Channels</b>	8
<b>Maximum PCM Audio Bandwidth (rate × bits × channels) (Mbps)</b>	36.864
<b>Compressed-audio Capabilities</b>	
<b>Maximum Compressed-audio Bandwidth (Mbps)</b>	24.576
<b>Audio Limits with HDCP (High-Bandwidth Digital Content Protection) Disabled (Applies to compressed and PCM audio)</b>	

HDMI Feature	Support
Maximum Sample Rate without HDCP Limit (kHz)	48
Maximum Bits per Sample without HDCP Limit	16
Maximum Compressed-audio Bandwidth without HDCP Limit (Mbps)	1.536
<b>Specific non-PCM Audio-format Support</b>	
IEC 61937 Compressed-format support. For example, 5.1-channel Dolby DTS and 5.1-channel AC-3.	Yes
Dolby®-TrueHD Bitstream Capable	Yes
DTS-HD Master-audio Bitstream Capable	Yes
DVD-A (DST) Support	No
SACD (DSD) Support	No
<b>Stereo 3D Display Capabilities</b>	
Packed Frame Stereo 3D Video Formats	2160p @ 30/25/24 Hz, 1080p @ 120/100/60/50/30/25/24 Hz, 720p @ 120/100/60/50/30/25/24 Hz
<b>Note:</b> * Applies to direct connections where GPU and HDMI connectors are on the same PCB with maximum trace lengths of 127 mm or 5 inches, otherwise re-driver is needed.	

### 2.3.2.2 DisplayPort (DP) Features

- Supports all the mandatory features of the *DisplayPort Standard Version 1.4* and the following optional features on all links:
  - HBR3 (8.1 Gbps) support
  - ACM packet-type support
  - ISRC packet-type support
  - HDR protocol support
- DisplayPort Multi-streaming Transport (MST) allowing up to four display pipelines to drive a single DisplayPort interface (provided the DisplayPort link bandwidth is not exceeded)
- Supports AMD FreeSync™ technology, which dynamically synchronizes the refresh rate of a display with the frame rate of the GPU:
  - Based on DisplayPort™ Adaptive-Sync technology
  - Requires at least one display that is capable of DisplayPort Adaptive-Sync technology
- Each DisplayPort link can support three options for the number of lanes and four options for link-data rate as follows:
  - Four, two, or one lane(s)
  - 8.1-, 5.4-, 2.7-, or 1.62-Gbps link-data rate per lane

- Supports YCbCr formats in 4:4:4, 4:2:2, and 4:2:0 and 8, 10, and 12 bits/component using Rec. 709 and Rec. 2020
- Supports all video modes supported by the display controller that do not oversubscribe the link bandwidth
  - Example of supported pixel rate/resolution support for four lanes at 8.1-Gbps link rate:
    - $5120 \times 2880$  @ 60 Hz, 24 bpp is supported using VESA timings @ 938.25 MP/sec
    - $3840 \times 2160$  @ 120 Hz, 24 bpp is supported using VESA timings @ 1075.804 MP/sec
  - Examples of supported pixel-rate/resolution for four lanes at 5.4-Gbps link rate:
    - $3840 \times 2160$  @ 60 Hz, 24 bpp or 30 bpp is supported using VESA timings @ 533.25 MP/sec
    - $3840 \times 2160$  @ 60 Hz, 24 bpp or 30 bpp is supported using CEA timings @ 594 MP/sec
    - $4096 \times 2160$  @ 60 Hz, 24 bpp or 30 bpp is supported using CEA timings @ 594 MP/sec
    - $2560 \times 1440$  @ 144 Hz, 24 bpp is supported using CEA timings @ 586.586 MP/sec
  - Examples of supported pixel-rate/resolution for two lanes at 5.4-Gbps link rate:
    - $2560 \times 1600$  @ 60 Hz, 24 bpp or 30 bpp is supported using VESA timings @ 268.5 MP/sec
  - The following table shows the maximum pixel rates for four, two, or one lane(s) at 8.1-GHz link rate.

Table 2–3 Maximum Pixel Rates for 4, 2, or 1 Lane(s) at 8.1-GHz Link Rate

	18 bpp	24 bpp	30 bpp	36 bpp
<b>One Lane</b>	360 MP/s	270 MP/s	216 MP/s	180 MP/s
<b>Two Lanes</b>	720 MP/s	540 MP/s	432 MP/s	360 MP/s
<b>Four Lanes</b>	1080 MP/s	1080 MP/s	864 MP/s	720 MP/s

### 2.3.3 Integrated HD-Audio Controller (Azalia) and Codec

- Each HDMI, DisplayPort, and wireless display output supports HD audio stream independently, up to a maximum of six output streams
- Maximum output bandwidth of 73.728 Mbit/s
- Low power ECN support
- Hardware silent stream for power optimization during no audio periods
- Function level reset
- Compatible Microsoft® UAA driver support for basic audio

- For advanced functionality (as follows), an AMD or a third party driver is required
- LPCM:
  - Speaker formats: 2.0, 2.1, 3.0, 4.0, 5.1, 6.1, and 7.1
  - Sample rates: 32, 44.1, 48, 88.2, 96, 176.4, and 192 kHz
  - Bits per sample: 16, 20, and 24
- Non-HBR compressed audio pass-through up to 6.144 Mbps:
  - Supports AC-3, MPEG1, MP3 (MPEG1 layer 3), MPEG2, AAC, DTS, ATRAC, Dolby Digital+, WMA Pro, and DTS-HD
- HBR compressed audio pass-through up to 24.576 Mbps:
  - Supports DTS-HD Master Audio and Dolby True HD
- Plug-and-Play:
  - Sink audio format capabilities declaration
  - Sink information
  - AV association
- Lip sync information
- HDCP content protection
- DisplayPort supports Global TimeCode using the regular AUX channel—GTC master mode only



## 2.4 Video Acceleration Features

- Video Decode Acceleration Technology:
  - Dedicated Unified Video Decoder hardware (UVD) for H.264, HEVC, VC-1, MPEG-4, MPEG-2, and MVC decode:
    - The H.264 implementation is based on the ISO/IEC 14496-10 specification. Up to HP@L5.1 decoding with a maximum bit rate of 160 Mbps. Support for constrained Baseline profile only (no FMO or ASO). Resolution support up to 4096 × 2160 (maximum 4K @ 60 fps).  
Multi View Coding (MVC) support for Blu-ray 3D content.
    - The HEVC implementation is based on the ISO/IEC 23008-2 specification. Up to Main/Main10 L5.1 decoding with a maximum bit rate of 160 Mbps. Resolution support up to 4096 × 2176 (maximum 4K @ 60 fps). Supports HDR-10 video playback.
    - The VC-1 implementation is based on the SMPTE 421M specification. Up to AP@L3 decoding with a maximum bit rate of 40 Mbit/sec. Resolution support up to 1920 × 1088 (maximum 1080p @ 60 fps).
    - MPEG-4 up to ASP@L5 decoding, supporting high-definition profiles. Sprite, GMC (global motion compensation), and RVLIC (reversible variable length coding) are not supported. Resolution support up to 1920 × 1088 (maximum 1080p @ 60 fps).
    - The MPEG-2 implementation is based on the ISO 13818-2 specification. Up to MP@HL decoding. Resolution support up to 1920 × 1088 (maximum 1080p @ 60 fps).
    - MJPEG implementation is based on the ISO/IEC 10918-1 specification. Supports Baseline (DCT based, interleaved only). JFIF input format, 4:2:0 and 4:2:2 format support. Reference performance is 1080p @ 60 fps. MJPEG decoder can operate concurrently with other video decode or encode operations.
  - Microsoft DirectX Video Acceleration (DXVA) application interface (API) for Windows® operating systems.
- HEVC (H.265) Video Encoding acceleration technology:
  - HEVC encoder is frame interleaved with Video Decoder hardware (UVD) H.264, HEVC, VC-1, MPEG-4, and MPEG-2 decode:
    - HEVC encoding is based on the ISO/IEC 23008-2 specification.
    - Up to main profile @ level 5.0 High-Tier (4096 × 2160p @ 30fps) I and P frame (no B-frame) encode.
    - Multi-stream support with total throughput up to 1080p @ 120 fps.
    - Constant bit rate and variable bit rate rate controls.

- Video processing acceleration:
  - Video scaling and YCrCb to RGB color space conversion for video playback and fully adjustable color controls.
  - Motion Adaptive and Vector based deinterlacing filter eliminates video artifacts caused by displaying interlaced video on non-interlaced displays, and by analyzing image and using optimal deinterlacing function on a per-pixel basis.
  - HD HQV and SD HQV support: noise removal, detail enhancement, color enhancement, cadence detection, sharpness, and advanced deinterlacing.
  - Advanced upscaling of SD content to HD resolution.
  - Multi-planes compositing engine for Blu-ray player applications.
- Supports top-quality DVD and Blu-ray disc playback with the lowest CPU usage.

## 2.5 Video Codec Engine (VCE) Features

- Video encoding technology:
  - Video codec engine (VCE):
    - H.264 encoding is based on the ISO/IEC 14496-10 specification.
    - Up to Main Profile @ level 5.1 (3840 × 2160p @ 30 fps) I & P-frame (no B-frame) encode.
    - Multi-stream support with total throughput up to 1080p @ 120 fps.
    - Wi-Fi Display (WFD) compliant H.264 video encoding, and MPEG-2 transport stream generation, including audio muxing support for LPCM or non-LPCM (AC3/AAC) format audio with two channels up to 48 kHz.
    - HDCP2.0/2.1 encryption of protected content in WFD mode.
    - H.264 Scalable Video Coding (SVC) temporal video encoding.
    - Constant bit rate and variable bit rate rate controls.

## 2.6 PCI Express® Bus Support Features

- Compliant with the PCI Express® Base Specification Revision 3.0, up to 8.0 GT/s.
- Supports ×1, ×2, ×4, ×8, and ×16 lane widths.
- Supports 2.5 GT/s, 5.0 GT/s, and 8.0 GT/s link-data rates.
- Supports ×16 lane reversal where the receivers on lanes 0 to 15 on the graphics endpoint are mapped to the transmitters on lanes 15 down to 0 on the root complex.
- Supports ×16 lane reversal where the transmitters on lanes 0 to 15 on the graphics endpoint are mapped to the receivers on lanes 15 down to 0 on the root complex (requires corresponding support on the root complex).
- Supports full-swing and low-swing transmitter output levels.

## 2.7 Power Management Features

- Single-chip solution in 14 nm.
- Full ACPI 1.0b, OnNow, and IAPC (instantly available PC) power management.
- Intelligent power control through AMD PowerTune technology.
- Clocks to every major functional block are controlled by a unique dynamic clock-switching technique which is completely transparent to the software. By turning off the clock to a block that is idle or not in use, power consumption is significantly reduced during normal operation.
- Dynamic Power Management (DPM) defines multiple power levels (up to eight) to achieve best overall performance and idle power.

## 2.8 Spread-spectrum Support

### 2.8.1 Engine and Memory Spread-spectrum Support

- Internal engine and memory spread-spectrum support:
  - Internal engine spread-spectrum support programmable from 0% to 2% down spread with modulation frequencies from 30 kHz to 33 kHz.
  - Internal memory spread-spectrum support programmable from 0% to 1.25% down spread with modulation frequencies from 30 kHz to 33 kHz.
- External memory spread-spectrum support:
  - For GDDR5 memory, the external spread-spectrum clock is not supported. Only internal spread spectrum is supported for GDDR5 memory.

### 2.8.2 DisplayPort Internal Spread-spectrum Support

- From 0.25% to 0.5% down spread.
- Modulation frequency between 30 kHz and 33 kHz.

## 2.9 Internal Thermal Sensor

"Polaris 10" has an integrated thermal sensor that offers the following advantages:

- Provides GPU die temperature (accuracy  $\pm 3^{\circ}\text{C}$ ) without the need for an external chip.
- High- and low-notification limits can be defined to generate interrupts and to change power states.
- Can be used to control a fan through PWM (see [Table 3-17 \(p. 34\)](#)).
- A critical temperature limit can be defined to allow the system to protect the GPU from damage (see GPIO\_19\_CTF).
- Temperature information can be provided through software (ACPI control methods) or directly through the SMBus hardware interface.

## 2.10 Thermal Diode

The thermal diode is a grounded collector PNP BJT. The thermal diode has two pins for its interface—DPLUS and DMINUS (see [Table 3-17 \(p. 34\)](#)). DPLUS connects to the emitter of the BJT while DMINUS connects to its base. The collector is tied to substrate ground.

**Note:**

- The thermal diode can only be used when the GPU is powered; for example, it cannot be used when in D3 cold. The 1.8-V supply has to be active for temperature sensing to work.
- The ideality factor of the on-die thermal diode varies significantly with temperature and sourcing current. If a design chooses to use the on die thermal diode of the GPU coupled with an external thermal sensor chip to read the GPU temperature, the external thermal sensor chip must support and enable beta compensation.

## 2.11 Logo Compliance

This product complies with the Windows Logo Program requirements for all target operating systems. This includes both the current logo and future (draft) requirements that will be enforced during the lifespan of the product.

## 2.12 Test Capability Features

"Polaris 10" has a variety of test modes and capabilities that provide a high-fault coverage and low-DPM (defect per million) ratio:

- Full-scan implementation on the digital core logic which provides high-fault coverage through ATPG (automatic test-pattern generation) vectors.
- Dedicated test logic for the on-chip custom memory macros to provide complete coverage on these modules.
- JTAG (Joint Test Action Group) test mode, largely compliant with the IEEE 1149.1 standard, with internal scan chain for access to chip-level test functions and some board-level connectivity testing.
- Integrated hardware-diagnostic tests performed automatically upon initialization.
- Improved access to analog modules and PLLs to allow full evaluation and characterization of these modules.

## 2.13 Other Features

- Support for serial-ROM video BIOS.
- Support for 32- and 64-bit operating systems based on Intel, AMD, and PowerPC CPUs.

## 2.14 Export Control Classification

For information on the export control classification of this product, please contact [dl.exportcontrol@amd.com](mailto:dl.exportcontrol@amd.com).



## Signal Descriptions

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This section describes the signals of "Polaris 10".

**The following conventions are used:**

- All active low signals are shown with the suffix "B", such as CASA0B.
- "PD" denotes a permanent internal pull down. "PD-register" denotes an internal pull down which is register controlled, and by default is turned off. "PD-reset" denotes an internal pull down which is register controlled, and by default is turned on. "PD-reset" also denotes that the internal pull down is active during reset. "PD" or "PD-reset" is not relevant when the pins are in output modes.
- To designate a group of pins that have the same pin name but are distinguished by a trailing number only, such as QSA\_0, QSA\_1, or QSA\_2, the abbreviation "Pin name[y:x]" is used. For example, QSA\_[7:0] means pins QSA\_7 to QSA\_0.
- In the "Polaris 10" pin assignment:
  - NC or NC\_\*: Pins marked as NC are free pins that have no electrical connection on the GPU package.
  - RSVD: These pins should float (i.e., no electrical connection) on the PCB.

To go to a topic of interest, use the following list of linked cross-references:

- [Pin Assignments \(p. 20\)](#)
- [PCI Express® Bus Interface \(p. 21\)](#)
- [Memory Interface \(SGRAM, SDRAM\) \(p. 23\)](#)
- [Display Configuration Overview \(p. 24\)](#)
- [Integrated HDMI™/TMDS Interface \(p. 25\)](#)
- [DisplayPort \(p. 26\)](#)
- [Hardware I2C Interface \(p. 28\)](#)
- [Serial Flash Interface \(p. 28\)](#)
- [General Purpose I/O Interface \(p. 28\)](#)
- [AMD SVI2 Master Interface \(p. 31\)](#)
- [Global Swap Lock on Multiple GPUs \(p. 31\)](#)
- [Display Identification Interface \(p. 32\)](#)
- [JTAG Interface \(p. 33\)](#)
- [Debug Port \(p. 34\)](#)
- [Thermal Information and Management Interface \(p. 34\)](#)
- [SMBus Interface \(p. 35\)](#)

- PLL Interface (p. 36)
- AMD PowerXpress Interface (p. 36)
- Power and Ground Descriptions and Operating Conditions (p. 37)
- Configuration Straps (p. 37)

## 3.1 Pin Assignments

Table 3–1 Pin Assignment - Left Half

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
A		VSS	DQB1_3 1		DDBI1_3	VSS		WCKB1_3	DQB1_2 1		VSS	EDCB1_2		DQB1_8	VSS		DQB0_2 1	EDCB0_2	VSS	DQB0_1 7		WCKB0_1
B	VSS	VSS		DQB1_3 0	EDCB1_3	DQB1_2 7		VSS	WCKB1B 1		DQB1_2 1	VSS	DQB1_2 2	DQB1_1 9	DQB1_1 6		VSS	DQB0_2 9	DQB0_1 9	VSS	WCKB0B 1	
C	DQCO_0			DQB1_2 9	VSS	DQB1_2 6		DQB1_2 4	VSS		DQB1_2 2	DDBI1_2		VSS	DQB1_1 7		DQB0_2 2	VSS	DDBI0B 2	DQB0_1 6	VSS	DQB0_3 1
D		DQCO_1	DQCO_2		DQB1_2 8	VSS		DQB1_2 5	EDCB1_1		VSS	DQB1_2 0		DQB1_6	VSS		DQB0_2 3	DQB0_1 5	VSS	DDBI0B 8	DQB0_1 1	DQB0_8
E	DDBI0_0		EDCC0_0	VSS	DQCO_3	VSS	VMEMIO		VSS	DQB1_1 2		DQB1_9	VMEMIO	DQB1_7	EDCB1_0		VMEMIO	DQB0_1 4	DQB0_1 2	VMEMIO	DQB0_8	
F	VSS	DQCO_4	DQCO_5	VSS	VMEMIO	VSS		DQB1_1 5	VSS		DQB1_1 0	WCKB1_0		VSS	DQB1_4		DQB1_2	VSS	DQB0_1 3	DQB0_1 1	VSS	
G								DQB1_1 3			VMEMIO	WCKB1B 0		CLKB1B	VMEMIO		DQB1_3	DQB1_0	VMEMIO	DQB0_1 0	WCKB0_0	
H	WCKCO_0	VSS	DQCO_7	DQCO_6	VSS	DQCO_1 6		VSS	DQB1_1 4		DQB1_1 1	VSS		CLKB1	DQB1_5		VSS	DQB1_1	DDBI0_1	VSS	WCKB0B 0	
J	DQB0_8	WCKCOB 0	VSS	EDCC0_9	DQCO_1	VSS	DQCO_1 8	DQCO_1 7	VSS		DDBI1_1	DQB1_8		VMEMIO	MAB1_5		DDBI1_0	VMEMIO	EDCB0_1	DQB0_9	VSS	
K												CSB1B_0		MAB1_9	VSS		MAB1_1	MAB1_7	VSS	RASB0B	CASB0B	
L	VSS	DQCO_1 0	DQCO_9	VSS	DQCO_2 2	DQCO_2 1	VSS	DQCO_2 0	DDBI0_2		VSS	VSS		VSS	MAB1_4		VMEMIO	MAB1_8	ADBI1	VMEMIO	ADBI0	
M	EDCC0_1	VSS	DDBI0_1	DQCO_1	VMEMIO	WCKCO_1	WCKCOB 1	VSS	DQCO_2 3		CSC0B_0	VSS	VMEMIO		DRAM_R STB	WEB1B		MAB1_3	VSS	CASB1B	RASB1B	VSS
N																VMEMIO		MAB1_2	MAB1_0	VMEMIO	CKEB1	CKEB0
P	DQCO_1 3	DQCO_1 2	VSS	DQCO_2 5	DQCO_2 4	VSS	CLKCOB	CLKCO	VSS	MAC0_9	VSS	DRAM_R STC		VMEMIO	MEM_CA LRB		VSS	VSS	MAB1_6	MVREFD B	VDDCI	
R	VSS	DQCO_1 5	DQCO_1 4	VSS	EDCC0_7	DQCO_2	VMEMIO	DQCO_2 6	MAC0_5	VSS	MAC0_4	WEC0B	VMEMIO	MEM_CA LRC	VSS	VDDCI	VSS	VDDCI	VDDCI	VDDCI	VSS	VSS
T																VDDCI	VDDC	VDDC	VSS	VSS	VDDC	VSS
U	DQCO_1 0	VSS	DQC1_9	DQC1_8	VMEMIO	DQCO_2 9	DQCO_2 8	VSS	DDBI0_3	MAC0_1	VMEMIO	MAC0_3	MAC0_2	VSS	VSS	VDDC	VDDC	VSS	VSS	VDDC	VDDC	VSS
V	EDCC1_1	DQC1_1	VSS	DQC1_1 6	DQC1_1 7	VSS	DQCO_3 0	DQCO_3 0	VMEMIO	MAC0_7	MAC0_8	VSS	MAC0_0	TEST6	VDDCI	VDDC	VDDC	VSS	VSS	VDDC	VDDC	VSS
W	VSS	DQC1_1	DDBI1_1	VSS	DQC1_1 9	DQC1_1 8	VMEMIO	DDBI1_2	EDCC1_2	VSS	ADBI0	CASC0B	VMEMIO	MAC0_6	VDDCI	VDDC	VDDC	VSS	VSS	VDDC	VDDC	VSS
Y	DQC1_1	VSS	DQC1_1 5	DQC1_1 3	VSS	DQC1_0	DQC1_2 1	VSS	DQC1_2 2	RASC1B	VMEMIO	RASC0B	CKEC0	MVREFD C	VDDCI	VDDC	VDDC	VSS	VSS	VDDC	VDDC	VSS
AA	WCKC1_0	WCKC1B 0	VSS	DQC1_0	DQC1_3	VSS	WCKC1_1	WCKC1B 1	VSS	CASC1B	ADBI1	VSS	CKEC1	VDDCI	VSS	VDDC	VDDC	VSS	VSS	VDDC	VDDC	VSS
AB															VSS	VDDC	VDDC	VSS	VSS	VDDC	VDDC	VSS
AC	DQC1_2	DQC1_1	VSS	DQC1_2 6	DQC1_2 5	VSS	DQC1_2 4	MAC1_0	VMEMIO	MAC1_8	MAC1_7	VSS	MAC1_6	VDDCI	VSS	VDDC	VDDC	VSS	VSS	VDDC	VDDC	VSS
AD	DQC1_3	VSS	DDBI1_0	EDCC1_0	VSS	EDCC1_3	DDBI1_3	VSS	DQC1_2 7	MAC1_2	VMEMIO	MAC1_3	MAC1_1	VSS	VDDCI	VDDC	VDDC	VSS	VSS	VDDC	VDDC	VSS
AE	VSS	DQC1_5	DQC1_4	VSS	DQC1_3 0	DQC1_3 9	VMEMIO	DQC1_2 8	WEC1B	VSS	MAC1_4	MAC1_5	VMEMIO	MVREFD D	VDDCI	VDDC	VDDC	VSS	VSS	VDDC	VDDC	VSS
AF	DQC1_7	DQC1_6	VSS	DQD0_2	DQD0_1	VSS	DQD0_0	VSS	VMEMIO	DQC1_3 1	CSC1B_0	VSS	CLKC1B	CLKC1	VDDCI	VDDC	VDDC	VSS	VSS	VDDC	VDDC	VSS
AG	DQD0_1 6	VSS	DQD0_1 7	DQD0_1 8	VMEMIO	DQD0_3	EDCC0_0	VSS	MAC1_9	VSS	VMEMIO	CSD0B_0	MAD0_9	VSS	VSS	VDDCI	VDDC	VSS	VSS	VDDC	VDDC	VSS
AH																VDDCI	VSS	VDDCI	VDDC	VDDC	VDDC	VDDC
AJ	VSS	DQD0_1 9	EDCC0_2	VSS	DQD0_5	DQD0_4	VMEMIO	DDBI0_0	DQD0_6	VSS	CLKD0B	CLKD0	VMEMIO	VSS	VSS	VDDCI	VSS	VDDCI	VDDC	VDDC	VDDC	VDDC
AK	DDBI0_2	DQD0_2	VSS	WCKD0_0	WCKD0B 0	VSS	DQD0_7	WED0B	VMEMIO	MAD0_4	MAD0_5	VSS		VMEMIO	VSS		VSS	VSS	DRAM_R STD	VSS	FB_VSS	
AL															VMEMIO		MAD1_8	MAD1_2	VMEMIO	MEM_CA LRD	FB_VDD	
AM	DQD0_3	VSS	DQD0_2 2	DQD0_2 1	VMEMIO	DQD0_9	DQD0_8	VSS	MAD0_2	MAD0_3	VSS	MAD0_1		VSS	CASD1B		MAD1_0	VSS	CLKD1	DRAIN	GATE	
AN	VSS	WCKD0_1	WCKD0B 1	VSS	DQD0_1 1	DQD0_1 0	VMEMIO	MAD0_0	MAD0_8		MAD0_7	VSS		RASD1B	MAD1_6	VMEMIO	MAD1_5	CLKD1B	VMEMIO	DBGDAT A_10		
AP													CKED0		CKED1	VSS		MAD1_1	WED1B	VSS	CSD1B_0	DBGDAT A_11
AR	DQD0_4	DQD0_2 4	VSS	EDCC0_1	DDBI0_1	VSS	DQD0_1 2	MAD0_6	VSS	CASD0B	RASD0B	VMEMIO	MAD1_7		MAD1_3	VMEMIO	MAD1_9	DBGDAT A_5	DBGDAT A_15			
AT	DQD0_2 6	VSS	DQD0_2 7	DDBI0_3	VSS	DQD0_1 3		DQD0_1 4	ADBI0		DQD1_7	VSS		ADBI1	DQD1_1 2		VSS	MAD1_4	DBGDAT A_2	DBGDAT A_6	VSS	
AU										DQD1_4	VMEMIO	DQD1_8		DQD1_1 0	VMEMIO		DQD1_1 4	VSS	VSS	DBGDAT A_9	DBGDAT A_14	
AV	VSS	EDCC0_8	DQD0_2	VSS	DQD0_1 5	VSS		EDCC1_0	VSS	WCKD1B 0	DQD1_9	VSS		DQD1_1 3	EDCC1_1		DQD1_1 5	DBGDAT A_0	DBGDAT A_3	VSS	DBGDAT A_13	
AW	DQD0_2 9	VSS	DQD0_1	DQD1_1	VSS	DDBI0_1		VSS	DQD1_5		WCKD1_0	VMEMIO		DQD1_1 1	EDCC1_1		VMEMIO	DBGDAT A_1	DBGDAT A_4	DBGDAT A_8	DBGDAT A_12	
AY		DQD0_3	VSS		DQD1_3	VSS		DDBI1_2	DQD1_6	VSS	DQD1_2 4			DDBI1_1	VSS		DQD1_2 9	VSS	VSS	DBGDAT A_7	TXCEM DPE3N	
BA	DQD0_3 1			VSS	DQD1_2	DQD1_1 9		DQD1_2 0	VSS		WCKD1B 5	DQD1_2 5		VSS	EDCC1_3		DQD1_3 0	VSS	TXOM_D F2P	TXOP_DP F2P	TX2M_D PF0N	
BB	VSS	VSS		DQD1_6	VSS	EDCC1_2		VSS	DQD1_2 7		WCKD1_1	VSS		DQD1_2 7	DQB1_2 8		VSS	VSS	TXCFM DPF3N	TX1P_DP F1M	TX2M_D PF0N	
BC		VSS	DQD1_1	DQD1_1 8	VSS			DQD1_2 1	DQD1_2	VSS	DQD1_2 6		VSS	DDBI1_3	VSS		DQD1_3 1	VSS	TXCFP_D PF3P	TX1P_DP F1M	TX2P_DP F0P	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22



Table 3–2 Pin Assignment - Right Half

23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43		
DOB0_29	DOB0_28	VSS	DOB0_24	DOA0_2_5		VSS	DOBIA1_1		DOA1_8	VSS		DOA1_7	DOA1_5		VSS	DOA1_2		DOA1_0	VSS		A	
DOB0_30	VSS	DOB0_27	DOB0_2_5	VSS		DOA1_1_2	DOA1_1_1		VSS	WCKA1_0		DOA1_6	VSS		EDCA1_0	VSS	DOA1_1		VSS	VSS	B	
VSS	DOBIB0_3	DOBIB0_6	VSS	DOA1_1_4		EDCA1_1	VSS		DOA1_9	WCKA1B_0		VSS	DOA1_4		DOA1_3_1	VSS				DOA0_1_4	C	
DOB0_5	EDCB0_3	VSS	DOA1_2_3	DOA1_1_9		VSS	WCKA1_1		DOA1_1_0	VSS		EDCA1_2	DOBIA1_0		VSS	DOA0_3_0		VSS	DOA0_1_5		D	
DOB0_6	VSS	DOB0_1	DOA1_3_0	VMEMIO		DOA1_2_6	WCKA1B_1		VMEMIO	DOA1_2_0		DOBIA1_2	VSS		DOA1_1_6	VSS	DOA0_2_8	DOA0_2_9	VSS	DOA0_1_3	E	
VSS	EDCB0_0	DOB0_2	VSS	DOA1_2_8		DOA1_2_7	VSS		DOA1_2_2	DOA1_2_1		VSS	DOA1_1_8		VSS	DOBIA0_3	VSS	DOA0_1_2		EDCA0_1	VSS	F
DOB0_7	DOBIB0_0	VMEMIO	DOA1_3_1	EDCA1_3		VMEMIO	DOA1_2_4		DOA1_2_3	VMEMIO		DOA1_1_9										G
MAB0_0	VSS	DOB0_3	VSS	VSS		DOBIA1_3	WEA1B		VSS	MAA1_0		MAA1_6	DOA1_1_7		EDCA0_3	VSS	DOBIA0_1	DOA0_1_1	VSS	DOA0_1_0	H	
VMEMIO	DOB0_4	WEA0B	VMEMIO	MAB0_9		DOA1_2_5	VMEMIO		MAA1_2	MAA1_8		VSS	ADBIA1_7	DOA0_2_7	VSS	DOA0_2_6	DOA0_2_5	VSS	DOA0_9	DOA0_8	I	
MAB0_8	MAB0_2	VSS	DOB0_0	VSS		VSS	MAA1_4		MAA1_3												J	
MAB0_7	VMEMIO	MAB0_4	CSB0B_0	VMEMIO		CLKA1B	MAA1_5		VSS	MAA1_7		CASA1B	DOA0_2_4	VMEMIO	WCKA0B_1	WCKA0_1	VSS	WCKA0B_0	WCKA0_0	VSS	K	
VSS	MAB0_3	MAB0_5	VSS	CSA1B_0		CLKA1	VSS		MAA1_1	VSS	CKEA1	RASA1B	VSS	DOA0_2_3	DOA0_2_2	VMEMIO	DOA0_7	DOA0_6	VSS	DOA0_5	L	
MAB0_6	MAB0_1	VMEMIO	CLKB0B	MAA1_9		VMEMIO															M	
VDDCI	VSS	MVREFD_A	CLKB0	VSS		VSS	VMEMIO		VSS	RASA0B	CKEA0	VMEMIO	ADBIA0_1	DOA0_2_1	VSS	DOA0_2_2	DOBIA0_0	VSS	DOA0_4_0	DOBIA0_0	N	
VSS	VDDCI	VDDCI	VDDCI	VSS	VDDCI	VSS	VSS	VMEMIO	CASA0B	MAA0_6	VSS	MAA0_7	DOA0_1_9	VMEMIO	DOA0_1_8	EDCA0_2	VSS	EDCA0_0	DOA0_3	VSS	P	
VSS	VDDC	VDDC	VSS	VDDCI	VSS	VDDCI															T	
VSS	VDDC	VDDC	VSS	VSS	VDDCI	VSS	VSS	MAA0_8	MAA0_0	VMEMIO	MAA0_1	MAA0_3	VSS	DOA0_1_7	DOA0_1_6	VMEMIO	DOA0_2	DOA0_1	VSS	DOA0_0	U	
VSS	VDDC	VDDC	VSS	VSS	VDDC	VDDCI	VSS	MAA0_2	VSS	MAA0_5	WEA0B	VMEMIO	MAA0_4	VSS	GPIO_1	GPIO_0	PX_EN	GPIO_13	GPIO_12	GPIO_11	V	
VSS	VDDC	VDDC	VSS	VSS	VDDC	VDDC		DRAM_RSTA	VMEMIO	CLKA0	CLKA0B	VSS	MAA0_9	VSS	GPIO_2	VSS	VSS	VSS	PCIE_RX_15P	PCIE_RX_15N	W	
VSS	VDDC	VDDC	VSS	VSS	VDDC	VSS		MEM_CA_LRA	TEST_PG_BAC0	VMEMIO	CSA0B_0	VSS	VSS	VSS	PCIE_TX_15P	PCIE_TX_15N	VSS	PCIE_RX_13N	PCIE_RX_14N	PCIE_RX_14P	Y	
VSS	VDDC	VDDC	VSS	VSS	VDDC	VSS		TS_A	TEST_PG	VSS	VSS	VDD_08	VDD_08	VSS	PCIE_TX_13N	PCIE_TX_14N	PCIE_TX_14P	VSS	PCIE_RX_13P	PCIE_RX_12P	PCIE_RX_12N	AA
VSS	VDDC	VDDC	VSS	VSS	VDDC	VSS															AB	
VSS	VDDC	VDDC	VSS	VSS	VDDC	VSS		JTAG_TR_STB	GPIO_19_CTF	VSS	VSS	DMINUS	DPLUS	VSS	PCIE_TX_13P	PCIE_TX_12P	PCIE_TX_12N	VSS	VSS	PCIE_RX_11N	PCIE_RX_11P	AC
VSS	VDDC	VDDC	VSS	VSS	VDDC	VSS		JTAG_TD0	JTAG_TD5	VSS	DDCVGA_DATA	DDCVGA_CLK	VSS	VDD_08	VSS	PCIE_TX_11N	PCIE_TX_11P	VSS	PCIE_RX_9N	PCIE_RX_10N	PCIE_RX_10P	AD
VSS	VDDC	VDDC	VSS	VSS	VDDC	VSS		TESTEN	JTAG_TM5	VSS	GPIO_17_THERM_INT	GPIO_6_TACH	VDD_08	VSS	PCIE_TX_9N	PCIE_TX_10N	PCIE_TX_10P	VSS	PCIE_RX_9P	PCIE_RX_8P	PCIE_RX_8N	AE
VSS	VDDC	VDDC	VSS	VSS	VDDC	VSS		JTAG_TC_K	GPIO_28_FDO	VSS	SDA	SCL	VDD_08	VSS	PCIE_TX_9P	PCIE_TX_8P	PCIE_TX_8N	VSS	VSS	PCIE_RX_7N	PCIE_RX_7P	AF
VSS	VDDC	VDDC	VSS	VSS	VDDC	VSS		GPIO_30	GPIO_29	VSS	TEMPIN0	TEMPINR	VSS	VDD_08	VSS	PCIE_TX_7N	PCIE_TX_7P	VSS	PCIE_RX_5N	PCIE_RX_6N	PCIE_RX_6P	AG
VDDC	VDDC	VDDC	VDDC	VDDC	VDDC	VSS	VDD_08	GPIO_15	VSS	GPIO_16_8P_DETECT	GPIO_5_REG_HO_T_AC_BATT	VDD_08	VSS	PCIE_TX_5N	PCIE_TX_6N	PCIE_TX_6P	VSS	PCIE_RX_5P	PCIE_RX_4P	PCIE_RX_4N		AJ
FB_VDDCI	VSS	DIGON	BL_ENABLE	VSS		VSS	PCIE_ZVSS		VSS	GPIO_20	GPIO_21	VDD_08	VSS	PCIE_TX_5P	PCIE_TX_4P	PCIE_TX_4N	VSS	VSS	PCIE_RX_3N	PCIE_RX_3P		AK
VSS	VDD_33	VSS	BL_PWM_DIM	GENLK_VSYNC		VSS																AL
GPIO_SVC	VDD_33	VDD_18	VSS	GENLK_CLK		PLLCHAR_Z_H	GPIO_10_ROMSC_K		VSS	SMBDAT	SMBCLK	VSS	VDD_08	VSS	PCIE_TX_3N	PCIE_TX_3P	VSS	PCIE_RX_1N	PCIE_RX_2N	PCIE_RX_2P		AM
GPIO_SVT	VSS	VDD_18	VDD_18	VSS		PLLCHAR_Z_L	GPIO_8_ROMSO		GPIO_22_ROMCS_B	VSS		VDD_08	VSS	PCIE_TX_1N	PCIE_TX_2N	PCIE_TX_2P	VSS	PCIE_RX_1P	PCIE_RX_0P	PCIE_RX_0N		AN
GPIO_SVD	HSYNC	VSS	VDD_18	VDD_18		VSS	VSS		GPIO_9_ROMSI													AP
DDC1DATA	VSYN	SWAPLO_CKB	TSVDD	VDD_18		GPIO_14_HPD2	GENERIC_D		VSS	VSS		VSS	VSS	PCIE_TX_1P	PCIE_TX_0P	PCIE_TX_0N	VSS	VSS	PCIE_RE_FCLKP	PCIE_RE_FCLKN		AR
DDC1CLKB	GENERIC_CKA	SWAPLO_CKA	VSS	VSS		GPIO_18_HPD3	GENERIC_C		HPD1	DDCAUX_4N		VSS	DP_ZVD_08		VSS	VSS	VSS	VSS	VSS	VSS		AT
VSS	VSS	VSS	DDC2CLK	DDCAUX_3P		GENERIC_E_HPD4	GENERIC_F_HPD5		GENERIC_G_HPD6	DDCAUX_4P		DDCAUX_5P										AU
AUX1P	BP_1	AUX2P	DDC2DATA	DDCAUX_3N		VSS	VSS		VSS	VSS		DDCAUX_5N	DP_ZVSS		VSS	VSS	VSS	CLKREQ_B	PERSTB	WAKEB		AV
AUX1N	BP_0	AUX2N	VSS	VSS		VSS	VSS		VSS	VSS		VSS	VSS		VSS	VSS	GENERIC_A	VSS	ANALOG_OUT	VSS		AW
TXCEP_DS	AUX_ZVS	VSS	TX1M_D_P01N	TX1P_DP_D1P		TX3M_D_PC2N	TX3P_DP_C2P		TXCBM_DPB3N	TXCBP_DP_P83P		TX2M_D_P80N	TX2P_DP_B0P		TX4M_D_PA1N	TX4P_DP_A1P		VSS	XTALOUT			AY
VSS	TX5M_D_P00N	TX5P_DP_E0P	VSS	VSS		VSS	VSS		VSS	VSS		VSS	VSS		VSS	VSS	VSS			XTALIN		BA
TX3P_DP_E2P	TX4M_D_P01N	TXCDP_DP03P	TX0M_D_P02N	TX2P_DP_D0P		TXCCM_DPC3N	TX4P_DP_C1P		TX5M_D_PC0N	TX0P_DP_B2P		TX1M_D_P81N	TXCAP_DP_PA3P		TX3M_D_PA2N	TX5P_DP_A0P		DDCAUX_6N		VSS	VSS	BB
TX3M_D_P02N	TX4P_DP_E1P	TXCDM_DP03N	TX0P_DP_D02P	TX2M_D_P00N		TXCCP_DP03P	TX4M_DP_C1N		TX5P_DP_PC0P	TX0M_DP_B2N		TX1P_DP_DP81P	TXCAM_DPA3N		TX3P_DP_A2P	TX5M_DP_PA0N		DDCAUX_6P	VSS			BC
23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43		

## 3.2 PCI Express® Bus Interface

For more information on signal definitions and electrical requirements, refer to the *PCI Express® Card Electromechanical 3.0 Specification* and *PCI Express Base 3.0 Specification*.

**Note:**

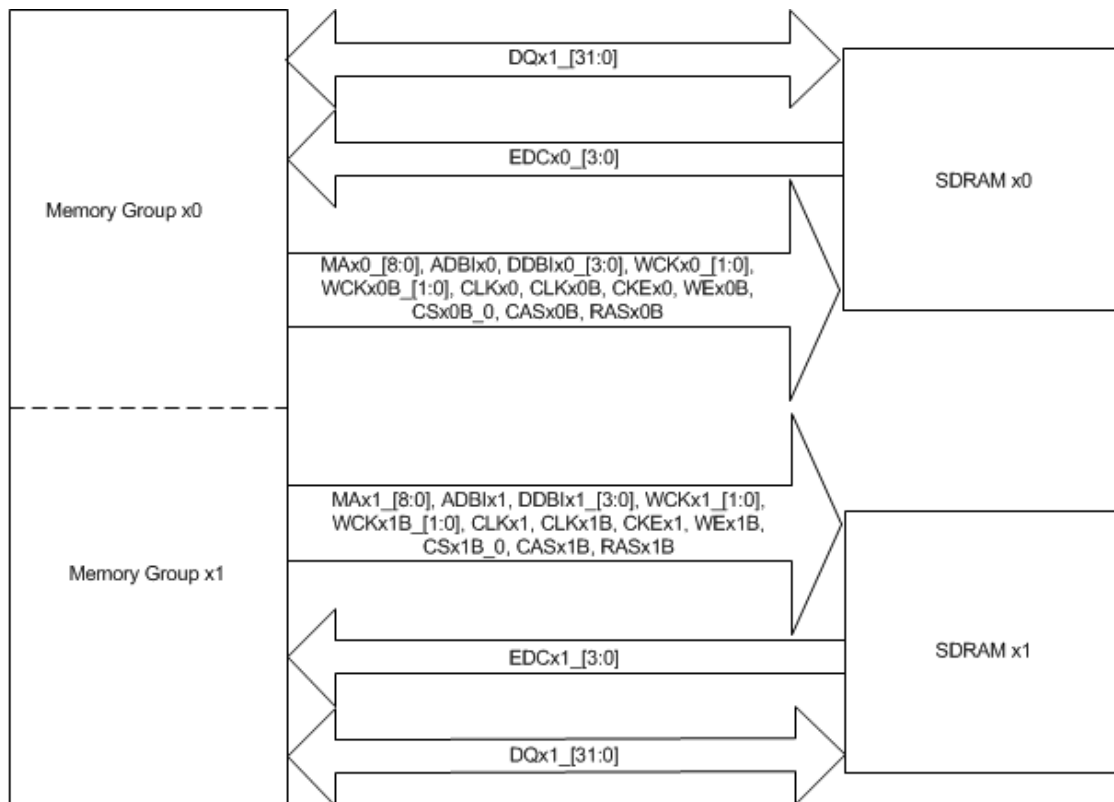
- "Polaris 10" supports  $\times 16$  lane reversal, where the receivers on lanes 0 to 15 of the graphics endpoint are mapped to the transmitter on lanes 15 down to 0 of the root complex. If  $\times 16$  lane reversal is employed, both the receive and transmit lanes must be reversed. In addition, polarity inversion is supported, such as when the + of the differential pair is connected to the - at the root complex.
- 220-nF AC-coupling capacitors are required.

Table 3–3 PCI Express® Bus Interface

Pin Name	I/O	Description
PERSTB	I	Fundamental reset. 3.3-V tolerant pad. This signal must be asserted during any fundamental reset event, such as power up, warm boot, reset button pressed, CTL-ALT-DEL, Windows restart, or wake from D3. A buffered reset signal dedicated to the GPU is required.
PCIE_REFCLKP/N	I	PCI Express PLL differential reference clock (+/-). 100-MHz ( $\pm 300$ ppm) input frequency; 0-V to 0.7-V single-ended swing.
PCIE_TX[15:0]P/N	O	PCI Express transmitter output data channel TX[15:0] (+/-). Differential serial data transmitted up to 8.0-GT/s bit rate.
PCIE_RX[15:0]P/N	I	PCI Express receiver input data channel RX[15:0] (+/-). Differential serial data received up to 8.0-GT/s bit rate.
PCIE_ZVSS	I	Connect to VSS through a 180 $\Omega$ (1% tolerance) resistor.
CLKREQB	I/O	CLKREQB only: CLKREQB is an open drain output on the GPU and an input on the platform which can be used to request the PCIe® reference clock to GPU on or off. L1 PM Substates: CLKREQB is a bi-directional open drain that can be asserted by either the GPU or the platform to initiate an L1 exit.
WAKEB	I	WAKEB is used as an input for the PCIe Optimized Buffer Flush/Fill (OBFF) feature. OBFF serves as a mechanism for the platform to tune power management (PM), and to align device activities. The signaling on WAKEB helps to tell the system status (CPU active or idle). The PCIe device will respond to this information to control its upstream traffic. Support from the platform is required.

### 3.3 Memory Interface (SGRAM, SDRAM)

Figure 3–1 Memory Interface



**Note:**

- A lower-case "x" is used to represent any of the available primary 64-bit-wide memory channels. "Polaris 10" uses memory groups A, B, C, and D.
- A "0" or "1" after "x" is used to separate the 64-bit-wide memory channel into two 32-bit wide sub-channels.
- "Polaris 10" supports GDDR5 memory with the mapping shown in [Table 3–5 \(p. 24\)](#).

Table 3–4 Memory Interface

Pin Name	Type	Description
<b>MEM_CALRx</b>	I	Connect to VSS through a 120-Ω (± 0.5%) resistor. Preferred resistor tolerance is 0.5%, but 1% is acceptable.
<b>DQx0_[31:0]</b>	I/O	Memory data bus for channel x0.
<b>DQx1_[31:0]</b>	I/O	Memory data bus for channel x1.
<b>MAx0_[9:0]</b>	O	Memory address bus for channel x0. Supplies bank addresses and row/column addresses for one 32-bit interface.
<b>MAx1_[9:0]</b>	O	Memory address bus for channel x1. Supplies bank addresses and row/column addresses for one 32-bit interface.
<b>EDCx0_[3:0]</b>	I	Error detection pins.
<b>EDCx1_[3:0]</b>	I	Error detection pins.
<b>ADBIx0</b>	O	Address dynamic bus inversion for channel x0.

Pin Name	Type	Description
<b>ADBIx1</b>	O	Address dynamic bus inversion for channel x1.
<b>DDBIx0_[3:0]</b>	I/O	Data dynamic bus inversion.
<b>DDBIx1_[3:0]</b>	I/O	Data dynamic bus inversion.
<b>WCKx0_[1:0]</b> <b>WCKx0B_[1:0]</b>	O	Forwarded clock.
<b>WCKx1_[1:0]</b> <b>WCKx1B_[1:0]</b>	O	Forwarded clock.
<b>CLKx0</b> <b>CLKx0B</b>	O	Differential memory clock for channel x0.
<b>CLKx1</b> <b>CLKx1B</b>	O	Differential memory clock for channel x1.
<b>CKEx0</b>	O	Clock enable control for channel x0.
<b>CKEx1</b>	O	Clock enable control for channel x1.
<b>WEx0B</b>	O	Write enable for channel x0.
<b>WEx1B</b>	O	Write enable for channel x1.
<b>CSx0B_0</b>	O	Chip select for channel x0.
<b>CSx1B_0</b>	O	Chip select for channel x1.
<b>CASx0B</b>	O	Column address strobe for channel x0.
<b>CASx1B</b>	O	Column address strobe for channel x1.
<b>RASx0B</b>	O	Row address strobe for channel x0.
<b>RASx1B</b>	O	Row address strobe for channel x1.
<b>MVREFDx</b>	A-I	Reference voltage per channel (memory data). $0.7 \times V_{MEMIO}$ .
<b>DRAM_RSTx</b>	O	Reset for all populated DRAMs (active low).

Table 3–5 GDDR5 Memory Mapping

GPU Signal	MAA0_9	MAA0_8	MAA0_7	MAA0_6	MAA0_5	MAA0_4	MAA0_3	MAA0_2	MAA0_1	MAA0_0
<b>Memory Signal Mapping when MF = 0</b>	RSVD	A13/A12	A7/A8	A6/A11	A5/BA1	A4/BA2	A3/BA3	A2/BA0	A1/A9	A0/A10

## 3.4 Display Configuration Overview

"Polaris 10" has six display links, A to F.

Table 3–6 Display Configuration Overview for Links A, B, C, D, E, and F

Pin Name	Possible Display Configurations		
<b>TX[5:3]P/M_DPA[0:2]P/N</b> <b>TXCAP/M_DPA3P/N</b>	Single-link DisplayPort/TMDS	Dual-link DVI	A DisplayPort can be connected to any of links A, B, C, D, E, or F. The six links are independent and can be active simultaneously.  HDMI™ can be connected to any of links A, B, C, D, E, or F.  Dual-link DVI is available on links A and B, C and D, or E and F, respectively.  B, D, or F must be the master link for the respective dual-link pair.
<b>TX[2:0]P/M_DPB[0:2]P/N</b> <b>TXCBP/M_DPB3P/N</b>	Single-link DisplayPort/TMDS		
<b>TX[5:3]P/M_DPC[0:2]P/N</b> <b>TXCCP/M_DPC3P/N</b>	Single-link DisplayPort/TMDS	Dual-link DVI	
<b>TX[2:0]P/M_DPD[0:2]P/N</b> <b>TXCDP/M_DPD3P/N</b>	Single-link DisplayPort/TMDS		
<b>TX[5:3]P/M_DPE[0:2]P/N</b> <b>TXCEP/M_DPE3P/N</b>	Single-link DisplayPort/TMDS	Dual-link DVI	
<b>TX[2:0]P/M_DPF[0:2]P/N</b> <b>TXCFP/M_DPF3P/N</b>	Single-link DisplayPort/TMDS		

### 3.5 Integrated HDMI™/TMDS Interface

"Polaris 10" has six display links, A to F.

**Note:**

- The maximum pixel clock rate is 594 MHz on direct connectors. The GPU and HDMI connector are on the same PCB with a maximum trace length of 127 mm or 5 inches, and may be affected by TMDS signals layout and trace lengths.
- For unused interfaces, all signal outputs can be unconnected. AUX\_ZVSS, DP\_ZVDD\_08, and DP\_ZVSS should always be connected.

Please refer to the *Digital Visual Interface (DVI) 1.0 Specification* and the *High-Definition Multimedia Interface (HDMI) Specification* for additional details.

Table 3–7 Integrated HDMI™/TMDS Interface

Pin Name	Type	Description
<b>TX[5:3]P/M_DPA[0:2]P/N</b> <b>TX[2:0]P/M_DPB[0:2]P/N</b> <b>TX[5:3]P/M_DPC[0:2]P/N</b> <b>TX[2:0]P/M_DPD[0:2]P/N</b> <b>TX[5:3]P/M_DPE[0:2]P/N</b> <b>TX[2:0]P/M_DPF[0:2]P/N</b>	O	TMDS data pairs (+/-). For single- and dual-link configurations. Transmitting at a bit rate of 10× pixel clock, up to 594-MHz pixel clock. A 100-nF capacitor is required on each differential signal placed near the connector. A 500-Ω resistor to ground is required on each differential-signal line. One FET is needed to disconnect the path from the 500-Ω resistors to ground when the system is off and the panel is on.
<b>TXCAP/M_DPA3P/N</b> <b>TXCBP/M_DPB3P/N</b> <b>TXCCP/M_DPC3P/N</b> <b>TXCDP/M_DPD3P/N</b> <b>TXCEP/M_DPE3P/N</b> <b>TXCFP/M_DPF3P/N</b>	O	TMDS clock channels (+/-). For single- and dual-link configurations. A 100-nF capacitor is required on each differential signal placed near the connector. A 500-Ω resistor to ground is required on each differential-signal line. One FET is needed to disconnect the path from the 500-Ω resistors to ground when the system is off and the panel is on. <b>Note:</b> TXCBP/M_DPB3P/N, TXCDP/M_DPD3P/N, or TXCFP/M_DPF3P/N should be used as the clock pairs for dual-link configurations.
<b>DDC[2:1]CLK</b> <b>DDC[2:1]DATA</b> <b>DDCAUX[6:3]N</b> <b>DDCAUX[6:3]P</b>	I/O	Differential signals for HDMI/TMDS DDC. For more details, see <a href="#">Table 3-14 (p. 32)</a> . NOT 5-V tolerant.
<b>AUX_ZVSS</b>	A	Analog calibration. Connect to VSS through a 150-Ω (1%) resistor.
<b>DP_ZVDD_08</b>	A	Analog calibration. Connect to VDD_08 through a 200-Ω (1%) resistor.
<b>DP_ZVSS</b>	A	Analog calibration. Connect to GND through a 200-Ω (1%) resistor.

## 3.6 DisplayPort

**Note:** If this interface is not used, all signal outputs can be unconnected. AUX\_ZVSS, DP\_ZVDD\_08, and DP\_ZVSS should always be connected.

"Polaris 10" supports six DisplayPort links.

The GPU and DisplayPort connector are on the same PCB with a maximum trace length of 127 mm or 5 inches.

Please refer to the *DisplayPort Standard Version 1.4* for additional details.

Table 3–8 DisplayPort Interface

Pin Name	Type	Description
<b>TX[5:3]P/M_DPA[0:2]P/N</b> <b>TXCAP/M_DPA3P/N</b>	O	DisplayPort (DPA) differential signals. DPA can be configured as a DisplayPort link. A 100-nF capacitor is required on each differential signal placed near the connector.
<b>TX[2:0]P/M_DPB[0:2]P/N</b> <b>TXCBP/M_DPB3P/N</b>	O	DisplayPort (DPB) differential signals. DPB can be configured as a DisplayPort link. A 100-nF capacitor is required on each differential signal placed near the connector.
<b>TX[5:3]P/M_DPC[0:2]P/N</b> <b>TXCCP/M_DPC3P/N</b>	O	DisplayPort (DPC) differential signals. DPC can be configured as a DisplayPort link. A 100-nF capacitor is required on each differential signal placed near the connector.
<b>TX[2:0]P/M_DPD[0:2]P/N</b> <b>TXCDP/M_DPD3P/N</b>	O	DisplayPort (DPD) differential signals. DPD can be configured as a DisplayPort link. A 100-nF capacitor is required on each differential signal placed near the connector.
<b>TX[5:3]P/M_DPE[0:2]P/N</b> <b>TXCEP/M_DPE3P/N</b>	O	DisplayPort (DPE) differential signals. DPE can be configured as a DisplayPort link. A 100-nF AC-coupling capacitor is required on each differential signal placed near the connector.
<b>TX[2:0]P/M_DPF[0:2]P/N</b> <b>TXCFP/M_DPF3P/N</b>	O	DisplayPort (DPF) differential signals. DPF can be configured as a DisplayPort link. A 100-nF AC-coupling capacitor is required on each differential signal placed near the connector.
<b>AUX[2:1]P/N</b> <b>DDCAUX[6:3]N</b> <b>DDCAUX[6:3]P</b>	I/O	DisplayPort auxiliary differential signals. See <a href="#">Table 3-14 (p. 32)</a>
<b>AUX_ZVSS</b>	A	Analog calibration. Connect to VSS through a 150-Ω (1%) resistor.
<b>DP_ZVDD_08</b>	A	Analog calibration. Connect to VDD_08 through a 200-Ω (1%) resistor.
<b>DP_ZVSS</b>	A	Analog calibration. Connect to GND through a 200-Ω (1%) resistor.

## 3.7 Hardware I<sup>2</sup>C Interface

Table 3–9 Hardware IC Interface

Pin Name	Type	Description
<b>SCL</b>	I/O 3.3 V (VDD_33)	I <sup>2</sup> C clock. <b>Note:</b> Can be left unconnected if not used.
<b>SDA</b>	I/O 3.3 V (VDD_33)	I <sup>2</sup> C data/address. <b>Note:</b> Can be left unconnected if not used.

## 3.8 Serial Flash Interface

Configuration straps must be set to identify the appropriate ROM type. See [ROM Configurations \(p. 40\)](#).

Table 3–10 Serial Flash Interface

Pin Name	Type	PD/PU	Description
<b>GPIO_8_ROMSO</b>	I 3.3 V (VDD_33)	PD-reset	Serial-ROM output from ROM. General purpose I/O or open-drain output.
<b>GPIO_9_ROMSI</b>	O 3.3 V (VDD_33)	PD-reset	Serial-ROM input to ROM. General purpose I/O or open-drain output.
<b>GPIO_10_ROMSCK</b>	O 3.3 V (VDD_33)	PD-reset	Serial-ROM clock to ROM. General purpose I/O or open-drain output.
<b>GPIO_22_ROMCSB</b>	O 3.3 V (VDD_33)	PU-reset	BIOS-ROM chip select. Used to enable the ROM for ROM read and program operations.

## 3.9 General Purpose I/O Interface

Table 3–11 General Purpose I/O Interface

Pin Name	Type	PD/PU	Description
3.3-V GPIOs			
The following signals, if not used for their primary purposes, may be used as GPIO pins.			
GPIO_0	I/O 3.3 V (VDD_33)	PD-reset	General purpose I/O and pin strap. See <a href="#">Table 3–24 (p. 38)</a> for pin strap definition.



Pin Name	Type	PD/PU	Description
GPIO_1	I/O 3.3 V (VDD_33)	PD-reset	General purpose I/O and pin strap. See <a href="#">Table 3-24 (p. 38)</a> for pin strap definition.
GPIO_5_REG_HOT_AC_BATT	I/O 3.3 V (VDD_33)	PD-reset	General purpose I/O
GPIO_6_TACH	I/O 3.3 V (VDD_33)	PD-reset	General purpose I/O or fan tachometer feedback. See <a href="#">Table 3-17 (p. 34)</a> for the latter usage.
GPIO_8_ROMSO	I/O 3.3 V (VDD_33)	PD-reset	Pin strap, general purpose I/O, or serial-ROM output. See <a href="#">Table 3-24 (p. 38)</a> for pin strap definition. See <a href="#">Table 3-10 (p. 28)</a> for serial ROM usage.
GPIO_9_ROMSI	I/O 3.3 V (VDD_33)	PD-reset	Pin strap, general purpose I/O, or serial-ROM input. See <a href="#">Table 3-24 (p. 38)</a> for pin strap definition. See <a href="#">Table 3-10 (p. 28)</a> for serial ROM usage.
GPIO_10_ROMSCK	I/O 3.3 V (VDD_33)	PD-reset	General purpose I/O or serial-ROM clock. See <a href="#">Table 3-10 (p. 28)</a> for serial ROM usage.
GPIO_12	I/O 3.3 V (VDD_33)	PD-reset	General purpose I/O and pin strap. See <a href="#">Table 3-24 (p. 38)</a> for pin strap definition.
GPIO_14_HPD2	I/O 3.3 V (VDD_33)	PD-reset	General purpose I/O or hot-plug detect signal from the display device. See <a href="#">Table 3-14 (p. 32)</a> for the latter usage.
GPIO_15	I/O 3.3 V (VDD_33)	PD-reset	General purpose I/O and pin strap. See <a href="#">Table 3-24 (p. 38)</a> for pin strap definition.
GPIO_16_8P_DETECT	I/O 3.3 V (VDD_33)	PD-reset	General purpose I/O on mobile.
GPIO_17_THERMAL_INT	I/O 3.3 V (VDD_33)	PD-reset	General purpose I/O or thermal interrupt. See <a href="#">Table 3-17 (p. 34)</a> for the latter usage.
GPIO_18_HPD3	I/O 3.3 V (VDD_33)	PD-reset	General purpose I/O or hot-plug detect signal from the display device. See <a href="#">Table 3-14 (p. 32)</a> for the latter usage.

Pin Name	Type	PD/PU	Description
GPIO_20	I/O 3.3 V (VDD_33)	PD-reset	General purpose I/O and pin strap. See <a href="#">Table 3-24 (p. 38)</a> for pin strap definition.
GPIO_21	I/O 3.3 V (VDD_33)	PD-reset	General purpose I/O.
GPIO_28_FDO	I/O 3.3 V (VDD_33)	PD-reset	General purpose I/O or fan drive. See <a href="#">Table 3-17 (p. 34)</a> for the latter usage.
GPIO_29	I/O 3.3 V (VDD_33)	PD-reset	General purpose I/O and pin strap. See <a href="#">Table 3-24 (p. 38)</a> for pin strap definition.
GPIO_30	I/O 3.3 V (VDD_33)	PD-reset	General purpose I/O.
GPIO_2	I/O 3.3 V (VDD_33)	PU-reset	General purpose I/O and pin strap. See <a href="#">Table 3-24 (p. 38)</a> for pin strap definition.
GPIO_11	I/O 3.3 V (VDD_33)	PU-reset	General purpose I/O and pin strap. See <a href="#">Table 3-24 (p. 38)</a> for pin strap definition.
GPIO_13	I/O 3.3 V (VDD_33)	PU-reset	General purpose I/O and pin strap. See <a href="#">Table 3-24 (p. 38)</a> for pin strap definition.
GPIO_22_ROMCSB	I/O 3.3 V (VDD_33)	PU-reset	Pin strap, general purpose I/O, or ROM chip-select. See <a href="#">Table 3-24 (p. 38)</a> for pin strap definition. See <a href="#">Table 3-10 (p. 28)</a> for serial ROM usage.

**Note:**

1. During the ramp-up of the VDD\_33 power rail, all GPIOs are undefined and a voltage bump may appear momentarily (up to 800 mV). GPIOs should be gated/filtered using an appropriate qualifier if they are connected to external circuits that are sensitive or responsive to the voltage bump.
2. Internal PU or PD is effective after VDDC is at ready state. Before VDDC is ready, the GPIOs are of Hi-Z state.
3. All GPIOs are configured as input by default after VDDC is at ready state. GPIOs can be programmed as output by the video BIOS. For any GPIOs that are default to PD internally, but used as output and expected to drive high level at power-up, if the external circuit is sensitive and responsive to the voltage level present on the GPIO during the period before the vBIOS is loaded, a strong pull-up of 1K  $\Omega$  (5%) is recommended.
4. For GPIOs that serve as pin straps, any external circuits using them must not conflict with the logic level required by the strap after power up until PCIe reset gets de-asserted.
5. See [Configuration Straps \(p. 37\)](#) for more information on pin strap configurations.

### 3.10 AMD SVI2 Master Interface

Table 3–12 AMD SVI2 Master Interface

Pin Name	Type	Description
<b>GPIO_SVC</b>	O	Serial VID clock.
	1.8 V (VDD_18)	Push-pull clock output for the SVI2 data bus; driven by the GPU. Point-to-point connection to the SVI2 voltage regulator controller.
	I/O	Serial VID data.
<b>GPIO_SVD</b>	1.8 V (VDD_18)	Push-pull data output for the SVI2 data bus; driven by the GPU. Sets the voltage, power-state indicator, load-line slope, and voltage offsets for two voltage rails. Point-to-point connection to the SVI2 voltage regulator controller.
	I	Serial VID telemetry.
	1.8 V (VDD_18)	Push-pull data input driven by the SVI2 voltage regulator controller. Continuously streams the voltage and current telemetry information to the GPU. Also provides an indication when positive voltage transitions are complete (VOTFC).

### 3.11 Global Swap Lock on Multiple GPUs

Global swap lock is used to synchronize the timing and surface flip for multiple display pipes on multiple GPUs.

If this feature is not required, the following signals can be used as 3.3-V GPIOs or left unconnected on the PCB.

Table 3–13 Global Swap Lock on Multiple GPUs

Pin Name	Type	PD/ PU	Description
<b>GENLK_CLK</b>	I/O 3.3 V (VDD_33)	PD- reset	Reference-clock input for the display PLLs (including the DCPLL and pixel PLLs) received from the framelock/genlock interface. <b>Note:</b> Can be unconnected if not used.
<b>GENLK_VSYNC</b>	I/O 3.3 V (VDD_33)	PD- reset	Frame-timing indicator. Output to the framelock/genlock interface.
<b>SWAPLOCKA</b>	Open drain 3.3 V	-	(Optional) Used in a multiple GPU design with multiple display outputs to allow all displays in group A to update at the same time and have synchronous left/right stereo timing. In a multiple GPU design where displays are connected to more than one GPU, connect SWAPLOCKA from all GPUs together with an external 10-kΩ pull-up resistor. GPU genlock is needed, either via a genlock system or by feeding all GPUs with the same reference clock. Connecting SWAPLOCKB is preferred but not required.
<b>SWAPLOCKB</b>	Open drain 3.3 V	-	(Optional) Used in a multiple GPU design with multiple display outputs to allow all displays in group B to update at the same time and have synchronous left/right stereo timing. In a multiple GPU design where displays are connected to more than one GPU, connect SWAPLOCKB from all GPUs together with an external 10-kΩ pull-up resistor. GPU genlock is needed, either via a genlock system or by feeding all GPUs with the same reference clock.

## 3.12 Display Identification Interface

Table 3–14 Display Identification Interface

Pin Name	Type	Description
<b>DDC1CLK/ DDC1DATA or AUX1P/N</b>	I/O 3.3 V (VDD_33)	<p>DDC1CLK/DDC1DATA and AUX1P/N signal pairs are mutually exclusive.</p> <p>A design can use either the DDC1 or AUX1 pair on one display connector. Alternatively, DDC1DATA can be connected to AUX1N, and DDC1CLK can be connected to AUX1P on one DisplayPort connector (see reference schematics).</p> <p><b>Note:</b> Can be unconnected if not used.</p> <p>For the DDC functionality (DDC data and clock signals (I<sup>2</sup>C master)):</p> <ul style="list-style-type: none"> <li>These pins can be used to support internal high-bandwidth digital content protection (HDCP).</li> <li>Outputs are open drain and NOT 5-V tolerant. External pull-up resistors to 3.3 V are required.</li> </ul> <p>For the AUX functionality (auxiliary differential signals for DisplayPort):</p> <ul style="list-style-type: none"> <li>A 100-nF AC-coupling capacitor is required on each differential signal placed near the connector, and</li> <li>A source detection pull-down resistor (100-kΩ 5% tolerance) is required on the AUXP signal and a pull-up resistor (100-kΩ 5% tolerance) to 3.3 V is required on the AUXN signal.</li> </ul>
<b>DDC2CLK/ DDC2DATA or AUX2P/N</b>	I/O 3.3 V (VDD_33)	<p>DDC2CLK/DDC2DATA and AUX2P/N signal pairs are mutually exclusive.</p> <p>A design can use either the DDC2 or AUX2 pair on one display connector.</p> <p>Alternatively, DDC2DATA can be connected to AUX2N, and DDC2CLK can be connected to AUX2P on one DisplayPort connector (see reference schematics).</p> <p><b>Note:</b> Can be unconnected if not used.</p> <p>For the DDC functionality (DDC data and clock signals (I<sup>2</sup>C master)):</p> <ul style="list-style-type: none"> <li>These pins can be used to support internal HDCP.</li> <li>Outputs are open drain and NOT 5-V tolerant. External pull-up resistors to 3.3 V are required.</li> </ul> <p>For the AUX functionality (auxiliary differential signals for DisplayPort):</p> <ul style="list-style-type: none"> <li>A 100-nF AC-coupling capacitor is required on each differential signal placed near the connector, and</li> <li>A source detection pull-down resistor (100-kΩ 5% tolerance) is required on the AUXP signal and a pull-up resistor (100-kΩ 5% tolerance) to 3.3 V is required on the AUXN signal.</li> </ul>
<b>DDCAUX[6:3]N DDCAUX[6:3]P</b>	I/O 3.3 V (VDD_33)	<p>DDC data/clock for DVI/HDMI or auxiliary differential signals for DisplayPort.</p> <p>These pins can be used to support internal HDCP.</p> <p><b>Note:</b> Can be unconnected if not used.</p> <p>For the AUX functionality:</p> <ul style="list-style-type: none"> <li>A 100-nF AC-coupling capacitor is required on each differential signal placed near the connector, and</li> <li>A source detection pull-down resistor (100-kΩ 5% tolerance) is required on each AUXP signal and a pull-up resistor (100-kΩ 5% tolerance) to 3.3 V is required on each AUXN signal.</li> </ul> <p>For the I<sup>2</sup>C functionality:</p>

Pin Name	Type	Description
		Outputs are open drain and NOT 5-V tolerant. External pull-up resistors to 3.3 V are required.
<b>HPD1</b> <b>GPIO_14_HPDP2</b> <b>GPIO_18_HPDP3</b> <b>GENERICE_HPDP4</b> <b>GENERICF_HPDP5</b> <b>GENERICG_HPDP6</b>	I 3.3 V (VDD_33)	Hot-plug detect signal from the display device to the GPU.

### 3.13 JTAG Interface

In order to debug issues, AMD requires access to the JTAG interface.

Test points can be used on the JTAG signals to minimize the PCB space needed.

Table 3–15 JTAG Interface

Pin Name	Type	PD/ PU	Description
<b>TESTEN</b>	I 3.3 V (VDD_33)	-	Reserved signal. This pin must be tied to ground (0 V) through a 1-kΩ to 10-kΩ resistor for normal GPU operation.
<b>JTAG_TRSTB</b>	I/O 3.3 V (VDD_33)	PU- reset	TRSTB (test reset). This pin can be left floating, or tied to 3.3 V through a 10-kΩ resistor for normal GPU operation. Must be accessible on all PCBs through a test point or resistor pad.
<b>JTAG_TDI</b>	I/O 3.3 V (VDD_33)	PU- reset	TDI (test data input). This pin can be left floating, or tied to 3.3 V through a 10-kΩ resistor for normal GPU operation. Must be accessible on all PCBs through a test point or resistor pad.
<b>JTAG_TCK</b>	I/O 3.3 V (VDD_33)	PD- reset	TCK (test clock). This pin can be left floating, or tied to ground (0 V) through a 10-kΩ resistor for normal GPU operation. Must be accessible on all PCBs through a test point or resistor pad.
<b>JTAG_TMS</b>	I/O 3.3 V (VDD_33)	PU- reset	TMS (test mode select). This pin can be left floating, or tied to 3.3 V through a 10-kΩ resistor for normal GPU operation. Must be accessible on all PCBs through a test point or resistor pad.
<b>JTAG_TDO</b>	I/O 3.3 V (VDD_33)	-	TDO (test data output). This pin can be left floating, or unconnected if not used. Must be accessible on all PCBs through a test point or resistor pad.

## 3.14 Debug Port

Table 3–16 Debug Port

Pin Name	Functional Name
<b>SMBDAT</b>	Serial debug port data
<b>SMBCLK</b>	Serial debug port clock
<b>DBGDATA[15:0]</b>	Debug bus output data
<b>TEST6</b>	Connect to GND through a zero-Ω resistor
<b>BP_0</b>	Provide a pull-up resistor to 1.8 V on the PCB
<b>BP_1</b>	Provide a pull-up resistor to 1.8 V on the PCB
<b>ANALOGIO</b>	Provide access on the PCB through a test pad
<b>GATE</b>	Provide access on the PCB through a test pad
<b>DRAIN</b>	Provide access on the PCB through a test pad
<b>PLLCHARZ_H</b>	Provide access on the PCB through a test pad
<b>PLLCHARZ_L</b>	Provide access on the PCB through a test pad

## 3.15 Thermal Information and Management Interface

Table 3–17 Thermal Interface Signals

Pin Name	Type	PU/PD	Description
<b>DPLUS</b>	Anode	-	Thermal diode plus side (anode), used by the external temperature controller to obtain GPU die temperature.  <b>Note:</b> Can be unconnected if not used.
<b>DMINUS</b>	Cathode	-	Thermal diode minus side (cathode), used by the external temperature controller to obtain the GPU die temperature.  <b>Note:</b> Can be unconnected if not used.
<b>GPIO_6_TACH</b>	I 3.3 V (VDD_33)	PD-reset	Fan tachometer feedback.
<b>GPIO_17_THERMAL_INT</b>	Bi-dir 3.3 V (VDD_33)	PD-reset	Thermal monitor interrupt. An input from an external temperature sensor (ALERTb).

Pin Name	Type	PU/PD	Description
<b>GPIO_19_CTF<sup>1</sup></b>	O 3.3 V (VDD_33)	PD-reset	<p>Critical temperature fault (CTF) (active high) will output 3.3 V if the on-die temperature sensor exceeds a critical temperature so that the motherboard can protect the GPU from damage by removing power.</p> <p>If GPIO_19_CTF is expected to be latched at “high” level upon occurrence of the CTF event, 1.8 V and 3.3 V to the GPU must remain.</p> <p>The CTF setpoint is 96°C by default, and is programmed during GPU initialization.</p>
<b>GPIO_28_FDO</b>	O	PD-reset	<p>Fan drive output (output to control fan).</p> <p>In PWM mode, the PWM frequency is 15 kHz to 50 kHz.</p>
<b>TEMPINO</b>	I	-	<p>A provision to connect to the anode of an external thermal diode for the GPU to read the temperature from a spot of interest on the board or platform.</p> <p>For experimental purposes and should be left unconnected.</p>
<b>TEMPINRETURN</b>	I	-	<p>A provision to connect to the cathode of an external thermal diode for the GPU to read the temperature from a spot of interest on the board or platform.</p> <p>For experimental purposes and should be left unconnected.</p>
<b>Note:</b> <b>1. Like other GPIOs, during the ramp-up of the VDD_33 power rail, GPIO_19_CTF is undefined and a voltage bump may appear momentarily (up to 800 mV). It should be gated/filtered using an appropriate qualifier if it is connected to a external circuit that is sensitive or responsive to the voltage bump.</b>			

## 3.16 SMBus Interface

Table 3–18 SMBus Interface

Pin Name	Type	Description
<b>SMBDAT</b>	Bi-dir 3.3 V (VDD_33)	<p>SMBus data.</p> <p>Connected to the SMBDAT line of the SMBus master with an external pull-up resistor to 3.3 V.</p> <p>Supports the SMBus 2.0 protocol.</p> <p>The SMBus slave address can be set to either 0x40 or 0x41 through pin strap on GPIO_1. For more details, see <a href="#">Table 3–24 (p. 38)</a>. The GPU also supports ARP.</p>
<b>SMBCLK</b>	Bi-dir 3.3 V (VDD_33)	<p>SMBus clock.</p> <p>Connected to the line of the SMBus master with an external pull-up resistor to 3.3 V.</p> <p>Supports the SMBus 2.0 protocol.</p> <p>The SMBus slave address can be set to either 0x40 or 0x41 through pin strap on GPIO_1. For more details, see <a href="#">Table 3–24 (p. 38)</a>. The GPU also supports ARP.</p>

## 3.17 PLL Interface

Table 3–19 PLL Interface

Pin Name	Type	Description
<b>XTALIN</b>	A-I 1.8 V	<p>An external 100-MHz non-spread 1.8-V oscillator is required to connect to XTALIN to provide the reference clock.</p> <p>Oscillator characteristics:</p> <ul style="list-style-type: none"> <li>Frequency: 100 MHz.</li> <li>Voltage swing: 1.8 V.</li> <li><math>V_{IH} = 1.45</math> V (min)</li> <li><math>V_{IL} = 0.45</math> V (max)</li> <li>Accuracy: <math>\pm 10</math> ppm at room temperature, (<math>\pm 30</math> ppm overall (including temperature drift)).</li> <li>Duty cycle (worst case): 45-55 (max).</li> <li>Jitter: <ul style="list-style-type: none"> <li>200 ps (max) cycle-to-cycle jitter.</li> <li>300 ps (max) long-term jitter (10,000 cycles after the triggered edge).</li> </ul> </li> </ul>
<b>XTALOUT</b>	A-O 1.8 V	<p>PLL Reference Clock</p> <p>Provides a provision to have a parallel-resonant crystal connected between XTALIN and XTALOUT as a reference clock to the GPU. Backup plan.</p> <p>Crystal characteristics:</p> <ul style="list-style-type: none"> <li>ESR: <math>&lt;80\Omega</math>.</li> <li>Combined frequency tolerance and stability: <math>\pm 30</math> ppm max.</li> </ul> <p>A 1-M<math>\Omega</math> resistor must be connected between XTALIN and XTALOUT when a crystal is used.</p> <p>Capacitive loading from the package and PCB trace should be subtracted from the C1 and C2 capacitor values.</p> <p><b>Note:</b> External oscillator must connect to XTALIN only. (An oscillator cannot be connected to XTALOUT.)</p>

Table 3–20 Recommended Clock-input Configurations

Memory Type	Description
<b>GDDR5</b>	100-MHz non-spread (1.8 V) oscillator connected to XTALIN.

## 3.18 AMD PowerXpress™ Interface

Table 3–21 AMD PowerXpress™ Interface

Pin Name	Type	PD/PU	Description
<b>PX_EN</b>	O	PD	<p>On/off regulator control signal for AMD ZeroCore Power feature (BACO mode). High (3.3 V) switches the regulators off (enter BACO mode).</p> <p>Low (0 V) switches the regulators on. (Default)</p> <p>PX_EN is tri-state before internal TEST_PG is asserted and PERSTb is de-asserted.</p> <p>Can be left unconnected if not used.</p>



## 3.19 Power and Ground Descriptions and Operating Conditions

**Note:**

- All power and ground pins must always be connected.

Table 3–22 Power and Ground Descriptions and Operating Conditions

Pin Name	Value	Description
<b>Main Power and Ground Pins</b>		
<b>VDDC</b>	XT: 0.800 V to 1.150 V PRO: 0.800 V to 1.125 V	Dedicated core power, provides power to the internal logic. Refer to <a href="#">Electrical Design Power (p. 53)</a> for the SVI2 and other requirements on VDDC. The voltage quoted is the set voltage through SVI2.
<b>VDDCI</b>	XT: 0.850 V to 0.950 V PRO: 0.850 V to 0.900 V	Isolated (clean) core power for the I/O logic. Particular attention should be paid to minimize AC ripple on VDDCI.
<b>FB_VDDC</b>	—	Provides VDDC feedback path to the regulator. If unused, connect to a test point or leave not connected.
<b>FB_VDDCI</b>	—	Provides VDDCI feedback path to the regulator. If unused, connect to a test point or leave not connected.
<b>FB_VSS</b>	—	Provides ground feedback path to the regulator. If unused, connect to a test point or leave not connected.
<b>VDD_08</b>	0.912 V	Digital power supply for PLL, PCIe, and display PHYs.
<b>VDD_18</b>	1.8 V	1.8-V I/O power for PLL, PCIe, and display PHYs.
<b>TSVDD</b>	1.8 V	On-die thermal sensor power.
<b>VMEMIO (memory)</b>	1.5 V or 1.55 V See memory specifications.	I/O power for the memory interface.
<b>VDD_33</b>	3.3 V	I/O power for 3.3-V pins, such as GPIOs.
<b>VSS</b>	Gnd	Ground.

Table 3–23 Other Signals

Pin Name	Type	Description
<b>TEST_PG</b> <b>TEST_PG_BACO</b>	I	TEST_PG and TEST_PG_BACO should be accessible for test purposes and must be pulled up to the 1.8-V power rail for normal operation.
<b>TS_A</b>	I	Reserved. Do not connect on the PCB.

## 3.20 Configuration Straps

### 3.20.1 GPIO Pin Straps

"Polaris 10" uses GPIO pin straps (i.e., one GPIO for one strap).

Some of the straps are on 3.3-V GPIOs while others are on 1.8-V GPIOs.

Each strap pin has either an internal pull-down resistor which provides a default value of 0, or an internal pull-up resistor which provides a default value of 1, at power up. For each strap that defaults to 0 by the GPU, provide a pull-up resistor option (to 3.3-V or 1.8-V depending on the GPIO type) on the PCB. For each strap that defaults to 1 by the GPU, provide a pull-down resistor option to GND on the PCB.

To change the straps from the default values, use pull-up or pull-down resistors of **5.1K  $\Omega$  (5%)** on the PCB.

Any external circuit using these pins must not conflict with the logic level required by the strap after power up until PCIe reset gets de-asserted.

Table 3–24 Pin Straps

Strap Name	Pin Name	Description	GPU Default	Recommended Settings <sup>1</sup>
BIF_VGA_DIS	GPIO_29	Determine whether or not the card will be recognized as the system's VGA controller (via the SUBCLASS field in the PCI configuration space).  0: VGA Controller capacity enabled.  1: The device will not be recognized as the system's VGA controller (for headless designs).	0 (Internal pull-down)	Design dependent  Provide a pull-up resistor option to VDD_33.
TX_DEEMPH_EN	GPIO_20	PCI Express transmitter de-emphasis enable  0: Tx de-emphasis disabled.  1: Tx de-emphasis enabled.	0 (Internal pull-down)	1  Through pull-up resistor to VDD_33.
TX_HALF_SWING	GPIO_0	Controls the transmitter full/half swing mode.  0: The transmitter full-swing is enabled.  1: The transmitter half-swing is enabled.	0 (Internal pull-down)	0  Provide a pull-up resistor option to VDD_33.
ROM_CONFIG[2:0]	GPIO_13 GPIO_12 GPIO_11	a) If BIOS_ROM_EN = 1, then ROM_CONFIG[2:0] defines the ROM type. See <a href="#">ROM Configurations (p. 40)</a> for details.  b) If BIOS_ROM_EN = 0, then ROM_CONFIG[2:0] defines the primary memory aperture size. See <a href="#">ROM Configurations (p. 40)</a> for details.	101 (Internal pull-up/pull-down)	Design dependent.  Provide a pull-down resistor option to GND on the PCB for GPIO_13.  Provide a pull-up resistor option to VDD_33 on the PCB for GPIO_12.  Provide a pull-down resistor option to GND on the PCB for GPIO_11.

Strap Name	Pin Name	Description	GPU Default	Recommended Settings <sup>1</sup>
BIOS_ROM_EN	GPIO_22_ROMCSB	Enable external BIOS ROM device.  0: Disable external BIOS ROM device.  1: Enable external BIOS ROM device.  <b>Note:</b> When an external BIOS ROM device is used, GPIO_22_ROMCSB also connects to the ROM device's chip select (active low).	1  (Internal pull-up)	Design dependent.  Provide a pull-down resistor option to GND on the PCB.
Special Usage [1] Special Usage [0]	HSYNC VSYNC	Special usage	0  (Internal pull-down)	Design dependent.  Refer to application note order #55739 on the special usage.  Provide a pull-up resistor option to VDD_33 on the PCB for each pin.
AUD_PORT_CONN [2:0]	DBGDATA_2 DBGDATA_1 DBGDATA_0	Determine the maximum number of digital display audio endpoints that will be presented to the OS and user. This should be set to the maximum number of digital display audio outputs that can be enabled simultaneously in the product, which is limited by the GPU itself, the number and type of connectors on the board (DP/HDMI), and the number of sinks for each DP connector (the DP MST link policy of the video driver). Unused endpoints should be disabled.  111: No usable endpoints 110: One usable endpoint 101: Two usable endpoints 100: Three usable endpoints 011: Four usable endpoints 010: Five usable endpoints 001: Six usable endpoints 000: All endpoints are usable	0  (Internal pull-down)	Design dependent, see description.  Provide a pull-up resistor option to <b>VDD_18</b> on the PCB for each pin.
BOARD_CONFIG [2:0]	DBGDATA_5 DBGDATA_4 DBGDATA_3	Provides an option to specify certain board-level specifics to the VBIOS or driver.	0  (Internal pull-down)	Design dependent.  Provide a pull-up resistor option to <b>VDD_18</b> on the PCB for each pin.

Strap Name	Pin Name	Description	GPU Default	Recommended Settings <sup>1</sup>
SMBUS_ADDR	GPIO_1	Provide a strap option to change the SMBUS slave address of the GPU. 0: 0×40 1: 0×41	0 (Internal pull-down)	Design dependent. Provide a pull-up resistor option to VDD_33 on the PCB for the pin.  Strap on the PCB the address <b>to 0×41</b> if it does not cause address conflict on the platform.
BIF_GEN3_EN_A	GPIO_2	PCIe Gen3 capability. 1: PCIe Gen3 is supported. 0: PCIe Gen3 is not supported.	1 (Internal pull-up)	Design dependent. Provide a pull-down resistor option to GND on the PCB.
BIF_CLK_PM_EN	GPIO_8_ROMSO	Determines whether or not the PCIe reference clock power management capability is reported in the PCI configuration space (otherwise known as CLKREQB). 0: The CLKREQB power management capability is disabled. 1: The CLKREQB power management capability is enabled.	0 (Internal pull-down)	Design dependent. Provide a pull-up resistor option to VDD_33 on the PCB.
Reserved	GPIO_15	Reserved	0 (Internal pull-down)	Must default to 0 for production. Provide a pull-up resistor option to VDD_33 on the PCB.
Reserved	GPIO_9_ROMSI	Reserved	0 (Internal pull-down)	Must default to 0 for production. Provide a pull-up resistor option to VDD_33 on the PCB.
<b>Note:</b> 1. To change the straps from the default values, use pull-up or pull-down resistors of 5.1K $\Omega$ (5%) on the PCB.				

### 3.20.2 ROM Configurations

For designs that have a dedicated ROM device for the GPU video BIOS:

- Use the GPU default strap on GPIO\_22\_ROMCSB (i.e., 1).
- Use the GPU default straps on GPIO\_13, GPIO\_12, and GPIO\_11 (i.e., 101).

### 3.20.3 Primary Memory Aperture Size

The following table shows the primary memory aperture sizes requested at PCI configuration.

Table 3–25 Primary Memory Aperture Sizes Requested at PCI Configuration

Size of the Primary Memory Apertures	ROM_CONFIG[2:0]
128 MB	000
256 MB	001
64 MB	010
8 GB	011
16 GB	100
1 GB	101
2 GB	110
4 GB	111

**Note:** The memory aperture size should be the same as the frame buffer size for 64 MB, 128 MB, and 256 MB. For a frame buffer size larger than 256 MB, memory aperture size should be set to 256 MB.

For designs requiring larger than 256 MB aperture size, consult with AMD.

### 3.20.4 ROM Straps for Add-in Card Design

If a dedicated ROM is used for the video BIOS (see ROM\_CONFIG[2:0] and BIOS\_ROM\_EN in [GPIO Pin Straps \(p. 37\)](#)), then after P<sub>ERSTB</sub> goes inactive (high), the ROM is read at the BIOS addresses and default BIOS settings in the following table.

The ROM straps are ORed with the corresponding pin straps.

Table 3–26 ROM Straps

Strap Name	Description	Default BIOS Setting
<b>F0_64BAR_DIS_A</b>	Enable 64-bit BAR for function 0. Affects bit 2 of BLOCK_MEM_TYPE for each BAR register in the PCI configuration space.	1
<b>SUBSYS_VEN_ID</b>	Subsystem vendor ID (SSVID) in the PCI configuration space. If a VBIOS ROM is not used, then the SBIOS is permitted to overwrite this register for each PCI function on the device before the enumeration cycle is initiated, otherwise the default value is used.	0x1002
<b>F0_SUBSYS_ID</b>	Subsystem ID (SSID) for the PCI configuration space for function 0. If enabled, SSID for the secondary display function (F1) is set to the same value as the primary display function (F0) with bit 0 inverted.	
<b>F0_BAR_EN</b>	0 = Disable resizable BAR feature. 1 = Enable resizable BAR feature.	1

Strap Name	Description	Default BIOS Setting
<b>MEM_AP_SIZE[2:0]</b>	<p>Size of the primary memory apertures claimed in the PCI configuration space:</p> <p>If F0_BAR_EN = 1 (i.e., resizable BAR enabled):</p> <ul style="list-style-type: none"> <li>• 000: 256 MB to 1 GB</li> <li>• 001: 256 MB to 4 GB</li> <li>• 010: 256 MB to 8 GB</li> <li>• 011: 256 MB to 16 GB</li> <li>• 100: 128 MB to 1 GB</li> <li>• 101: 128 MB to 2 GB</li> <li>• 110: 128 MB to 8 GB</li> <li>• 111: 128 MB to 16 GB</li> </ul> <p>If F0_BAR_EN = 0 (i.e., resizable BAR disabled):</p> <ul style="list-style-type: none"> <li>• 000: 128 MB</li> <li>• 001: 256 MB</li> <li>• 010: 64 MB</li> <li>• 011: 8 GB</li> <li>• 100: 16 GB</li> <li>• 101: 1 GB</li> <li>• 110: 2 GB</li> <li>• 111: 4 GB</li> </ul> <p>When F0_BAR_EN = 0, the aperture size should be set to the same size as the frame buffer size for 64 MB, 128 MB, and 256 MB. For a frame buggger size larger than 256 MB, the aperture size should be set to 256 MB. For designs requiring larger than 256 MB aperture size, contact AMD.</p>	Depends on the board configuration, see the description.
<b>AUDIO_EN</b>	<p>Multi-function device select.</p> <p>Affects bit seven of the header register in the PCI configuration space.</p> <p>PCI configuration setting:</p> <p>0 = Audio function not present.</p> <p>1 = Audio function present.</p> <p>Boards with a ROM will require both the ROM and the specific pin straps to be set in order to enable the audio function. Boards without a ROM will only require the pin straps to be set in order to enable the audio function.</p>	Depends on the board configuration, see the description.
<b>VGA_DIS</b>	<p>VGA disable determines whether or not the card will be recognized as the system's VGA controller (via the SUBCLASS field in PCI configuration space):</p> <p>0 = VGA controller capacity enabled.</p> <p>1 = The device will not be recognized as the system's VGA controller.</p>	0
<b>DEBUG_ACCESS</b>	The debug access sets the debug MUX settings from the ROM in order to bring out internal signals for observation when registers are inaccessible through the host interface.	0

# Timing Specifications

This chapter describes bus and memory timing specifications of "Polaris 10".

To link to a topic of interest, use the following list of linked cross-references:

- [DRAM Timing \(p. 43\)](#)
- [SMBus Timing \(p. 44\)](#)
- [Initialization Sequence and Timing \(p. 48\)](#)
- [Serial Flash Read/Write Timing \(p. 51\)](#)

## 4.1 DRAM Timing

### 4.1.1 Programming Timing Values

The following tables show the memory-timing parameters that can be programmed through the registers MC\_SEQ\_RAS\_TIMING, MC\_SEQ\_CAS\_TIMING, MC\_SEQ\_MISC\_TIMING, and MC\_SEQ\_MISC\_TIMING2.

The MC\_SEQ\_RAS\_TIMING register allows the programming of the row operation timing parameters.

Table 4–1 MC\_SEQ\_RAS\_TIMING Parameters

Field	Bits	Description
<b>TRCDW</b>	4:0	ACTIVE to WRITE (in hclk) - 1.
<b>TRCDWA</b>	9:5	ACTIVE to WRITE with AUTO PRECHARGE (in hclk) - 1.
<b>TRCDR</b>	14:10	ACTIVE to READ (in hclk) - 1.
<b>TRCDRA</b>	19:15	ACTIVE to READ with AUTO PRECHARGE (in hclk) - 1.
<b>TRRD</b>	23:20	ACTIVE bank a to ACTIVE bank b (in hclk) - 1.
<b>TRC</b>	30:24	ACTIVE to ACTIVE (same bank)/AUTO REFRESH period (in hclk).
<b>TRCDW</b>	31	Most significant bit of TRCDW.

The MC\_SEQ\_CAS\_TIMING register allows the programming of the column operation timing parameters.

Table 4–2 MC\_SEQ\_CAS\_TIMING Parameters

Field	Bits	Description
<b>TNOPW</b>	1:0	Extra write pitch between bursts for debug purposes (in hclk).
<b>TNOPR</b>	3:2	Extra read pitch between bursts for debug purposes (in hclk).
<b>TR2W</b>	8:4	READ to WRITE turnaround time (in hclk) - 1.

Field	Bits	Description
<b>TCCDL</b>	11:9	Col to Col access delay - 1 (within the same bank group). GDDR5 only.
<b>TR2R</b>	15:12	READ to READ different rank (in hclk) - 1.
<b>TW2R</b>	20:16	WRITE to READ turn around time (in hclk) - 1.
<b>TCL</b>	28:24	CAS to read data return latency - 2 (0 to 20).

The MC\_SEQ\_MISC\_TIMING and MC\_SEQ\_MISC\_TIMING2 registers allow programming of miscellaneous timing parameters.

Table 4-3 MC\_SEQ\_MISC\_TIMING Parameters

Field	Bits	Description
<b>TRP_WRA</b>	5:0	AUTO PRECHARGE to ACTIVE for WRITE (in hclk) - 1.
<b>TRP_RDA</b>	13:8	AUTO PRECHARGE to ACTIVE for READ (in hclk) - 1.
<b>TRP</b>	19:16	PRECHARGE command period (in hclk) - 1.
<b>TRFC</b>	28:20	AUTO REFRESH command period (in hclk) -1.
<b>TRCDWA</b>	29	Most significant bit of TRCDWA described in <a href="#">Table 4-1 (p. 43)</a> .
<b>TRCDR</b>	30	Most significant bit of TRCDR described in <a href="#">Table 4-1 (p. 43)</a> .
<b>TRCDRA</b>	31	Most significant bit of TRCDRA described in <a href="#">Table 4-1 (p. 43)</a> .

Table 4-4 MC\_SEQ\_MISC\_TIMING2 Parameters

Field	Bits	Description
<b>PA2RDATA</b>	2:0	READ PREAMBLE (for GDDR4 only) (in hclk).
<b>PA2WDATA</b>	6:4	WRITE PREAMBLE (for GDDR4 only) (in hclk).
<b>FAW</b>	12:8	FOUR ACTIVE WINDOW (in mclk) - 5.
<b>TREDC</b>	15:13	READ EDC LATENCY in addition to READ DATA LATENCY (in hclk).
<b>TWEDC</b>	20:16	WRITE EDC LATENCY (in hclk)- 8.
<b>T32AW</b>	24:21	32 ACTIVE TIMING WINDOW (in mclk).
<b>TWDATATR</b>	24:21	DQ→WCMD timing for write training.

Table 4-5 Mapping DRAM Parameters to Programmed Values (GDDR5)

Parameter	Programmed Value	Unit
<b>Burst Length</b>	8	edge
<b>YCLK</b>	4000	MHz
<b>HCLK (memory clock)</b>	1000	MHz
<b>MCLK</b>	500	MHz
<b>HCLK Period</b>	1.0	ns

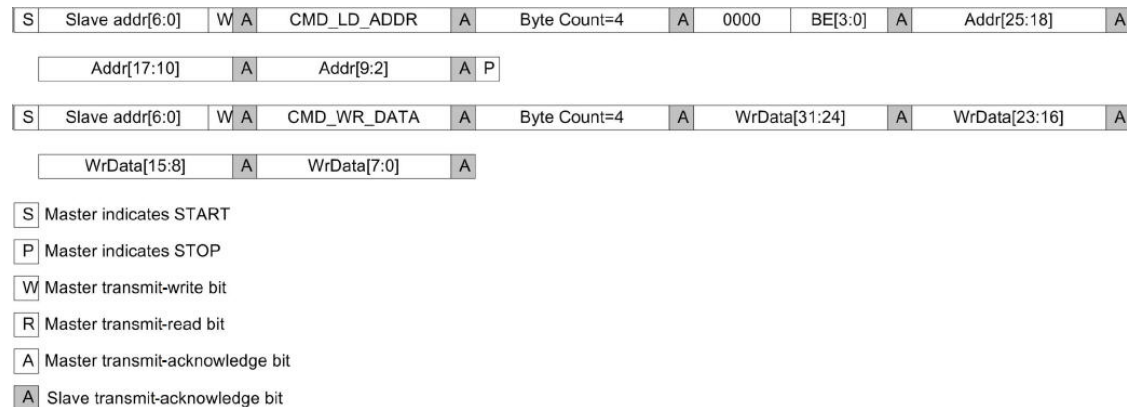
## 4.2 SMBus Timing



### 4.2.1 SMBus Write Cycle

The following figure shows an SRBM (system register bus manager) write cycle on the SMBus interface.

Figure 4–1 SMBus Write Cycle



A typical SMBus write cycle consists of the following steps:

1. Issuing a Load Address Command to the SMB\_ADDR register:
  - a. The SMBus master issues a START bit to the slave.
  - b. The SMBus master issues 7-bit slave address to the slave.
  - c. The SMBus master issues a write bit to the slave.
  - d. The SMBus slave acknowledges the master.
  - e. The SMBus master issues an 8-bit CMD\_LD\_ADDR command to the slave.
  - f. The SMBus slave acknowledges the master.
  - g. The SMBus master sends a byte count (always 4).
  - h. The SMBus slave acknowledges the master.
  - i. The SMBus master issues a 4-bit byte enable with a 4-bit zero padding.
  - j. The SMBus slave acknowledges the master.
  - k. The SMBus master sends SMB\_ADDR[25:18] to the slave.
  - l. The SMBus slave acknowledges the master.
  - m. The SMBus master sends SMB\_ADDR[17:10] to the slave.
  - n. The SMBus slave acknowledges the master.
  - o. The SMBus master sends SMB\_ADDR[9:2] to the slave.
  - p. The SMBus slave acknowledges the master.
  - q. The SMBus master sends a STOP bit to the slave.
2. Issuing a Write Data Command to the SMB\_WR\_DATA register:
  - a. The SMBus master issues a START bit to the slave.

- ### 4.2.2 SMBus Read Cycle

Figure 4-2 SMBus Read Cycle



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- e.** The SMBus master issues an 8-bit CMD\_LD\_ADDR command to the slave.
  - f.** The SMBus slave acknowledges the master.
  - g.** The SMBus master sends a byte count (always 4).
  - h.** The SMBus slave acknowledges the master.
  - i.** The SMBus master issues a 4-bit byte enable with a 4-bit zero padding. These bits should have no effect on the reads.
  - j.** The SMBus slave acknowledges the master.
  - k.** The SMBus master sends SMB\_ADDR[25:18] to the slave.
  - l.** The SMBus slave acknowledges the master.
  - m.** The SMBus master sends SMB\_ADDR[17:10] to the slave.
  - n.** The SMBus slave acknowledges the master.
  - o.** The SMBus master sends SMB\_ADDR[9:2] to the slave.
  - p.** The SMBus slave acknowledges the master.
  - q.** The SMBus master sends a STOP bit to the slave.
- 2.** Issuing a Read Data Command to the slave.
  - a.** The SMBus master issues a START bit to the slave.
  - b.** The SMBus master issues a 7-bit slave address to the slave.
  - c.** The SMBus master issues a write bit to the slave.
  - d.** The SMBus slave acknowledges the master.
  - e.** The SMBus master issues an 8-bit CMD\_RD\_DATA command to the slave.
  - f.** The SMBus slave acknowledges the master.
  - g.** The SMBus master terminates the transaction with a STOP.
- 3.** Issuing an SMBus read to the slave:
  - a.** The SMBus master issues a START bit to the slave.
  - b.** The SMBus master issues an 7-bit slave address to the slave.
  - c.** The SMBus master issues a read bit to the slave.
  - d.** The SMBus slave acknowledges the master.
  - e.** The SMBus slave sends a byte count (always 4).
  - f.** The SMBus master acknowledges the slave.
  - g.** The SMBus slave sends SMB\_RD\_DATA[31:24] to the master.
  - h.** The SMBus master acknowledges the slave.
  - i.** The SMBus slave sends SMB\_RD\_DATA[23:16] to the master.
  - j.** The SMBus master acknowledges the slave.
  - k.** The SMBus slave sends SMB\_RD\_DATA[15:8] to the master.

- l.** The SMBus master acknowledges the slave.
- m.** The SMBus slave sends SMB\_RD\_DATA[7:0] to the master.
- n.** The SMBus master acknowledges the slave.
- o.** The SMBus master terminates the transaction with a STOP.

### 4.2.3 SMBus Read Thermal Sensor

Since SMU has moved thermal value register into indirect space, so if we want to access it, we need 2 indirect steps.

Programming sequence is shown below:

1. SMB Issue a Load Address Command(cmd1) to the SMC\_IND\_INDEX\_7 address. (Tell SMBus slave the index address.)  
82 01 04 0f 00 00 8E
2. SMB Issue a Write Data Command(cmd2) to the thermal register real address. (Tell SMBus slave to write the real address to #1's index.)  
82 02 04 c0 30 00 14
3. SMB Issue a Load Address Command(cmd1) to the SMC\_IND\_DATA\_7 (Tell SMBus slave the index pair's data address.)  
82 01 04 0f 00 00 8F
4. SMB Issue a Read Data Command(cmd3) (Tell SMBus slave to read out thermal value.)  
82 03 83 <value read back>
5. Repeat step 4.

## 4.3 Initialization Sequence and Timing

### 4.3.1 Initialization Sequence and Timing

1. Chip reset (PERSTB) is asserted, and PCIE\_REFCLK starts running.
2. All GPIOs go to a tristate (input) mode at RESETB. Some GPIOs have internal pull-down (PD) or pull-up (PU) resistors—see descriptions of pin-based straps.
3. External pin straps are driving their values onto the GPU pins.
4. Chip reset (PERSTB) is deasserted.
5. External pin-strap values are latched internally.
6. In parallel:
  - a. eFuse state machine begins to read "eFuse straps."
  - b. If a ROM exists (and is programmed), a request is sent to the ROM controller to read the "ROM straps."

7. eFuse and ROM straps are "forwarded" to PHY.
  8. In parallel:
    - a. If GPU memory repair is required, then memory repair starts.
    - b. eFuse and ROM straps are "forwarded" to other blocks in the GPU.
  9. Wait for memory repair to complete. De-assert a hard reset to all the blocks including BIF. Enable PCIe® PHY impedance calibration. After polling for the PHY impedance calibration, distribute the remaining fuses and poll for BIF to complete its reset sequence.
  10. The GPU begins link training according to the PCIe specification.
- After link training and the reset sequence are complete, the system is ready for the first transaction, such as a configuration space request.

The following figure and table provide an outline of the "Polaris 10" reset sequence.

Figure 4–3 Reset Sequence

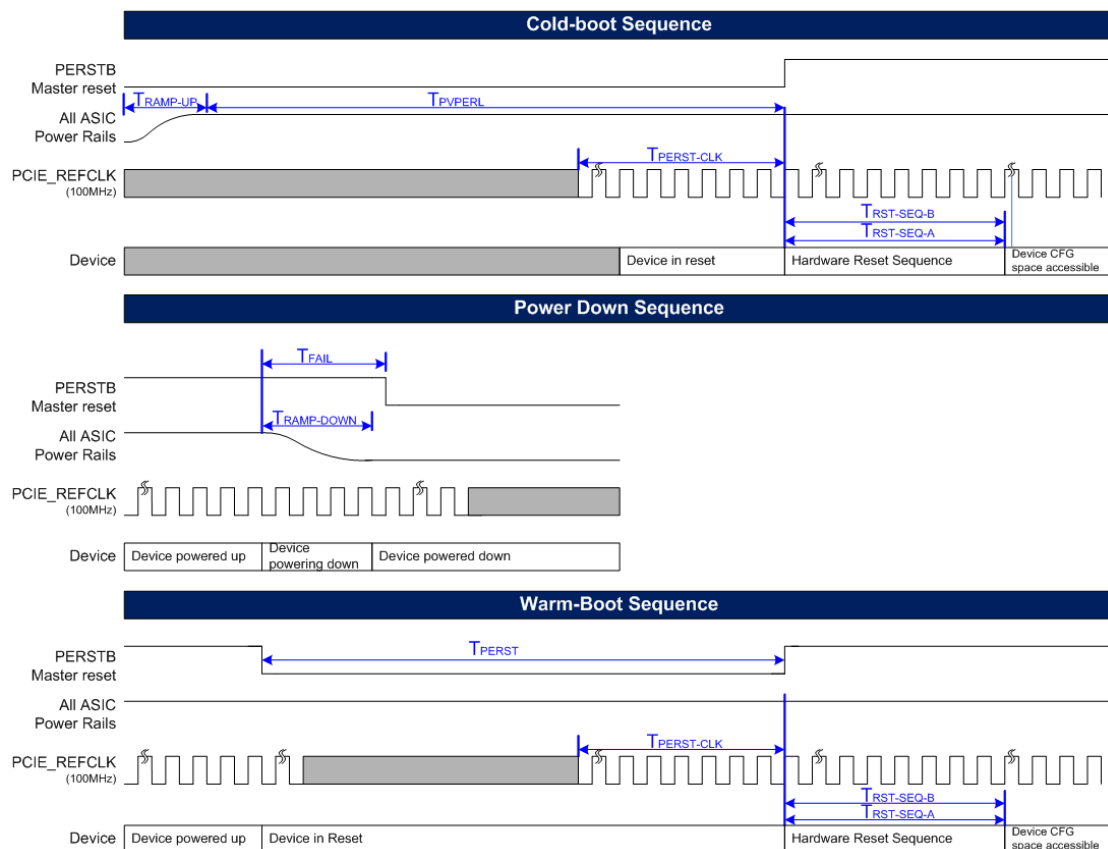


Table 4–6 Power-on Reset Sequence Timing Parameters

Parameter	Description	Minimum Time	Maximum Time
$T_{RAMP-UP}$	Power rail ramp-up time	0 ms	20 ms
$T_{PVPERL}$	All GPU power rails stable to PERSTB inactive	100 ms	Not limited
$T_{PERST-CLK}$	PCIE_REFCLK stable before PERSTB inactive	100 $\mu$ s	Not limited
$T_{RST-SEQ-A}$	The time required by the GPU to complete its internal reset sequence, and become ready for PCI configuration space access	N/A	100 ms

Parameter	Description	Minimum Time	Maximum Time
T <sub>RST-SEQ-B</sub>	The time the system software must wait after de-assertion of PERSTB before accessing the GPU's PCI configuration space	100 ms	Not limited
T <sub>RAMP-DOWN</sub>	Power rail ramp-down time	0 ms	20 ms
T <sub>FAIL</sub>	Power level invalid to PERSTB active	No requirements	No requirements
T <sub>PERST</sub>	PERSTB active time	100 $\mu$ s	Not limited

### 4.3.2 Standard Boot-up Sequence

1. PERSTB (fundamental reset) is asserted to the device.
2. Select internal-strap values are determined by the configuration of pin straps on a subset of GPIOs on the board.
3. PERSTB is deasserted, and pin-strap settings are latched permanently into the device (until PERSTB is asserted again, or the power is removed).
4. In parallel:
  - a. The device begins to read "eFuse straps."
  - b. If a ROM exists (and is programmed), the device begins to read "ROM straps" from its external ROM.

**Note:** The system may not issue a configuration transaction to the device until the device internal reset sequence is complete.

5. For an add-in card implementation, the device completes reading the "ROM straps."
6. Device internal reset is complete. The system begins enumerating the devices attached to it by issuing configuration transactions.
7. The chip responds to any pending transaction requests, and the system continues PCI Express® enumeration, which sets up the configuration registers of the device.
8. The system copies the contents of the ROM into system memory, and executes the video BIOS, completing the device initialization. This occurs before POST begins in the system BIOS, based on the *PC 98 System Design Guide*.

The device is ready for normal operation.

There are three configurations for strap/BIOS implementation:

**Configuration 1.** The controller is located on an add-in card, and there is access to a local video BIOS serial flash memory.

The ROM state machine of "Polaris 10" will read in all the "ROM-based straps" right after PERSTB reset is deasserted. There are a total of 33 DWORDs of "ROM-based straps" which are stored at byte locations 0x70 through 0xF4 in the serial flash memory. See [Table 3-26 \(p. 41\)](#) for details.

For "Polaris 10", security features have been implemented to block access to the ROM when a fuse is set. After this, when the ROM needs to be accessed, external software will have to message the SMU firmware which will authenticate the new ROM contents and write it out.

**Configuration 2.** The controller is located on the system motherboard and the video BIOS is stored in the system BIOS serial-flash memory (i.e., no dedicated ROM for the video BIOS).

The system BIOS will be responsible for loading the SUBSYSTEM\_ID and SUBSYSTEM\_VENDOR\_ID through an aliased address in the controller chip's configuration space. The reason for writing through an aliased address (16#4c) is that the configuration location 16#2c is read only. Any writes to this location (16#4c) will also change the content of the SUBSYSTEM\_VENDOR\_ID at 16#2c.

**Configuration 3.** A combination of configurations 1 and 2 (add-in card and device on the motherboard)

The system BIOS will take care of the graphics device on the motherboard as in case 2, while the chip on the add-in board will be taken care of as in case 1. This should cover the situation where the OS does not read the add-in card's video BIOS because the ROM state machine from the graphics chip reads the "ROM-based straps" independently from the video BIOS.

**Note:** If neither the system BIOS nor the add-in card video BIOS supply the SUBSYSTEM\_ID and SUBSYSTEM\_VENDOR\_ID, their values default to the DEVICE\_ID and VENDOR\_ID respectively inside the chip.

## 4.4 Serial Flash Read/Write Timing

Figure 4–4 Serial Flash Write/Read Timing

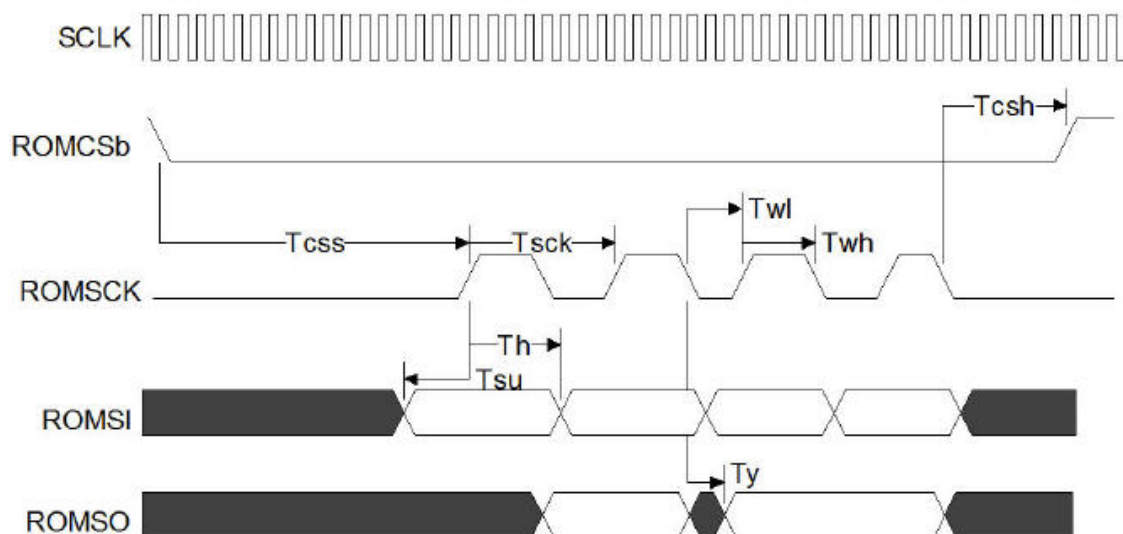


Table 4–7 Serial Flash Write/Read Timing Parameters for the Bootup Case

Symbol	Description	Min (ns)	Max (ns)
<b>Tcss</b>	ROMCSb falling edge to first clock sent to the device.	110	
<b>Tsck</b>	ROMSCK period.	70	
<b>Twl</b>	ROMSCK low time.	30	
<b>Twh</b>	ROMSCK high time.	30	
<b>Tsu</b>	ROMSI data setup.	20	

Symbol	Description	Min (ns)	Max (ns)
<b>Th</b>	ROMSI data hold.	40	
<b>Ty</b>	ROMSO data valid.	0	20
<b>Tcsh</b>	Last clock sent to the ROMCSb rising edge.	70	
<b>SCLK = 100 MHz, XTALIN = 27 MHz, ROM_CNTL.SCK_PRESCALE_CRYSTAL_CLK=0x1</b>			



# Electrical Characteristics

This chapter describes the electrical characteristics of "Polaris 10".

All voltages are with respect to VSS unless specified otherwise.

To link to a topic of interest, use the following list of linked cross-references:

- [Maximum Voltage Ranges \(p. 53\)](#)
- [Electrical Design Power \(p. 53\)](#)
- [Power-up/down Sequence \(p. 55\)](#)
- [TTL Interface Electrical Characteristics \(p. 56\)](#)
- [Memory Interface Electrical Characteristics \(p. 56\)](#)
- [DDC I22C Mode Electrical Characteristics \(p. 56\)](#)
- [DisplayPort AUX Electrical Specification \(p. 57\)](#)
- [DisplayPort Main Link Electrical Characteristics \(p. 57\)](#)
- [SMBus Electrical Characteristics \(p. 58\)](#)

## 5.1 Maximum Voltage Ranges

**Note:** The maximum voltage ranges are stress voltage ranges only, and the operation of the device at these conditions is not implied. Voltage ranges refer to the delta between FB\_VDDC and FB\_VSS, FB\_VDDCI and FB\_VSS, or power balls and VSS for rails that do not have voltage sensing feedback. Any stress voltage greater than the *absolute maximum range* may cause permanent damage to the device, or adversely affect the device reliability.

Table 5–1 Maximum Voltage Ranges

Supply	Maximum Voltage Range
VDDC, VDDCI	0 V to 1.075 V
VDD_33	0 V to 3.630 V
VMEMIO	0 V to 1.600 V
VDD_18, TSVDD	0 V to 1.980 V
VDD_08	0 V to 0.945 V

## 5.2 Electrical Design Power

The following table lists the estimated Thermal Design Current (TDC) numbers for all GPU power rails. Designers must ensure that their regulator circuits are capable of supplying continuous TDC safely. The regulator circuits must also meet AMD's

Electrical Design Current (EDC) requirement that is defined as the minimum current for which the voltage regulator must be capable of safely supplying for a minimum of 1 ms. This means that if a voltage regulator design can safely supply this amount of current for more than 1 ms, it meets AMD's EDC criterion. EDC can be estimated to be 1.5 times of TDC unless otherwise specified.

It is required that AMD's SVI2-compliant voltage controllers be used on all "Polaris 10" designs for VDDC. A SVI2-compliant voltage controller has two independent voltage domains built in such that one controller can deliver two power rails to the GPU (the main domain powers VDDC, and the 2nd domain powers VDDCI), saving both cost and space compared to two-regulator solutions. Both voltage outputs are controlled through the high-speed SVI2 bus from dedicated GPU pins.

All voltage regulators that are compliant with AMD's SVI2 specification use the SVT pin to serially stream real-time voltage and current telemetry to the GPU. "Polaris 10" uses the telemetry information to enable power management features. In order to maintain the accuracy of the current measurement, it is required that the passive current-sensing components have a tolerance less than or equal to  $\pm 5\%$ . For example, if an inductor DCR (direct current resistance) is being used as the current-sensing element, the tolerance of the DCR must be less than or equal to  $\pm 5\%$ . Full-scale current calibration is also required. Please refer to AMD's application note, order# 54265, for details on the calibration procedure.

For the power-up sequence requirements affected by the adoption of SVI2-compliant voltage regulators, refer to [Power-up/down Sequence \(p. 55\)](#).

To allow for driver optimizations, faster CPUs, and new applications, designers need to provide adequate electrical margins.

The numbers are preliminary estimates and subject to change.

Table 5–2 Regulator Guidelines

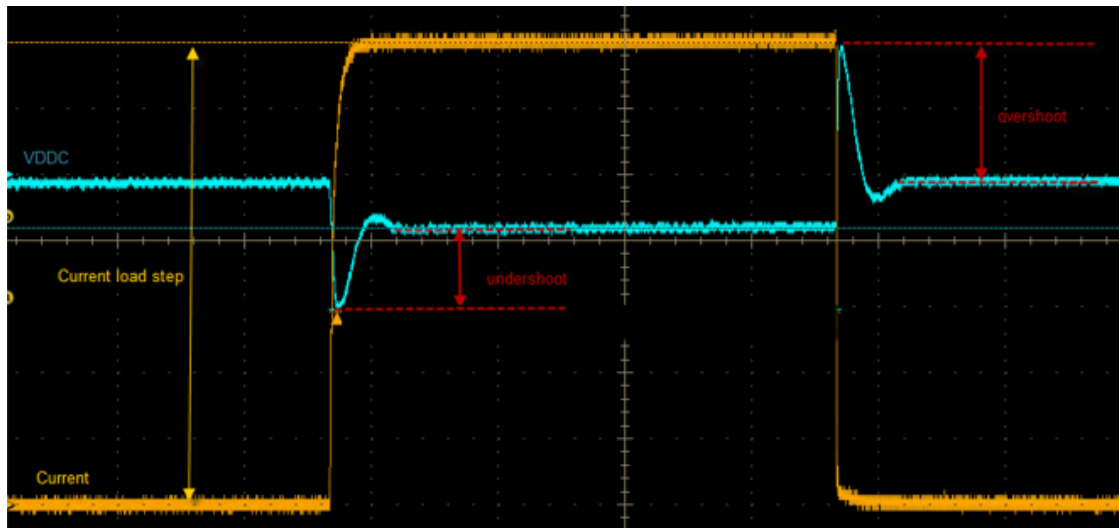
Rail Name		Nominal Voltage	DC Tolerance	AC Tolerance	Maximum Current	Notes
VDDC	"Polaris 10 PRO"	0.800 V to 1.125 V	$VID\_VDDC - I\_VDDC \times 0.3 \text{ m}\Omega \pm 20 \text{ mV}$	Overshoot: 240 mV Undershoot: 160 mV	84 A (TDC) 250 A (EDC)	1, 2, 4, 7
	"Polaris 10 XT"	0.800 V to 1.150 V		Overshoot: 145 mV Undershoot: 87 mV	110 A (TDC) 300 A (EDC)	
VDDCI	"Polaris 10 PRO"	0.850 V to 0.900 V	$\pm 3\%$	$\pm 3\%$	17 A (TDC)	
	"Polaris 10 XT"	0.850 V to 0.950 V				
VDD_08		0.912 V	$\pm 3\%$	$\pm 3\%$	4 A (TDC)	
VMEMIO		1.5 V or 1.55 V	$\pm 3\%$	$\pm 3\%$	5 A (TDC) 10 A (EDC)	3

Rail Name	Nominal Voltage	DC Tolerance	AC Tolerance	Maximum Current	Notes
VDD_18	1.8 V	±3%	±3%	1 A (TDC)	5, 6
VDD_33	3.3 V	±3%	±3%	10 mA (TDC)	
TSVDD	1.8 V	±3%	±3%	13 mA (TDC)	

**Note:**

1. The SVI2 regulator can provide any voltage required on VDDC.
2. EDC can be optimized based on the platform specifics. Contact AMD for more details.
3. GPU consumption only and does not include memory parts. Consult with your memory vendor for additional current requirements to size the regulator. Voltage requirements are vendor- and speed-dependent.
4. AMD requires an effective load line of 0.3 mΩ on the VDDC rail. Some AMD reference designs set initial load line to 0.5 mΩ on the PCB and rely on the VBIOS to trim it down to 0.3 mΩ.
5. If a switching regulator is used to power VDD\_18, a filter inductor should be placed between the output of the regulator circuit and the GPU decoupling capacitors, and outside the feedback loop of the switching regulator. The filter inductor should be of 0.24 μH, and its DCR should be of 15 mΩ or less. The LDO solution does not need the filter inductor.
6. For the switching regulator, tolerance is defined at the 1.8-V regulator output before the filter inductor.
7. Undershoot and overshoot are conceptually illustrated in the following figure (Figure 5-1 (p. 55)). The set voltage is 1.0 V. The current load step is 150 A.

Figure 5-1 Sample Undershoot and Overshoot



### 5.3 Power-up/down Sequence

**"Polaris 10" has the following requirements with regards to power-supply sequencing to avoid damaging the GPU:**

- All the GPU supplies, except for VDD\_33, must fully reach their respective nominal voltages within 20 ms of the start of the ramp-up sequence, though a shorter ramp-up duration is preferred. The maximum slew rate on all rails is 50 mV/μs.
- It is recommended that the 3.3-V rail ramps up first.
- The 1.8 rail must reach its steady state at least 10 μs before VDDC, VDDCI, and VDD\_08 start to ramp up.

## 5.4 TTL Interface Electrical Characteristics

The following table provides the electrical characteristics of the TTL Interface (GPIOs).

Table 5–3 DC Characteristics for 3.3-V GPIO Pads

Parameter	Condition	Min	Max	Unit	Notes
<b>V<sub>IL</sub>—input voltage low level.</b>	Maximum DC voltage at the PAD pin that will produce a logic low.	—	0.7	V	—
<b>V<sub>IH</sub>—input voltage high level.</b>	Minimum DC voltage at the PAD pin that will produce logic high.	1.7	—	V	—
<b>V<sub>OL</sub>—output voltage low level.</b>	Maximum output low voltage @ I = 8 mA.	—	0.42	V	1, 2
<b>V<sub>OH</sub>—output voltage high level.</b>	Minimum output high voltage @ I = 8 mA.	2.5	—	V	1, 2
<b>I<sub>OL</sub>—output current low level.</b>	Minimum output low current @ V = 0.1 V.	1.9	—	mA	1, 2
<b>I<sub>OH</sub>—output current high level.</b>	Minimum output high current @ V = V <sub>DDR</sub> - 0.1 V.	1.9	—	mA	1, 2

## 5.5 Memory Interface Electrical Characteristics

The following table provides the electrical characteristics of the memory interface.

Table 5–4 Memory Interface Electrical Characteristics

Parameters	Min	Typical	Max
<b>DDR3/GDDR5:</b> <b>MVREFx, MVREFDx—input reference voltages.</b>	$0.69 \times V_{MEMIO}$	$0.7 \times V_{MEMIO}$	$0.71 \times V_{MEMIO}$
<b>V<sub>IH-DC</sub>—DC input logic high level.</b>	MVREFDx + 100 mV	—	V <sub>MEMIO</sub>
<b>V<sub>IL-DC</sub>—DC input logic low level.</b>	0	—	MVREFDx - 100 mV
<b>V<sub>IH-AC</sub>—AC input logic high level.</b>	MVREFDx + 150 mV	—	—
<b>V<sub>IL-AC</sub>—AC input logic low level.</b>	—	—	MVREFDx - 150 mV
<b>V<sub>OL</sub>(DC)<sub>V<sub>MEMIO</sub> = 1.5 V</sub>—output logic low-level voltage.</b>	—	—	0.62 V
<b>Note:</b> <ul style="list-style-type: none"> <li>• Peak-to-peak AC noise on MVREFDx/MVREFx may not exceed <math>\pm 25</math> mV.</li> <li>• VTT of the transmitting device must track VREF of the receiving device.</li> <li>• A 1-V/ns input-signal minimum slew rate is to be maintained for DDR3.</li> <li>• A 3-V/ns input-signal minimum slew rate is to be maintained for GDDR5.</li> <li>• The VI-xx voltage levels exceed the DRAM specification for GDDR5, leading to higher performance.</li> </ul>			

## 5.6 DDC I<sup>2</sup>C Mode Electrical Characteristics

The following tables provide the electrical characteristics for the DDC pins in I<sup>2</sup>C mode.

Table 5–5 Transmitter Electrical Specification for DDC I<sup>2</sup>C

Symbol	Description	Min	Max	Unit	Notes
I2C_Tx <sub>Freq</sub>	Supported transmittable data rate.	—	100	kHz	Standard
			400	kHz	Fast
			1	MHz	Fast Plus
I2C_V <sub>OL</sub>	Maximum output low voltage @ I = 3 mA.	—	400	mV	1, 2
<b>Note:</b> <b>1. Measurement taken with NMOS strength set to default values, PVT = Noml case.</b> <b>2. The I<sup>2</sup>C interface is an open-drain circuit and pull high is determined by external power.</b>					

Table 5–6 Receiver Electrical Specification for DDC I<sup>2</sup>C Pins

Symbol	Description	Min	Max	Unit	Notes
I2C_Y_V <sub>IH-DC</sub>	Minimum DC voltage at the PAD pin that will produce a stable high on the receiver.	2.086		V	1
I2C_Y_V <sub>IL-DC</sub>	Maximum DC voltage at the PAD pin that will produce a stable low on the receiver.		1.089	V	1
I2C_Y_Rx <sub>Freq</sub>	Supported received frequency.		100	kHz	Standard
			400	kHz	Fast
			1	MHz	Fast Plus
I2C_Y <sub>dc</sub>	I2C_Y output duty cycle.	40	60	%	2
<b>Note:</b> <b>1. Measured with an edge rate of 1 μs at the PAD pin.</b> <b>2. Assuming perfect duty cycle on input.</b>					

## 5.7 DisplayPort AUX Electrical Specification

This table provides the electrical characteristics of the DisplayPort AUX.

Table 5–7 DisplayPort AUX Electrical Specification

Symbol	Description	Min	Max	Unit	Notes
AUX_V <sub>cm</sub>	Input/output common-mode voltage.	550	620	mV	-
AUX_V <sub>diff</sub>	Pad differential-output swing.	525	622	mV	-
AUX_Tx <sub>Freq</sub>	Supported transmit-data rate.	—	5	MHz	-
AUX_Rx <sub>Freq</sub>	Supported received frequency.	—	5	MHz	-
AUX_Pad <sub>dc</sub>	PADP/N output duty cycle.	40	60	%	1
<b>Note:</b> <b>1. Assuming perfect duty cycle on input.</b>					

## 5.8 DisplayPort Main Link Electrical Characteristics

This table provides the electrical characteristics of the DisplayPort main link.

Table 5–8 DisplayPort Main Link Electrical Specification

Symbol	Parameter	Min	Typ	Max	Unit	Notes
<b>UI<sub>HIGH_RATE</sub></b>	Unit interval for the DP high bit rate (2.7 Gbps/lane).	—	370	—	ps	High limit = +300 ppm Low limit = -5300 ppm
<b>UI<sub>LOW_RATE</sub></b>	Unit interval for the DP reduced bit rate (1.62 Gbps/lane).	—	617	—	ps	High limit = +300 ppm Low limit = -5300 ppm
<b>UI<sub>HIGH_RATE2</sub></b>	Unit interval for DP high-bit rate 2 (5.4 Gbps/lane).	—	185	—	ps	High limit = +300 ppm Low limit = -5300 ppm
<b>V<sub>TX-OUTPUT-RATIO_RBR_HBR</sub></b>	Ratio of output voltage level 1/ level 0.	0.8		6.0	dB	-
	Ratio of output voltage level 2/ level 1.	0.1		5.1	dB	-
<b>V<sub>TX-OUTPUT-RATIO_HBR2</sub></b>	Ratio of output voltage level 2/ level 0.	5.2		6.9	dB	-
	Ratio of output voltage level 2/ level 1.	1.6		3.5	dB	-
<b>V<sub>TX-OUTPUT-RATIO_RBR_HBR</sub></b>	Delta of pre-emphasis level 1 versus level 0.	2.0			dB	-
	Delta of pre-emphasis level 2 versus level 1.	1.6			dB	-
<b>V<sub>TX-PREEMP-OFF</sub></b>	Maximum pre-emphasis when disabled.			0.25	dB	-

## 5.9 SMBus Electrical Characteristics

The following tables provide the electrical characteristics for the SMBus DATA, CLOCK, and CLK\_REQB pads.

Table 5–9 Transmitter Electrical Specification

Symbol	Description	Min	Max	Unit
<b>F<sub>TX</sub></b>	Supported transmit data rate.	—	100	kHz
<b>V<sub>OL</sub></b>	Maximum output low voltage @ I = 4 mA.	—	200	mV

Table 5–10 Receiver Electrical Specification

Symbol	Description	Min	Max	Unit	Notes
<b>VIH<sub>AC</sub></b>	Minimum AC voltage at the PAD pin that will produce a stable high at the Y pin of the macro at FRX.	2.0	—	V	3
<b>VIL<sub>AC</sub></b>	Maximum AC voltage at the PAD pin that will produce a stable low at the Y pin of the macro.	—	0.8	V	3
<b>VIH<sub>DC</sub></b>	Minimum DC voltage at the PAD pin that will produce a stable high at the Y pin of the macro.	2.0	—	V	1
<b>VIL<sub>DC</sub></b>	Maximum DC voltage at the PAD pin that will produce a stable low at the Y pin of the macro.	—	0.8	V	1
<b>F<sub>RX</sub></b>	Supported received frequency.	—	100	kHz	-

Symbol	Description	Min	Max	Unit	Notes
$Y_{dc}$	Y output duty cycle.	40	60	%	2
$Y_{tiPDr}$	Receiver propagation delay rise.	—	400	ns	1, 2, 4
$Y_{tiPDF}$	Receiver propagation delay fall.	—	20	ns	1, 2, 4
<b>1. Measured with an edge rate of 1 <math>\mu</math>s at the PAD pin.</b> <b>2. Assuming perfect duty cycle on input.</b> <b>3. Measured at the maximum operating frequency.</b> <b>4. Typical simulation corner only.</b>					





# Thermal Data

To link to a topic of interest, use the following list of linked cross-references:

- [Thermal Equations \(p. 61\)](#)
- [Thermal Characteristics \(p. 61\)](#)
- [Thermal Design Power \(TDP\) \(p. 62\)](#)
- [Thermal Diode Characteristics \(p. 62\)](#)
- [Storage Requirements \(p. 63\)](#)

## 6.1 Thermal Equations

For the thermal equations, the Delphi model is recommended.

**Note:** Thermal simulation models are available. Please refer to the AMD OEM Resource Center for more information.

## 6.2 Thermal Characteristics

For engineering design purposes, the thermal characteristics,  $T_{Cmax}$  and  $T_{jmax}$ , found in the thermal simulation models are not practical as they are not easily determined. Instead, it is more convenient to define a new parameter, maximum recommended operating temperature ( $T_{j,op}$ ), and re-define  $T_{j,max}$  as shown in the following table:

Table 6–1 Thermal Characteristics

Variable	Value
<b><math>T_{j,op}</math>: Maximum recommended operating temperature.</b> <b>This is the maximum temperature at which the functionality is qualified and tested. Operation above this temperature will negatively impact product reliability.</b> <b>This temperature is measured using an on-die temperature sensor near the integrated thermal diode (see <a href="#">Thermal Diode Characteristics (p. 62)</a>).</b>	90°C
<b><math>T_{j,max}</math>: Absolute maximum rated junction temperature.</b> <b>This is the maximum allowable instantaneous GPU temperature, above which damage to the GPU is likely.</b> <b>This temperature is measured using an on-die temperature sensor near the integrated thermal diode (see <a href="#">Thermal Diode Characteristics (p. 62)</a>).</b>	96°C
<b>Minimum ambient operating temperature.</b>	0°C
<b><math>\theta_{JC}</math>: Junction to case thermal resistance (based on the two-resistor model).</b> <b>Note: Case here means the center of the top of the GPU package.</b>	0.05°C/W
<b><math>\theta_{JB}</math>: Junction to board thermal resistance (based on the two-resistor model).</b>	6.49°C/W

## 6.3 Thermal Design Power (TDP)

The thermal design power is defined as the power dissipated by the GPU while running a selected application at up to the maximum recommended operating temperature, and is measured as the maximum average power in a five-second moving window.

The TDP is intended as a recommended thermal design point; it is not an absolute maximum power under all conditions.

"Polaris 10" has up to eight defined Dynamic Power Management (DPM) states, from DPM\_0 to DPM\_7, in ascending order of performance and power. When a graphics demanding application (such as a game) is running, AMD's PowerTune constantly switches GPU among the states based on run-time analysis of GPU activities, power and thermal conditions. The effective power/performance depends on the percentage of time spent in each state.

The data are targets only, and are subject to change.

Table 6–2 TDP for Discrete Variants

Variant		"Polaris 10 PRO"	"Polaris 10 XT"
<b>VDDC (V)</b>		0.800 to 1.125	0.800 to 1.150
<b>VDDCI (V)</b>		0.850 to 0.900	0.850 to 0.950
<b>Engine (MHz)</b>	DPM_7	1206	1266
	DPM_6	1169	1236
	DPM_5	1126	1191
	DPM_4	1074	1145
	DPM_3	1019	1077
	DPM_2	751	910
	DPM_1	466	608
	DPM_0	300	300
<b>Memory (MHz)</b>		300 to 1650	300 to 2000
<b>Memory Voltage (V)</b>		1.5 or 1.55	
<b>Memory Interface (bits)</b>		256	
<b>GPU Leakage</b>		Variable	
<b>GPU Die Temperature (°C)</b>		90	
<b>Driver</b>		16.20	
<b>Test Platform</b>		Intel Core™ i7-4790X Extreme Edition 3.6-GHz CPU, 16-GB RAM	
<b>PCIe® Configuration</b>		PCIe revision 3.0, up to 8.0 GT/s	
<b>TDP Targets (W)</b>		85	110

## 6.4 Thermal Diode Characteristics

For "Polaris 10", the ideality factor of the on-die thermal diode varies significantly with temperature and sourcing current. If a design chooses to use the GPU's on-die thermal diode coupled with an external thermal sensor chip to read the GPU temperature, the external thermal sensor chip must support and enable beta compensation.

## 6.5 Storage Requirements

Ambient temperature < 40°C

Relative humidity < 90%



# Mechanical Data

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This chapter contains information on the mechanical data for "Polaris 10". To go to a topic of interest, use the following list of linked cross-references:

- [Physical Dimensions \(p. 65\)](#)
- [Pressure Specification \(p. 69\)](#)
- [Board Solder Reflow Process Recommendations \(p. 69\)](#)

## 7.1 Physical Dimensions

### 7.1.1 "Polaris 10"-L4 Physical Dimensions

HFCBGA 40 mm × 40 mm—1401 pins

Figure 7-1 "Polaris 10"-L4 Package Outline (MOD-00280 REV 03)

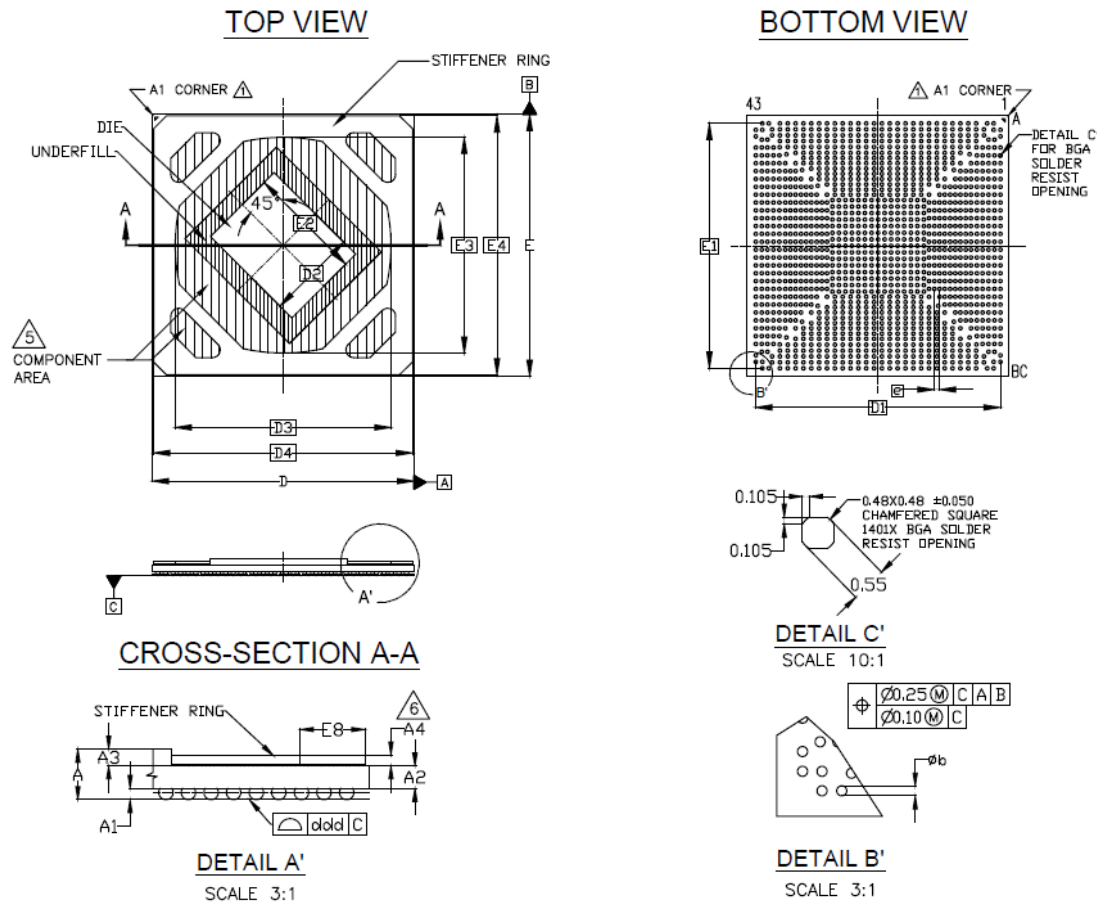
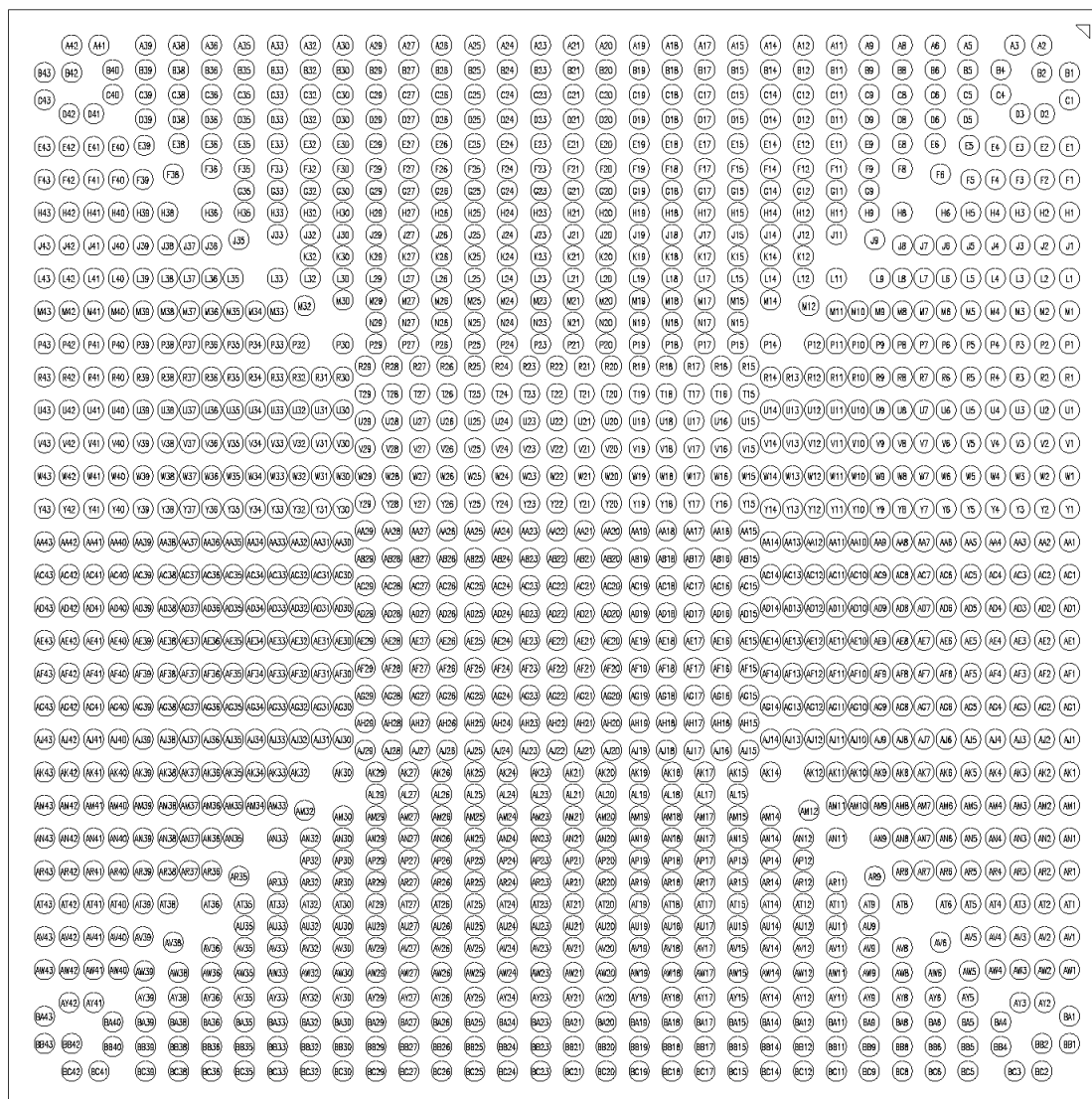
**ORGANIC BALL GRID ARRAY**

Table 7-1 -L4 Physical Dimensions (mm)

Symbol	Minimum	Normal	Maximum	Note
<b>A</b>	2.21	2.40	2.59	See side view.
<b>A1</b>	0.25	0.35	0.45	See side view.
<b>A2</b>	1.05	1.15	1.25	See side view.
<b>A3</b>	0.80	0.85	0.90	See side view.
<b>A4</b>	0.50	0.55	0.60	See side view.
<b>øb</b>	—	—	—	See note 3 below and bottom view.
<b>D</b>	39.90	40.00	40.10	See top view.
<b>D1</b>	—	37.40	—	See bottom view.
<b>D2</b>	—	13.80	—	See top view.
<b>D3</b>	—	33.00	—	See top view.
<b>D4</b>	—	39.60	—	See top view.
<b>E</b>	39.90	40.00	40.10	See top view.
<b>E1</b>	—	37.40	—	See bottom view.
<b>E2</b>	—	17.63	—	See top view.
<b>E3</b>	—	33.00	—	See top view.



Figure 7-3 "Polaris 10"-L4 Ball Arrangement





## 7.2 Pressure Specification

To avoid damage to the GPU (die or solder-ball joint cracks) caused by improper mechanical assembly of the cooling device, follow the following recommendations:

- It is recommended that the maximum pressure that is evenly applied across the contact area between the thermal management device and the die does not exceed 75 PSI. A contact pressure of 30-40 PSI is adequate to secure the thermal management device and to achieve the lowest thermal contact resistance with a temperature drop across the thermal interface material of no more than 3°C. Also, the surface flatness of the metal spreader should be 0.001 inch/1 inch.
- Pre-test the assembly fixture with a strain gauge to ensure that the flexing of the final assembled board and the pressure applying around the GPU package will not exceed 600-micron strain under any circumstance.
- Ensure that any distortion (bow or twist) of the board after SMT and cooling device assembly is within industry guidelines (IPC/EIA J-STD-001). For the measurement method, refer to the industry approved technique described in the manual, *IPC-TM-650*, section 2.4.22.

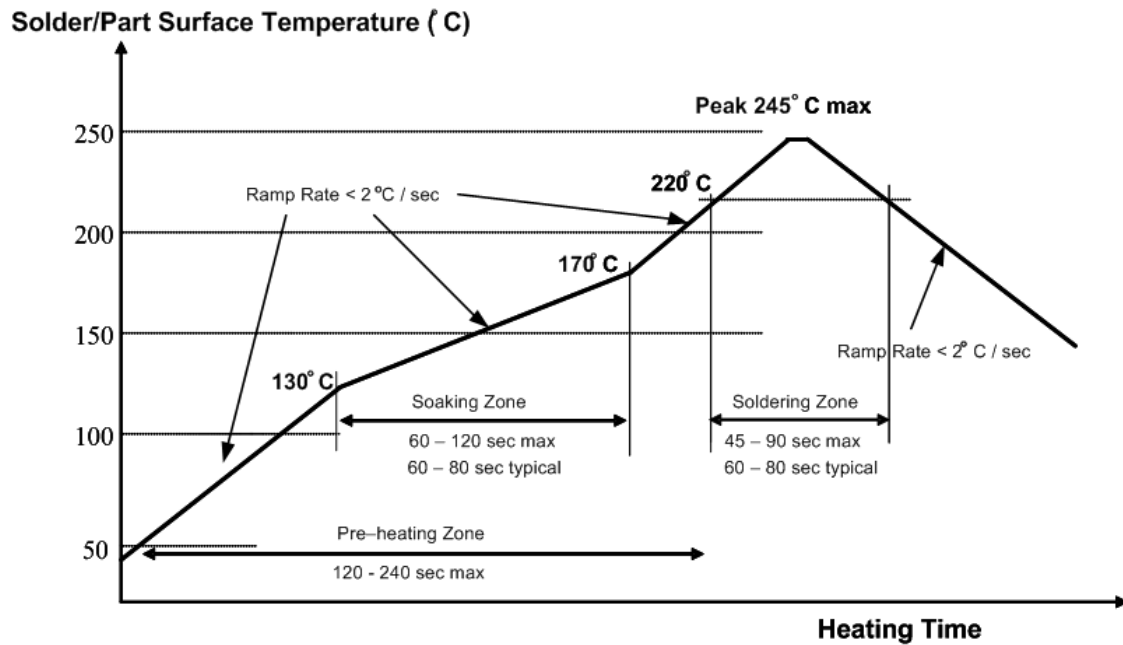
## 7.3 Board Solder Reflow Process Recommendations

### 7.3.1 Stencil Opening Size for Solderball Pads on PCB

Warping of the PCB and the BGA package may cause solder-joint quality issues at the surface mount. Therefore, it is recommended that the stencil opening sizes be adjusted to compensate for the warpage. The recommendation is for the stencil aperture of BGA balls to be kept as the same size as the PWB BGA pad design.

### 7.3.2 FCBGA Reference Reflow Profile for RoHS/Lead-free Solder

Figure 7-4 FCBGA Reference Reflow Profile for RoHS/Lead-Free SMT



Notes when using RoHS/lead-free solder (SAC305 Tin-Silver-Cu):

- The final reflow temperature profile will depend on the type of solder paste and chemistry of flux used in the SMT process or BGA rework process. Modifications to this reference reflow profile may also be required in order to accommodate to other critical components.
- The use of a reflow oven with 10 heating zones or above is highly recommended.
- To ensure that the reflow profile meets the target specification on both sides of SMT components, a different reflow profile for the first and second reflow may be required.
- A mechanical stiffening carrier boat can be used to minimize PWB warpage during the reflow process.
- It is suggested to decrease the temperature cooling rate to minimize BGA component and PWB warpage.
- This recommended reflow profile applies only to the RoHS/lead-free (high temperature) soldering process, and it should not be applied to Eutectic solder packages without any reliability validation.
- Maximum three reflows are allowed on the same part.

Table 7-2 Recommended Profiling — RoHS/Lead-Free Solder

Profiling Stage	Temperature	Process Range
Overall Preheat	Room temperature to 220°C	Two to four minutes
Soaking Time	130°C to 170°C	Typically 60 to 80 seconds
Liquidus	220°C	Typically 60 to 80 seconds
Ramp Rate	Ramp up and cooling	< 2°C / second
Peak	Maximum 245°C	235°C ± 5°C
Temperature at Peak Within 5°C	240°C to 245°C	10 to 30 seconds



# Boundary Scan Specification

This chapter contains information on boundary scan specifications as they apply to "Polaris 10". To go to a topic of interest, use the following list of linked cross-references:

- [Introduction \(p. 73\)](#)
- [Boundary Scan \(p. 73\)](#)
- [JTAG Interface Signals \(p. 73\)](#)
- [JTAG Timing Characteristics \(p. 74\)](#)

## 8.1 Introduction

"Polaris 10" has a JTAG 1149.1 compliant TAP controller. The boundary scan implementation is IEEE compliant. The implementation supports BYPASS, EXTEST, and PRELOAD instructions. A BSDL file for each of the modes can be obtained from the AMD OEM Resource Center.

## 8.2 Boundary Scan

The "Polaris 10" boundary scan can perform board-level capture and drive out on all pins mentioned in the BSDL file.

## 8.3 JTAG Interface Signals

Table 8–1 JTAG Interface

Pin-name	I/O	Description
<b>JTAG_TCK</b>	I	TCK: Test clock.
<b>JTAG_TMS</b>	I	TMS: Test mode select.
<b>JTAG_TDI</b>	I	TDI: Test data in.
<b>JTAG_TDO</b>	O	TDO: Test data out.
<b>JTAG_TRSTB</b>	I	TRST#: Test asynchronous reset.
<b>TESTEN</b>	I	Compliance pin: Pull up to 3.3 V to enable JTAG access.

## 8.4 JTAG Timing Characteristics

Table 8–2 JTAG Timing Characteristics

Symbol	Description	Min	Max
$f_{cyc}$	Frequency of operation.	0.001 MHz	10 MHz
$t_{cyc}$	TCK cycle period.	0.10 $\mu$ s	1000 $\mu$ s
$t_{bsst}$	Input data setup time to TCK rise.	15 ns	
$t_{bsht}$	Input data hold time to TCK rise.	20 ns	
$t_{bsdv}$	TCK low to output data valid.	0.00 $\mu$ s	0.05 $\mu$ s
$t_{tcst}$	TDI, TMS setup time to TCK rise.	2.5 ns	
$t_{tcht}$	TDI, TMS hold time to TCK rise.	3.0 ns	
$t_{tcdv}$	TCK low to TDO data valid.	0.0 $\mu$ s	0.05 $\mu$ s

Figure 8–1 Timing of the Boundary Scan Signals with Respect to TCK

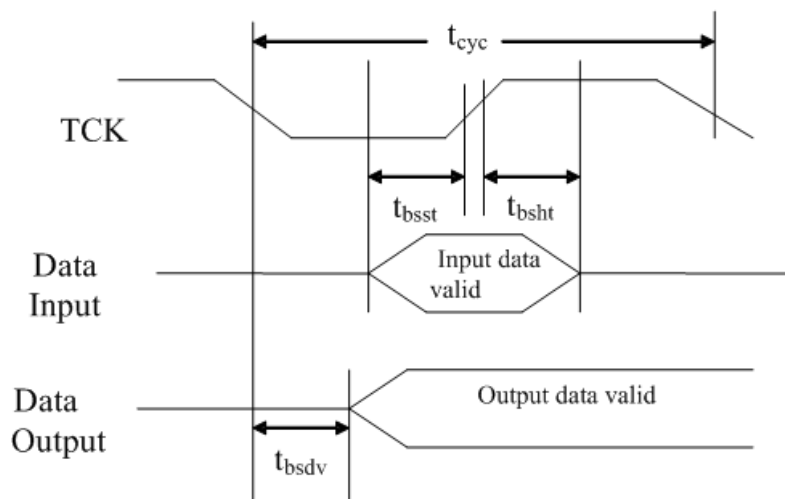
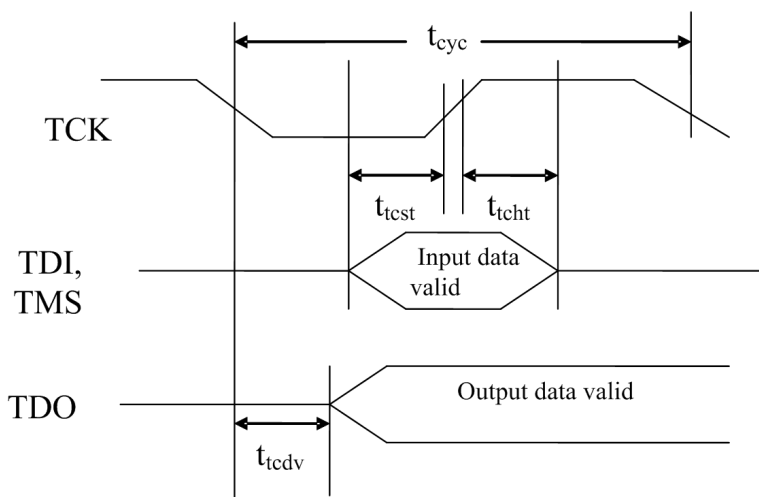


Figure 8–2 Timing of the TAP Ports (TDI, TMS, and TDO) with Respect to TCK



# Appendix A

## Pin Listings

This appendix contains pin listings for "Polaris 10" sorted in two ways. To go to the listing of interest, use the following list of linked cross-references:

- [Pins Sorted by Ball Reference \(p. 75\)](#)
- [Pins Sorted by Signal Name \(p. 108\)](#)

### A.1 Pins Sorted by Ball Reference

Table A–1 "Polaris 10" Pins Sorted by Ball Reference

Ball Reference	Signal Name
A2	VSS
A3	DQB1_31
A5	DDBIB1_3
A6	VSS
A8	WCKB1_1
A9	DQB1_23
A11	VSS
A12	EDCB1_2
A14	DQB1_18
A15	VSS
A17	DQB0_21
A18	EDCB0_2
A19	VSS
A20	DQB0_17
A21	WCKB0_1
A23	DQB0_29
A24	DQB0_28
A25	VSS
A26	DQB0_24
A27	DQA1_15
A29	VSS
A30	DDBIA1_1
A32	DQA1_8
A33	VSS
A35	DQA1_7
A36	DQA1_5

Ball Reference	Signal Name
A38	VSS
A39	DQA1_2
A41	DQA1_0
A42	VSS
B1	VSS
B2	VSS
B4	DQB1_30
B5	EDCB1_3
B6	DQB1_27
B8	VSS
B9	WCKB1B_1
B11	DQB1_21
B12	VSS
B14	DQB1_19
B15	DQB1_16
B17	VSS
B18	DQB0_20
B19	DQB0_19
B20	VSS
B21	WCKB0B_1
B23	DQB0_30
B24	VSS
B25	DQB0_27
B26	DQB0_25
B27	VSS
B29	DQA1_12
B30	DQA1_11
B32	VSS
B33	WCKA1_0
B35	DQA1_6
B36	VSS
B38	EDCA1_0
B39	VSS
B40	DQA1_1
B42	VSS
B43	VSS
C1	DQC0_0
C4	DQB1_29
C5	VSS
C6	DQB1_26
C8	DQB1_24
C9	VSS



Ball Reference	Signal Name
C11	DQB1_22
C12	DDBIB1_2
C14	VSS
C15	DQB1_17
C17	DQB0_22
C18	VSS
C19	DDBIB0_2
C20	DQB0_16
C21	VSS
C23	VSS
C24	DDBIB0_3
C25	DQB0_26
C26	VSS
C27	DQA1_14
C29	EDCA1_1
C30	VSS
C32	DQA1_9
C33	WCKA1B_0
C35	VSS
C36	DQA1_4
C38	DQA1_3
C39	DQA0_31
C40	VSS
C43	DQA0_14
D2	DQC0_1
D3	DQC0_2
D5	DQB1_28
D6	VSS
D8	DQB1_25
D9	EDCB1_1
D11	VSS
D12	DQB1_20
D14	DQB1_6
D15	VSS
D17	DQB0_23
D18	DQB0_15
D19	VSS
D20	DQB0_18
D21	DQB0_31
D23	DQB0_5
D24	EDCB0_3
D25	VSS

Ball Reference	Signal Name
D26	DQA1_29
D27	DQA1_13
D29	VSS
D30	WCKA1_1
D32	DQA1_10
D33	VSS
D35	EDCA1_2
D36	DDBIA1_0
D38	VSS
D39	DQA0_30
D41	VSS
D42	DQA0_15
E1	DDBIC0_0
E2	EDCC0_0
E3	VSS
E4	DQC0_3
E5	VSS
E6	VMEMIO
E8	VSS
E9	DQB1_12
E11	DQB1_9
E12	VMEMIO
E14	DQB1_7
E15	EDCB1_0
E17	VMEMIO
E18	DQB0_14
E19	DQB0_12
E20	VMEMIO
E21	DQB0_8
E23	DQB0_6
E24	VSS
E25	DQB0_1
E26	DQA1_30
E27	VMEMIO
E29	DQA1_26
E30	WCKA1B_1
E32	VMEMIO
E33	DQA1_20
E35	DDBIA1_2
E36	VSS
E38	DQA1_16
E39	VSS

Ball Reference	Signal Name
E40	DQA0_28
E41	DQA0_29
E42	VSS
E43	DQA0_13
F1	VSS
F2	DQC0_4
F3	DQC0_5
F4	VSS
F5	VMEMIO
F6	VSS
F8	DQB1_15
F9	VSS
F11	DQB1_10
F12	WCKB1_0
F14	VSS
F15	DQB1_4
F17	DQB1_2
F18	VSS
F19	DQB0_13
F20	DQB0_11
F21	VSS
F23	VSS
F24	EDCB0_0
F25	DQB0_2
F26	VSS
F27	DQA1_28
F29	DQA1_27
F30	VSS
F32	DQA1_22
F33	DQA1_21
F35	VSS
F36	DQA1_18
F38	VSS
F39	DDBIA0_3
F40	VSS
F41	DQA0_12
F42	EDCA0_1
F43	VSS
G9	DQB1_13
G11	VMEMIO
G12	WCKB1B_0
G14	CLKB1B

Ball Reference	Signal Name
G15	VMEMIO
G17	DQB1_3
G18	DQB1_0
G19	VMEMIO
G20	DQB0_10
G21	WCKB0_0
G23	DQB0_7
G24	DDBIB0_0
G25	VMEMIO
G26	DQA1_31
G27	EDCA1_3
G29	VMEMIO
G30	DQA1_24
G32	DQA1_23
G33	VMEMIO
G35	DQA1_19
H1	WCKC0_0
H2	VSS
H3	DQC0_7
H4	DQC0_6
H5	VSS
H6	DQC0_16
H8	VSS
H9	DQB1_14
H11	DQB1_11
H12	VSS
H14	CLKB1
H15	DQB1_5
H17	VSS
H18	DQB1_1
H19	DDBIB0_1
H20	VSS
H21	WCKB0B_0
H23	MAB0_0
H24	VSS
H25	DQB0_3
H26	VSS
H27	VSS
H29	DDBIA1_3
H30	WEA1B
H32	VSS
H33	MAA1_0

Ball Reference	Signal Name
H35	MAA1_6
H36	DQA1_17
H38	EDCA0_3
H39	VSS
H40	DDBIA0_1
H41	DQA0_11
H42	VSS
H43	DQA0_10
J1	DQC0_8
J2	WCKC0B_0
J3	VSS
J4	EDCC0_2
J5	DQC0_19
J6	VSS
J7	DQC0_18
J8	DQC0_17
J9	VSS
J11	DDBIB1_1
J12	DQB1_8
J14	VMEMIO
J15	MAB1_5
J17	DDBIB1_0
J18	VMEMIO
J19	EDCB0_1
J20	DQB0_9
J21	VSS
J23	VMEMIO
J24	DQB0_4
J25	WEB0B
J26	VMEMIO
J27	MAB0_9
J29	DQA1_25
J30	VMEMIO
J32	MAA1_2
J33	MAA1_8
J35	VSS
J36	ADBIA1
J37	DQA0_27
J38	VSS
J39	DQA0_26
J40	DQA0_25
J41	VSS

Ball Reference	Signal Name
J42	DQA0_9
J43	DQA0_8
K12	CSB1B_0
K14	MAB1_9
K15	VSS
K17	MAB1_1
K18	MAB1_7
K19	VSS
K20	RASB0B
K21	CASB0B
K23	MAB0_8
K24	MAB0_2
K25	VSS
K26	DQB0_0
K27	VSS
K29	VSS
K30	MAA1_4
K32	MAA1_3
L1	VSS
L2	DQC0_10
L3	DQC0_9
L4	VSS
L5	DQC0_22
L6	DQC0_21
L7	VSS
L8	DQC0_20
L9	DDBIC0_2
L11	VSS
L12	VSS
L14	VSS
L15	MAB1_4
L17	VMEMIO
L18	MAB1_8
L19	ADBIB1
L20	VMEMIO
L21	ADBIB0
L23	MAB0_7
L24	VMEMIO
L25	MAB0_4
L26	CSB0B_0
L27	VMEMIO
L29	CLKA1B

Ball Reference	Signal Name
L30	MAA1_5
L32	VSS
L33	MAA1_7
L35	CASA1B
L36	DQA0_24
L37	VMEMIO
L38	WCKA0B_1
L39	WCKA0_1
L40	VSS
L41	WCKA0B_0
L42	WCKA0_0
L43	VSS
M1	EDCC0_1
M2	VSS
M3	DDBIC0_1
M4	DQC0_11
M5	VMEMIO
M6	WCKC0_1
M7	WCKC0B_1
M8	VSS
M9	DQC0_23
M10	CSC0B_0
M11	VSS
M12	VMEMIO
M14	DRAM_RSTB
M15	WEB1B
M17	MAB1_3
M18	VSS
M19	CASB1B
M20	RASB1B
M21	VSS
M23	VSS
M24	MAB0_3
M25	MAB0_5
M26	VSS
M27	CSA1B_0
M29	CLKA1
M30	VSS
M32	MAA1_1
M33	VSS
M34	CKEA1
M35	RASA1B

Ball Reference	Signal Name
M36	VSS
M37	DQA0_23
M38	DQA0_22
M39	VMEMIO
M40	DQA0_7
M41	DQA0_6
M42	VSS
M43	DQA0_5
N15	VMEMIO
N17	MAB1_2
N18	MAB1_0
N19	VMEMIO
N20	CKEB1
N21	CKEB0
N23	MAB0_6
N24	MAB0_1
N25	VMEMIO
N26	CLKB0B
N27	MAA1_9
N29	VMEMIO
P1	DQC0_13
P2	DQC0_12
P3	VSS
P4	DQC0_25
P5	DQC0_24
P6	VSS
P7	CLKC0B
P8	CLKC0
P9	VSS
P10	MAC0_9
P11	VSS
P12	DRAM_RSTC
P14	VMEMIO
P15	MEM_CALRB
P17	VSS
P18	VSS
P19	MAB1_6
P20	MVREFDB
P21	VDDCI
P23	VDDCI
P24	VSS
P25	MVREFDA



Ball Reference	Signal Name
P26	CLKB0
P27	VSS
P29	VSS
P30	VMEMIO
P32	VSS
P33	RASA0B
P34	CKEA0
P35	VMEMIO
P36	ADBIA0
P37	DQA0_21
P38	VSS
P39	DQA0_20
P40	DDBIA0_2
P41	VSS
P42	DQA0_4
P43	DDBIA0_0
R1	VSS
R2	DQC0_15
R3	DQC0_14
R4	VSS
R5	EDCC0_3
R6	DQC0_27
R7	VMEMIO
R8	DQC0_26
R9	MAC0_5
R10	VSS
R11	MAC0_4
R12	WEC0B
R13	VMEMIO
R14	MEM_CALRC
R15	VSS
R16	VDDCI
R17	VSS
R18	VDDCI
R19	VDDCI
R20	VDDCI
R21	VSS
R22	VSS
R23	VSS
R24	VDDCI
R25	VDDCI
R26	VDDCI

Ball Reference	Signal Name
R27	VSS
R28	VDDCI
R29	VSS
R30	VSS
R31	VMEMIO
R32	CASA0B
R33	MAA0_6
R34	VSS
R35	MAA0_7
R36	DQA0_19
R37	VMEMIO
R38	DQA0_18
R39	EDCA0_2
R40	VSS
R41	EDCA0_0
R42	DQA0_3
R43	VSS
T15	VDDCI
T16	VDDC
T17	VDDC
T18	VSS
T19	VSS
T20	VDDC
T21	VDDC
T22	VSS
T23	VSS
T24	VDDC
T25	VDDC
T26	VSS
T27	VDDCI
T28	VSS
T29	VDDCI
U1	DQC1_10
U2	VSS
U3	DQC1_9
U4	DQC1_8
U5	VMEMIO
U6	DQC0_29
U7	DQC0_28
U8	VSS
U9	DDBIC0_3
U10	MAC0_1

Ball Reference	Signal Name
U11	VMEMIO
U12	MAC0_3
U13	MAC0_2
U14	VSS
U15	VSS
U16	VDDC
U17	VDDC
U18	VSS
U19	VSS
U20	VDDC
U21	VDDC
U22	VSS
U23	VSS
U24	VDDC
U25	VDDC
U26	VSS
U27	VSS
U28	VDDCI
U29	VSS
U30	VSS
U31	MAA0_8
U32	MAA0_0
U33	VMEMIO
U34	MAA0_1
U35	MAA0_3
U36	VSS
U37	DQA0_17
U38	DQA0_16
U39	VMEMIO
U40	DQA0_2
U41	DQA0_1
U42	VSS
U43	DQA0_0
V1	EDCC1_1
V2	DQC1_11
V3	VSS
V4	DQC1_16
V5	DQC1_17
V6	VSS
V7	DQC0_31
V8	DQC0_30
V9	VMEMIO

Ball Reference	Signal Name
V10	MAC0_7
V11	MAC0_8
V12	VSS
V13	MAC0_0
V14	TEST6
V15	VDDCI
V16	VDDC
V17	VDDC
V18	VSS
V19	VSS
V20	VDDC
V21	VDDC
V22	VSS
V23	VSS
V24	VDDC
V25	VDDC
V26	VSS
V27	VSS
V28	VDDC
V29	VDDCI
V30	VSS
V31	MAA0_2
V32	VSS
V33	MAA0_5
V34	WEA0B
V35	VMEMIO
V36	MAA0_4
V37	VSS
V38	GPIO_1
V39	GPIO_0
V40	PX_EN
V41	GPIO_13
V42	GPIO_12
V43	GPIO_11
W1	VSS
W2	DQC1_12
W3	DDBIC1_1
W4	VSS
W5	DQC1_19
W6	DQC1_18
W7	VMEMIO
W8	DDBIC1_2

Ball Reference	Signal Name
W9	EDCC1_2
W10	VSS
W11	ADBIC0
W12	CASC0B
W13	VMEMIO
W14	MAC0_6
W15	VDDCI
W16	VDDC
W17	VDDC
W18	VSS
W19	VSS
W20	VDDC
W21	VDDC
W22	VSS
W23	VSS
W24	VDDC
W25	VDDC
W26	VSS
W27	VSS
W28	VDDC
W29	VDDC
W30	DRAM_RSTA
W31	VMEMIO
W32	CLKA0
W33	CLKA0B
W34	VSS
W35	MAA0_9
W36	VSS
W37	GPIO_2
W38	VSS
W39	VSS
W40	VSS
W41	VSS
W42	PCIE_RX15P
W43	PCIE_RX15N
Y1	DQC1_14
Y2	VSS
Y3	DQC1_15
Y4	DQC1_13
Y5	VSS
Y6	DQC1_20
Y7	DQC1_21

Ball Reference	Signal Name
Y8	VSS
Y9	DQC1_22
Y10	RASC1B
Y11	VMEMIO
Y12	RASC0B
Y13	CKEC0
Y14	MVREFDC
Y15	VDDCI
Y16	VDDC
Y17	VDDC
Y18	VSS
Y19	VSS
Y20	VDDC
Y21	VDDC
Y22	VSS
Y23	VSS
Y24	VDDC
Y25	VDDC
Y26	VSS
Y27	VSS
Y28	VDDC
Y29	VDDC
Y30	VSS
Y31	MEM_CALRA
Y32	TEST_PG_BACO
Y33	VMEMIO
Y34	CSA0B_0
Y35	VSS
Y36	VSS
Y37	VSS
Y38	PCIE_TX15P
Y39	PCIE_TX15N
Y40	VSS
Y41	PCIE_RX13N
Y42	PCIE_RX14N
Y43	PCIE_RX14P
AA1	WCKC1_0
AA2	WCKC1B_0
AA3	VSS
AA4	DQC1_0
AA5	DQC1_23
AA6	VSS

Ball Reference	Signal Name
AA7	WCKC1_1
AA8	WCKC1B_1
AA9	VSS
AA10	CASC1B
AA11	ADBIC1
AA12	VSS
AA13	CKEC1
AA14	VDDCI
AA15	VSS
AA16	VDDC
AA17	VDDC
AA18	VSS
AA19	VSS
AA20	VDDC
AA21	VDDC
AA22	VSS
AA23	VSS
AA24	VDDC
AA25	VDDC
AA26	VSS
AA27	VSS
AA28	VDDC
AA29	VDDC
AA30	TS_A
AA31	TEST_PG
AA32	VSS
AA33	VSS
AA34	VDD_08
AA35	VDD_08
AA36	VSS
AA37	PCIE_TX13N
AA38	PCIE_TX14N
AA39	PCIE_TX14P
AA40	VSS
AA41	PCIE_RX13P
AA42	PCIE_RX12P
AA43	PCIE_RX12N
AB15	VSS
AB16	VDDC
AB17	VDDC
AB18	VSS
AB19	VSS

Ball Reference	Signal Name
AB20	VDDC
AB21	VDDC
AB22	VSS
AB23	VSS
AB24	VDDC
AB25	VDDC
AB26	VSS
AB27	VSS
AB28	VDDC
AB29	VDDC
AC1	DQC1_2
AC2	DQC1_1
AC3	VSS
AC4	DQC1_26
AC5	DQC1_25
AC6	VSS
AC7	DQC1_24
AC8	MAC1_0
AC9	VMEMIO
AC10	MAC1_8
AC11	MAC1_7
AC12	VSS
AC13	MAC1_6
AC14	VDDCI
AC15	VSS
AC16	VDDC
AC17	VDDC
AC18	VSS
AC19	VSS
AC20	VDDC
AC21	VDDC
AC22	VSS
AC23	VSS
AC24	VDDC
AC25	VDDC
AC26	VSS
AC27	VSS
AC28	VDDC
AC29	VDDC
AC30	JTAG_TRSTB
AC31	GPIO_19_CTF
AC32	VSS



Ball Reference	Signal Name
AC33	VSS
AC34	DMINUS
AC35	DPLUS
AC36	VSS
AC37	PCIE_TX13P
AC38	PCIE_TX12P
AC39	PCIE_TX12N
AC40	VSS
AC41	VSS
AC42	PCIE_RX11N
AC43	PCIE_RX11P
AD1	DQC1_3
AD2	VSS
AD3	DDBIC1_0
AD4	EDCC1_0
AD5	VSS
AD6	EDCC1_3
AD7	DDBIC1_3
AD8	VSS
AD9	DQC1_27
AD10	MAC1_2
AD11	VMEMIO
AD12	MAC1_3
AD13	MAC1_1
AD14	VSS
AD15	VDDCI
AD16	VDDC
AD17	VDDC
AD18	VSS
AD19	VSS
AD20	VDDC
AD21	VDDC
AD22	VSS
AD23	VSS
AD24	VDDC
AD25	VDDC
AD26	VSS
AD27	VSS
AD28	VDDC
AD29	VDDC
AD30	JTAG_TDI
AD31	JTAG_TDO

Ball Reference	Signal Name
AD32	VSS
AD33	DDCVGADATA
AD34	DDCVGACLK
AD35	VSS
AD36	VDD_08
AD37	VSS
AD38	PCIE_TX11N
AD39	PCIE_TX11P
AD40	VSS
AD41	PCIE_RX9N
AD42	PCIE_RX10N
AD43	PCIE_RX10P
AE1	VSS
AE2	DQC1_5
AE3	DQC1_4
AE4	VSS
AE5	DQC1_30
AE6	DQC1_29
AE7	VMEMIO
AE8	DQC1_28
AE9	WEC1B
AE10	VSS
AE11	MAC1_4
AE12	MAC1_5
AE13	VMEMIO
AE14	MVREFDD
AE15	VDDCI
AE16	VDDC
AE17	VDDC
AE18	VSS
AE19	VSS
AE20	VDDC
AE21	VDDC
AE22	VSS
AE23	VSS
AE24	VDDC
AE25	VDDC
AE26	VSS
AE27	VSS
AE28	VDDC
AE29	VDDC
AE30	TESTEN

Ball Reference	Signal Name
AE31	JTAG_TMS
AE32	VSS
AE33	GPIO_17_THERMAL_INT
AE34	GPIO_6_TACH
AE35	VDD_08
AE36	VSS
AE37	PCIE_TX9N
AE38	PCIE_TX10N
AE39	PCIE_TX10P
AE40	VSS
AE41	PCIE_RX9P
AE42	PCIE_RX8P
AE43	PCIE_RX8N
AF1	DQC1_7
AF2	DQC1_6
AF3	VSS
AF4	DQD0_2
AF5	DQD0_1
AF6	VSS
AF7	DQD0_0
AF8	VSS
AF9	VMEMIO
AF10	DQC1_31
AF11	CSC1B_0
AF12	VSS
AF13	CLKC1B
AF14	CLKC1
AF15	VDDCI
AF16	VDDC
AF17	VDDC
AF18	VSS
AF19	VSS
AF20	VDDC
AF21	VDDC
AF22	VSS
AF23	VSS
AF24	VDDC
AF25	VDDC
AF26	VSS
AF27	VSS
AF28	VDDC
AF29	VDDC

Ball Reference	Signal Name
AF30	JTAG_TCK
AF31	GPIO_28_FDO
AF32	VSS
AF33	SDA
AF34	SCL
AF35	VDD_08
AF36	VSS
AF37	PCIE_TX9P
AF38	PCIE_TX8P
AF39	PCIE_TX8N
AF40	VSS
AF41	VSS
AF42	PCIE_RX7N
AF43	PCIE_RX7P
AG1	DQD0_16
AG2	VSS
AG3	DQD0_17
AG4	DQD0_18
AG5	VMEMIO
AG6	DQD0_3
AG7	EDCD0_0
AG8	VSS
AG9	MAC1_9
AG10	VSS
AG11	VMEMIO
AG12	CSD0B_0
AG13	MAD0_9
AG14	VSS
AG15	VSS
AG16	VDDCI
AG17	VDDC
AG18	VSS
AG19	VSS
AG20	VDDC
AG21	VDDC
AG22	VSS
AG23	VSS
AG24	VDDC
AG25	VDDC
AG26	VSS
AG27	VSS
AG28	VDDC

Ball Reference	Signal Name
AG29	VDDC
AG30	GPIO_30
AG31	GPIO_29
AG32	VSS
AG33	TEMPIN0
AG34	TEMPINRETURN
AG35	VSS
AG36	VDD_08
AG37	VSS
AG38	PCIE_TX7N
AG39	PCIE_TX7P
AG40	VSS
AG41	PCIE_RX5N
AG42	PCIE_RX6N
AG43	PCIE_RX6P
AH15	VDDCI
AH16	VSS
AH17	VDDCI
AH18	VDDC
AH19	VDDC
AH20	VDDC
AH21	VDDC
AH22	VDDC
AH23	VDDC
AH24	VDDC
AH25	VDDC
AH26	VDDC
AH27	VDDC
AH28	VDDC
AH29	VDDC
AJ1	VSS
AJ2	DQD0_19
AJ3	EDCD0_2
AJ4	VSS
AJ5	DQD0_5
AJ6	DQD0_4
AJ7	VMEMIO
AJ8	DDBID0_0
AJ9	DQD0_6
AJ10	VSS
AJ11	CLKD0B
AJ12	CLKD0

Ball Reference	Signal Name
AJ13	VMEMIO
AJ14	VSS
AJ15	VSS
AJ16	VDDCI
AJ17	VSS
AJ18	VDDCI
AJ19	VDDC
AJ20	VDDC
AJ21	VDDC
AJ22	VDDC
AJ23	VDDC
AJ24	VDDC
AJ25	VDDC
AJ26	VDDC
AJ27	VDDC
AJ28	VDDC
AJ29	VSS
AJ30	VDD_08
AJ31	GPIO_15
AJ32	VSS
AJ33	GPIO_16_8P_DETECT
AJ34	GPIO_5_REG_HOT_AC_BATT
AJ35	VDD_08
AJ36	VSS
AJ37	PCIE_TX5N
AJ38	PCIE_TX6N
AJ39	PCIE_TX6P
AJ40	VSS
AJ41	PCIE_RX5P
AJ42	PCIE_RX4P
AJ43	PCIE_RX4N
AK1	DDBID0_2
AK2	DQD0_20
AK3	VSS
AK4	WCKD0_0
AK5	WCKD0B_0
AK6	VSS
AK7	DQD0_7
AK8	WED0B
AK9	VMEMIO
AK10	MAD0_4
AK11	MAD0_5

Ball Reference	Signal Name
AK12	VSS
AK14	VMEMIO
AK15	VSS
AK17	VSS
AK18	VSS
AK19	DRAM_RSTD
AK20	VSS
AK21	FB_VSS
AK23	FB_VDDCI
AK24	VSS
AK25	DIGON
AK26	BL_ENABLE
AK27	VSS
AK29	VSS
AK30	PCIE_ZVSS
AK32	VSS
AK33	GPIO_20
AK34	GPIO_21
AK35	VDD_08
AK36	VSS
AK37	PCIE_TX5P
AK38	PCIE_TX4P
AK39	PCIE_TX4N
AK40	VSS
AK41	VSS
AK42	PCIE_RX3N
AK43	PCIE_RX3P
AL15	VMEMIO
AL17	MAD1_8
AL18	MAD1_2
AL19	VMEMIO
AL20	MEM_CALRD
AL21	FB_VDDC
AL23	VSS
AL24	VDD_33
AL25	VSS
AL26	BL_PWM_DIM
AL27	GENLK_VSYNC
AL29	VSS
AM1	DQD0_23
AM2	VSS
AM3	DQD0_22

Ball Reference	Signal Name
AM4	DQD0_21
AM5	VMEMIO
AM6	DQD0_9
AM7	DQD0_8
AM8	VSS
AM9	MAD0_2
AM10	MAD0_3
AM11	VSS
AM12	MAD0_1
AM14	VSS
AM15	CASD1B
AM17	MAD1_0
AM18	VSS
AM19	CLKD1
AM20	DRAIN
AM21	GATE
AM23	GPIO_SVC
AM24	VDD_33
AM25	VDD_18
AM26	VSS
AM27	GENLK_CLK
AM29	PLLCHARZ_H
AM30	GPIO_10_ROMSCK
AM32	VSS
AM33	SMBDAT
AM34	SMBCLK
AM35	VSS
AM36	VDD_08
AM37	VSS
AM38	PCIE_TX3N
AM39	PCIE_TX3P
AM40	VSS
AM41	PCIE_RX1N
AM42	PCIE_RX2N
AM43	PCIE_RX2P
AN1	VSS
AN2	WCKD0_1
AN3	WCKD0B_1
AN4	VSS
AN5	DQD0_11
AN6	DQD0_10
AN7	VMEMIO



Ball Reference	Signal Name
AN8	MAD0_0
AN9	MAD0_8
AN11	MAD0_7
AN12	VSS
AN14	RASD1B
AN15	MAD1_6
AN17	VMEMIO
AN18	MAD1_5
AN19	CLKD1B
AN20	VMEMIO
AN21	DBGDATA_10
AN23	GPIO_SVT
AN24	VSS
AN25	VDD_18
AN26	VDD_18
AN27	VSS
AN29	PLLCHARZ_L
AN30	GPIO_8_ROMSO
AN32	GPIO_22_ROMCSB
AN33	VSS
AN35	VDD_08
AN36	VSS
AN37	PCIE_TX1N
AN38	PCIE_TX2N
AN39	PCIE_TX2P
AN40	VSS
AN41	PCIE_RX1P
AN42	PCIE_RX0P
AN43	PCIE_RX0N
AP12	CKED0
AP14	CKED1
AP15	VSS
AP17	MAD1_1
AP18	WED1B
AP19	VSS
AP20	CSD1B_0
AP21	DBGDATA_11
AP23	GPIO_SVD
AP24	HSYNC
AP25	VSS
AP26	VDD_18
AP27	VDD_18

Ball Reference	Signal Name
AP29	VSS
AP30	VSS
AP32	GPIO_9_ROMSI
AR1	DQD0_24
AR2	DQD0_25
AR3	VSS
AR4	EDCD0_1
AR5	DDBID0_1
AR6	VSS
AR7	DQD0_12
AR8	MAD0_6
AR9	VSS
AR11	CASD0B
AR12	RASD0B
AR14	VMEMIO
AR15	MAD1_7
AR17	MAD1_3
AR18	VMEMIO
AR19	MAD1_9
AR20	DBGDATA_5
AR21	DBGDATA_15
AR23	DDC1DATA
AR24	VSYN
AR25	SWAPLOCKB
AR26	TSVDD
AR27	VDD_18
AR29	GPIO_14_HPDP2
AR30	GENERICD
AR32	VSS
AR33	VSS
AR35	VSS
AR36	VSS
AR37	PCIE_TX1P
AR38	PCIE_TX0P
AR39	PCIE_TX0N
AR40	VSS
AR41	VSS
AR42	PCIE_REFCLKP
AR43	PCIE_REFCLKN
AT1	DQD0_26
AT2	VSS
AT3	DQD0_27

Ball Reference	Signal Name
AT4	DDBID0_3
AT5	VSS
AT6	DQD0_13
AT8	DQD0_14
AT9	ADBID0
AT11	DQD1_7
AT12	VSS
AT14	ADBID1
AT15	DQD1_12
AT17	VSS
AT18	MAD1_4
AT19	DBGDATA_2
AT20	DBGDATA_6
AT21	VSS
AT23	DDC1CLK
AT24	GENERICB
AT25	SWAPLOCKA
AT26	VSS
AT27	VSS
AT29	GPIO_18_HPD3
AT30	GENERICC
AT32	HPD1
AT33	DDCAUX4N
AT35	VSS
AT36	DP_ZVDD_08
AT38	VSS
AT39	VSS
AT40	VSS
AT41	VSS
AT42	VSS
AT43	VSS
AU9	DQD1_4
AU11	VMEMIO
AU12	DQD1_8
AU14	DQD1_10
AU15	VMEMIO
AU17	DQD1_14
AU18	VSS
AU19	VSS
AU20	DBGDATA_9
AU21	DBGDATA_14
AU23	VSS

Ball Reference	Signal Name
AU24	VSS
AU25	VSS
AU26	DDC2CLK
AU27	DDCAUX3P
AU29	GENERICF_HPD4
AU30	GENERICF_HPD5
AU32	GENERICG_HPD6
AU33	DDCAUX4P
AU35	DDCAUX5P
AV1	VSS
AV2	EDCD0_3
AV3	DQD0_28
AV4	VSS
AV5	DQD0_15
AV6	VSS
AV8	EDCD1_0
AV9	VSS
AV11	WCKD1B_0
AV12	DQD1_9
AV14	VSS
AV15	DQD1_13
AV17	DQD1_15
AV18	DBGDATA_0
AV19	DBGDATA_3
AV20	VSS
AV21	DBGDATA_13
AV23	AUX1P
AV24	BP_1
AV25	AUX2P
AV26	DDC2DATA
AV27	DDCAUX3N
AV29	VSS
AV30	VSS
AV32	VSS
AV33	VSS
AV35	DDCAUX5N
AV36	DP_ZVSS
AV38	VSS
AV39	VSS
AV40	VSS
AV41	CLKREQB
AV42	PERSTB

Ball Reference	Signal Name
AV43	WAKEB
AW1	DQD0_29
AW2	VSS
AW3	DQD1_0
AW4	DQD1_1
AW5	VSS
AW6	DDBID1_0
AW8	VSS
AW9	DQD1_5
AW11	WCKD1_0
AW12	VMEMIO
AW14	DQD1_11
AW15	EDCD1_1
AW17	VMEMIO
AW18	DBGDATA_1
AW19	DBGDATA_4
AW20	DBGDATA_8
AW21	DBGDATA_12
AW23	AUX1N
AW24	BP_0
AW25	AUX2N
AW26	VSS
AW27	VSS
AW29	VSS
AW30	VSS
AW32	VSS
AW33	VSS
AW35	VSS
AW36	VSS
AW38	VSS
AW39	VSS
AW40	GENERICA
AW41	VSS
AW42	ANALOGIO
AW43	VSS
AY2	DQD0_30
AY3	VSS
AY5	DQD1_3
AY6	VSS
AY8	DDBID1_2
AY9	DQD1_6
AY11	VSS

Ball Reference	Signal Name
AY12	DQD1_24
AY14	DDBID1_1
AY15	VSS
AY17	DQD1_29
AY18	VSS
AY19	VSS
AY20	DBGDATA_7
AY21	TXCEM_DPE3N
AY23	TXCEP_DPE3P
AY24	AUX_ZVSS
AY25	VSS
AY26	TX1M_DPD1N
AY27	TX1P_DPD1P
AY29	TX3M_DPC2N
AY30	TX3P_DPC2P
AY32	TXCBM_DPB3N
AY33	TXCBP_DPB3P
AY35	TX2M_DPB0N
AY36	TX2P_DPB0P
AY38	TX4M_DPA1N
AY39	TX4P_DPA1P
AY41	VSS
AY42	XTALOUT
BA1	DQD0_31
BA4	VSS
BA5	DQD1_2
BA6	DQD1_19
BA8	DQD1_20
BA9	VSS
BA11	WCKD1B_1
BA12	DQD1_25
BA14	VSS
BA15	EDCD1_3
BA17	DQD1_30
BA18	VSS
BA19	TX0M_DPF2N
BA20	TX0P_DPF2P
BA21	VSS
BA23	VSS
BA24	TX5M_DPE0N
BA25	TX5P_DPE0P
BA26	VSS

Ball Reference	Signal Name
BA27	VSS
BA29	VSS
BA30	VSS
BA32	VSS
BA33	VSS
BA35	VSS
BA36	VSS
BA38	VSS
BA39	VSS
BA40	VSS
BA43	XTALIN
BB1	VSS
BB2	VSS
BB4	DQD1_16
BB5	VSS
BB6	EDCD1_2
BB8	VSS
BB9	DQD1_22
BB11	WCKD1_1
BB12	VSS
BB14	DQD1_27
BB15	DQD1_28
BB17	VSS
BB18	VSS
BB19	TXCFM_DPF3N
BB20	TX1P_DPF1P
BB21	TX2M_DPF0N
BB23	TX3P_DPE2P
BB24	TX4M_DPE1N
BB25	TXCDP_DPD3P
BB26	TX0M_DPD2N
BB27	TX2P_DPD0P
BB29	TXCCM_DPC3N
BB30	TX4P_DPC1P
BB32	TX5M_DPC0N
BB33	TX0P_DPB2P
BB35	TX1M_DPB1N
BB36	TXCAP_DPA3P
BB38	TX3M_DPA2N
BB39	TX5P_DPA0P
BB40	DDCAUX6N
BB42	VSS

Ball Reference	Signal Name
BB43	VSS
BC2	VSS
BC3	DQD1_17
BC5	DQD1_18
BC6	VSS
BC8	DQD1_21
BC9	DQD1_23
BC11	VSS
BC12	DQD1_26
BC14	DDBID1_3
BC15	VSS
BC17	DQD1_31
BC18	VSS
BC19	TXCFP_DPF3P
BC20	TX1M_DPF1N
BC21	TX2P_DPF0P
BC23	TX3M_DPE2N
BC24	TX4P_DPE1P
BC25	TXCDM_DPD3N
BC26	TX0P_DPD2P
BC27	TX2M_DPD0N
BC29	TXCCP_DPC3P
BC30	TX4M_DPC1N
BC32	TX5P_DPC0P
BC33	TX0M_DPB2N
BC35	TX1P_DPB1P
BC36	TXCAM_DPA3N
BC38	TX3P_DPA2P
BC39	TX5M_DPA0N
BC41	DDCAUX6P
BC42	VSS

## A.2 Pins Sorted by Signal Name

Table A-2 "Polaris 10" Pins Sorted by Signal Name

Signal Name	Ball Reference
ADBIA0	P36
ADBIA1	J36
ADBIB0	L21
ADBIB1	L19
ADBIC0	W11



Signal Name	Ball Reference
ADBIC1	AA11
ADBID0	AT9
ADBID1	AT14
ANALOGIO	AW42
AUX1N	AW23
AUX1P	AV23
AUX2N	AW25
AUX2P	AV25
AUX_ZVSS	AY24
BL_ENABLE	AK26
BL_PWM_DIM	AL26
BP_0	AW24
BP_1	AV24
CASA0B	R32
CASA1B	L35
CASB0B	K21
CASB1B	M19
CASC0B	W12
CASC1B	AA10
CASD0B	AR11
CASD1B	AM15
CKEA0	P34
CKEA1	M34
CKEB0	N21
CKEB1	N20
CKEC0	Y13
CKEC1	AA13
CKED0	AP12
CKED1	AP14
CLKA0	W32
CLKA0B	W33
CLKA1	M29
CLKA1B	L29
CLKB0	P26
CLKB0B	N26
CLKB1	H14
CLKB1B	G14
CLKC0	P8
CLKC0B	P7
CLKC1	AF14
CLKC1B	AF13
CLKD0	AJ12

Signal Name	Ball Reference
CLKD0B	AJ11
CLKD1	AM19
CLKD1B	AN19
CLKREQB	AV41
CSA0B_0	Y34
CSA1B_0	M27
CSB0B_0	L26
CSB1B_0	K12
CSC0B_0	M10
CSC1B_0	AF11
CSD0B_0	AG12
CSD1B_0	AP20
DBGDATA_0	AV18
DBGDATA_1	AW18
DBGDATA_2	AT19
DBGDATA_3	AV19
DBGDATA_4	AW19
DBGDATA_5	AR20
DBGDATA_6	AT20
DBGDATA_7	AY20
DBGDATA_8	AW20
DBGDATA_9	AU20
DBGDATA_10	AN21
DBGDATA_11	AP21
DBGDATA_12	AW21
DBGDATA_13	AV21
DBGDATA_14	AU21
DBGDATA_15	AR21
DDBIA0_0	P43
DDBIA0_1	H40
DDBIA0_2	P40
DDBIA0_3	F39
DDBIA1_0	D36
DDBIA1_1	A30
DDBIA1_2	E35
DDBIA1_3	H29
DDBIB0_0	G24
DDBIB0_1	H19
DDBIB0_2	C19
DDBIB0_3	C24
DDBIB1_0	J17
DDBIB1_1	J11

Signal Name	Ball Reference
DDBIB1_2	C12
DDBIB1_3	A5
DDBIC0_0	E1
DDBIC0_1	M3
DDBIC0_2	L9
DDBIC0_3	U9
DDBIC1_0	AD3
DDBIC1_1	W3
DDBIC1_2	W8
DDBIC1_3	AD7
DDBID0_0	AJ8
DDBID0_1	AR5
DDBID0_2	AK1
DDBID0_3	AT4
DDBID1_0	AW6
DDBID1_1	AY14
DDBID1_2	AY8
DDBID1_3	BC14
DDC1CLK	AT23
DDC1DATA	AR23
DDC2CLK	AU26
DDC2DATA	AV26
DDCAUX3N	AV27
DDCAUX3P	AU27
DDCAUX4N	AT33
DDCAUX4P	AU33
DDCAUX5N	AV35
DDCAUX5P	AU35
DDCAUX6N	BB40
DDCAUX6P	BC41
DDCVGACLK	AD34
DDCVGADATA	AD33
DIGON	AK25
DMINUS	AC34
DPLUS	AC35
DP_ZVDD_08	AT36
DP_ZVSS	AV36
DQA0_0	U43
DQA0_1	U41
DQA0_2	U40
DQA0_3	R42
DQA0_4	P42

Signal Name	Ball Reference
DQA0_5	M43
DQA0_6	M41
DQA0_7	M40
DQA0_8	J43
DQA0_9	J42
DQA0_10	H43
DQA0_11	H41
DQA0_12	F41
DQA0_13	E43
DQA0_14	C43
DQA0_15	D42
DQA0_16	U38
DQA0_17	U37
DQA0_18	R38
DQA0_19	R36
DQA0_20	P39
DQA0_21	P37
DQA0_22	M38
DQA0_23	M37
DQA0_24	L36
DQA0_25	J40
DQA0_26	J39
DQA0_27	J37
DQA0_28	E40
DQA0_29	E41
DQA0_30	D39
DQA0_31	C39
DQA1_0	A41
DQA1_1	B40
DQA1_2	A39
DQA1_3	C38
DQA1_4	C36
DQA1_5	A36
DQA1_6	B35
DQA1_7	A35
DQA1_8	A32
DQA1_9	C32
DQA1_10	D32
DQA1_11	B30
DQA1_12	B29
DQA1_13	D27
DQA1_14	C27

Signal Name	Ball Reference
DQA1_15	A27
DQA1_16	E38
DQA1_17	H36
DQA1_18	F36
DQA1_19	G35
DQA1_20	E33
DQA1_21	F33
DQA1_22	F32
DQA1_23	G32
DQA1_24	G30
DQA1_25	J29
DQA1_26	E29
DQA1_27	F29
DQA1_28	F27
DQA1_29	D26
DQA1_30	E26
DQA1_31	G26
DQB0_0	K26
DQB0_1	E25
DQB0_2	F25
DQB0_3	H25
DQB0_4	J24
DQB0_5	D23
DQB0_6	E23
DQB0_7	G23
DQB0_8	E21
DQB0_9	J20
DQB0_10	G20
DQB0_11	F20
DQB0_12	E19
DQB0_13	F19
DQB0_14	E18
DQB0_15	D18
DQB0_16	C20
DQB0_17	A20
DQB0_18	D20
DQB0_19	B19
DQB0_20	B18
DQB0_21	A17
DQB0_22	C17
DQB0_23	D17
DQB0_24	A26

Signal Name	Ball Reference
DQB0_25	B26
DQB0_26	C25
DQB0_27	B25
DQB0_28	A24
DQB0_29	A23
DQB0_30	B23
DQB0_31	D21
DQB1_0	G18
DQB1_1	H18
DQB1_2	F17
DQB1_3	G17
DQB1_4	F15
DQB1_5	H15
DQB1_6	D14
DQB1_7	E14
DQB1_8	J12
DQB1_9	E11
DQB1_10	F11
DQB1_11	H11
DQB1_12	E9
DQB1_13	G9
DQB1_14	H9
DQB1_15	F8
DQB1_16	B15
DQB1_17	C15
DQB1_18	A14
DQB1_19	B14
DQB1_20	D12
DQB1_21	B11
DQB1_22	C11
DQB1_23	A9
DQB1_24	C8
DQB1_25	D8
DQB1_26	C6
DQB1_27	B6
DQB1_28	D5
DQB1_29	C4
DQB1_30	B4
DQB1_31	A3
DQC0_0	C1
DQC0_1	D2
DQC0_2	D3

Signal Name	Ball Reference
DQC0_3	E4
DQC0_4	F2
DQC0_5	F3
DQC0_6	H4
DQC0_7	H3
DQC0_8	J1
DQC0_9	L3
DQC0_10	L2
DQC0_11	M4
DQC0_12	P2
DQC0_13	P1
DQC0_14	R3
DQC0_15	R2
DQC0_16	H6
DQC0_17	J8
DQC0_18	J7
DQC0_19	J5
DQC0_20	L8
DQC0_21	L6
DQC0_22	L5
DQC0_23	M9
DQC0_24	P5
DQC0_25	P4
DQC0_26	R8
DQC0_27	R6
DQC0_28	U7
DQC0_29	U6
DQC0_30	V8
DQC0_31	V7
DQC1_0	AA4
DQC1_1	AC2
DQC1_2	AC1
DQC1_3	AD1
DQC1_4	AE3
DQC1_5	AE2
DQC1_6	AF2
DQC1_7	AF1
DQC1_8	U4
DQC1_9	U3
DQC1_10	U1
DQC1_11	V2
DQC1_12	W2

Signal Name	Ball Reference
DQC1_13	Y4
DQC1_14	Y1
DQC1_15	Y3
DQC1_16	V4
DQC1_17	V5
DQC1_18	W6
DQC1_19	W5
DQC1_20	Y6
DQC1_21	Y7
DQC1_22	Y9
DQC1_23	AA5
DQC1_24	AC7
DQC1_25	AC5
DQC1_26	AC4
DQC1_27	AD9
DQC1_28	AE8
DQC1_29	AE6
DQC1_30	AE5
DQC1_31	AF10
DQD0_0	AF7
DQD0_1	AF5
DQD0_2	AF4
DQD0_3	AG6
DQD0_4	AJ6
DQD0_5	AJ5
DQD0_6	AJ9
DQD0_7	AK7
DQD0_8	AM7
DQD0_9	AM6
DQD0_10	AN6
DQD0_11	AN5
DQD0_12	AR7
DQD0_13	AT6
DQD0_14	AT8
DQD0_15	AV5
DQD0_16	AG1
DQD0_17	AG3
DQD0_18	AG4
DQD0_19	AJ2
DQD0_20	AK2
DQD0_21	AM4
DQD0_22	AM3



Signal Name	Ball Reference
DQD0_23	AM1
DQD0_24	AR1
DQD0_25	AR2
DQD0_26	AT1
DQD0_27	AT3
DQD0_28	AV3
DQD0_29	AW1
DQD0_30	AY2
DQD0_31	BA1
DQD1_0	AW3
DQD1_1	AW4
DQD1_2	BA5
DQD1_3	AY5
DQD1_4	AU9
DQD1_5	AW9
DQD1_6	AY9
DQD1_7	AT11
DQD1_8	AU12
DQD1_9	AV12
DQD1_10	AU14
DQD1_11	AW14
DQD1_12	AT15
DQD1_13	AV15
DQD1_14	AU17
DQD1_15	AV17
DQD1_16	BB4
DQD1_17	BC3
DQD1_18	BC5
DQD1_19	BA6
DQD1_20	BA8
DQD1_21	BC8
DQD1_22	BB9
DQD1_23	BC9
DQD1_24	AY12
DQD1_25	BA12
DQD1_26	BC12
DQD1_27	BB14
DQD1_28	BB15
DQD1_29	AY17
DQD1_30	BA17
DQD1_31	BC17
DRAIN	AM20

Signal Name	Ball Reference
DRAM_RSTA	W30
DRAM_RSTB	M14
DRAM_RSTC	P12
DRAM_RSTD	AK19
EDCA0_0	R41
EDCA0_1	F42
EDCA0_2	R39
EDCA0_3	H38
EDCA1_0	B38
EDCA1_1	C29
EDCA1_2	D35
EDCA1_3	G27
EDCB0_0	F24
EDCB0_1	J19
EDCB0_2	A18
EDCB0_3	D24
EDCB1_0	E15
EDCB1_1	D9
EDCB1_2	A12
EDCB1_3	B5
EDCC0_0	E2
EDCC0_1	M1
EDCC0_2	J4
EDCC0_3	R5
EDCC1_0	AD4
EDCC1_1	V1
EDCC1_2	W9
EDCC1_3	AD6
EDCD0_0	AG7
EDCD0_1	AR4
EDCD0_2	AJ3
EDCD0_3	AV2
EDCD1_0	AV8
EDCD1_1	AW15
EDCD1_2	BB6
EDCD1_3	BA15
FB_VDDC	AL21
FB_VDDCI	AK23
FB_VSS	AK21
GATE	AM21
GENERICA	AW40
GENERICB	AT24

Signal Name	Ball Reference
GENERICC	AT30
GENERICD	AR30
GENERIC_E_HPD4	AU29
GENERICF_HPD5	AU30
GENERICG_HPD6	AU32
GENLK_CLK	AM27
GENLK_VSYNC	AL27
GPIO_0	V39
GPIO_1	V38
GPIO_2	W37
GPIO_5_REG_HOT_AC_BATT	AJ34
GPIO_6_TACH	AE34
GPIO_8_ROMSO	AN30
GPIO_9_ROMSI	AP32
GPIO_10_ROMSCK	AM30
GPIO_11	V43
GPIO_12	V42
GPIO_13	V41
GPIO_14_HPD2	AR29
GPIO_15	AJ31
GPIO_16_8P_DETECT	AJ33
GPIO_17_THERMAL_INT	AE33
GPIO_18_HPD3	AT29
GPIO_19_CTF	AC31
GPIO_20	AK33
GPIO_21	AK34
GPIO_22_ROMCSB	AN32
GPIO_28_FDO	AF31
GPIO_29	AG31
GPIO_30	AG30
GPIO_SVC	AM23
GPIO_SVD	AP23
GPIO_SVT	AN23
HPD1	AT32
HSYNC	AP24
JTAG_TCK	AF30
JTAG_TDI	AD30
JTAG_TDO	AD31
JTAG_TMS	AE31
JTAG_TRSTB	AC30
MAA0_0	U32
MAA0_1	U34

Signal Name	Ball Reference
MAA0_2	V31
MAA0_3	U35
MAA0_4	V36
MAA0_5	V33
MAA0_6	R33
MAA0_7	R35
MAA0_8	U31
MAA0_9	W35
MAA1_0	H33
MAA1_1	M32
MAA1_2	J32
MAA1_3	K32
MAA1_4	K30
MAA1_5	L30
MAA1_6	H35
MAA1_7	L33
MAA1_8	J33
MAA1_9	N27
MAB0_0	H23
MAB0_1	N24
MAB0_2	K24
MAB0_3	M24
MAB0_4	L25
MAB0_5	M25
MAB0_6	N23
MAB0_7	L23
MAB0_8	K23
MAB0_9	J27
MAB1_0	N18
MAB1_1	K17
MAB1_2	N17
MAB1_3	M17
MAB1_4	L15
MAB1_5	J15
MAB1_6	P19
MAB1_7	K18
MAB1_8	L18
MAB1_9	K14
MAC0_0	V13
MAC0_1	U10
MAC0_2	U13
MAC0_3	U12

Signal Name	Ball Reference
MAC0_4	R11
MAC0_5	R9
MAC0_6	W14
MAC0_7	V10
MAC0_8	V11
MAC0_9	P10
MAC1_0	AC8
MAC1_1	AD13
MAC1_2	AD10
MAC1_3	AD12
MAC1_4	AE11
MAC1_5	AE12
MAC1_6	AC13
MAC1_7	AC11
MAC1_8	AC10
MAC1_9	AG9
MAD0_0	AN8
MAD0_1	AM12
MAD0_2	AM9
MAD0_3	AM10
MAD0_4	AK10
MAD0_5	AK11
MAD0_6	AR8
MAD0_7	AN11
MAD0_8	AN9
MAD0_9	AG13
MAD1_0	AM17
MAD1_1	AP17
MAD1_2	AL18
MAD1_3	AR17
MAD1_4	AT18
MAD1_5	AN18
MAD1_6	AN15
MAD1_7	AR15
MAD1_8	AL17
MAD1_9	AR19
MEM_CALRA	Y31
MEM_CALRB	P15
MEM_CALRC	R14
MEM_CALRD	AL20
MVREFDA	P25
MVREFDB	P20

Signal Name	Ball Reference
MVREFDC	Y14
MVREFDD	AE14
PCIE_REFCLKN	AR43
PCIE_REFCLKP	AR42
PCIE_RX0N	AN43
PCIE_RX0P	AN42
PCIE_RX1N	AM41
PCIE_RX1P	AN41
PCIE_RX2N	AM42
PCIE_RX2P	AM43
PCIE_RX3N	AK42
PCIE_RX3P	AK43
PCIE_RX4N	AJ43
PCIE_RX4P	AJ42
PCIE_RX5N	AG41
PCIE_RX5P	AJ41
PCIE_RX6N	AG42
PCIE_RX6P	AG43
PCIE_RX7N	AF42
PCIE_RX7P	AF43
PCIE_RX8N	AE43
PCIE_RX8P	AE42
PCIE_RX9N	AD41
PCIE_RX9P	AE41
PCIE_RX10N	AD42
PCIE_RX10P	AD43
PCIE_RX11N	AC42
PCIE_RX11P	AC43
PCIE_RX12N	AA43
PCIE_RX12P	AA42
PCIE_RX13N	Y41
PCIE_RX13P	AA41
PCIE_RX14N	Y42
PCIE_RX14P	Y43
PCIE_RX15N	W43
PCIE_RX15P	W42
PCIE_TX0N	AR39
PCIE_TX0P	AR38
PCIE_TX1N	AN37
PCIE_TX1P	AR37
PCIE_TX2N	AN38
PCIE_TX2P	AN39

Signal Name	Ball Reference
PCIE_TX3N	AM38
PCIE_TX3P	AM39
PCIE_TX4N	AK39
PCIE_TX4P	AK38
PCIE_TX5N	AJ37
PCIE_TX5P	AK37
PCIE_TX6N	AJ38
PCIE_TX6P	AJ39
PCIE_TX7N	AG38
PCIE_TX7P	AG39
PCIE_TX8N	AF39
PCIE_TX8P	AF38
PCIE_TX9N	AE37
PCIE_TX9P	AF37
PCIE_TX10N	AE38
PCIE_TX10P	AE39
PCIE_TX11N	AD38
PCIE_TX11P	AD39
PCIE_TX12N	AC39
PCIE_TX12P	AC38
PCIE_TX13N	AA37
PCIE_TX13P	AC37
PCIE_TX14N	AA38
PCIE_TX14P	AA39
PCIE_TX15N	Y39
PCIE_TX15P	Y38
PCIE_ZVSS	AK30
PERSTB	AV42
PLLCHARZ_H	AM29
PLLCHARZ_L	AN29
PX_EN	V40
RASA0B	P33
RASA1B	M35
RASB0B	K20
RASB1B	M20
RASC0B	Y12
RASC1B	Y10
RASD0B	AR12
RASD1B	AN14
SCL	AF34
SDA	AF33
SMBCLK	AM34

Signal Name	Ball Reference
SMBDAT	AM33
SWAPLOCKA	AT25
SWAPLOCKB	AR25
TEMPIN0	AG33
TEMPINRETURN	AG34
TEST6	V14
TESTEN	AE30
TEST_PG	AA31
TEST_PG_BACO	Y32
TSVDD	AR26
TS_A	AA30
TX0M_DPB2N	BC33
TX0M_DPD2N	BB26
TX0M_DPF2N	BA19
TX0P_DPB2P	BB33
TX0P_DPD2P	BC26
TX0P_DPF2P	BA20
TX1M_DPB1N	BB35
TX1M_DPD1N	AY26
TX1M_DPF1N	BC20
TX1P_DPB1P	BC35
TX1P_DPD1P	AY27
TX1P_DPF1P	BB20
TX2M_DPB0N	AY35
TX2M_DPD0N	BC27
TX2M_DPF0N	BB21
TX2P_DPB0P	AY36
TX2P_DPD0P	BB27
TX2P_DPF0P	BC21
TX3M_DPA2N	BB38
TX3M_DPC2N	AY29
TX3M_DPE2N	BC23
TX3P_DPA2P	BC38
TX3P_DPC2P	AY30
TX3P_DPE2P	BB23
TX4M_DPA1N	AY38
TX4M_DPC1N	BC30
TX4M_DPE1N	BB24
TX4P_DPA1P	AY39
TX4P_DPC1P	BB30
TX4P_DPE1P	BC24
TX5M_DPA0N	BC39



Signal Name	Ball Reference
TX5M_DPC0N	BB32
TX5M_DPE0N	BA24
TX5P_DPA0P	BB39
TX5P_DPC0P	BC32
TX5P_DPE0P	BA25
TXCAM_DPA3N	BC36
TXCAP_DPA3P	BB36
TXCBM_DPB3N	AY32
TXCBP_DPB3P	AY33
TXCCM_DPC3N	BB29
TXCCP_DPC3P	BC29
TXCDM_DPD3N	BC25
TXCDP_DPD3P	BB25
TXCEM_DPE3N	AY21
TXCEP_DPE3P	AY23
TXCFM_DPF3N	BB19
TXCFP_DPF3P	BC19
VDDC	T16
VDDC	T17
VDDC	T20
VDDC	T21
VDDC	T24
VDDC	T25
VDDC	U16
VDDC	U17
VDDC	U20
VDDC	U21
VDDC	U24
VDDC	U25
VDDC	V16
VDDC	V17
VDDC	V20
VDDC	V21
VDDC	V24
VDDC	V25
VDDC	V28
VDDC	W16
VDDC	W17
VDDC	W20
VDDC	W21
VDDC	W24
VDDC	W25

Signal Name	Ball Reference
VDDC	W28
VDDC	W29
VDDC	Y16
VDDC	Y17
VDDC	Y20
VDDC	Y21
VDDC	Y24
VDDC	Y25
VDDC	Y28
VDDC	Y29
VDDC	AA16
VDDC	AA17
VDDC	AA20
VDDC	AA21
VDDC	AA24
VDDC	AA25
VDDC	AA28
VDDC	AA29
VDDC	AB16
VDDC	AB17
VDDC	AB20
VDDC	AB21
VDDC	AB24
VDDC	AB25
VDDC	AB28
VDDC	AB29
VDDC	AC16
VDDC	AC17
VDDC	AC20
VDDC	AC21
VDDC	AC24
VDDC	AC25
VDDC	AC28
VDDC	AC29
VDDC	AD16
VDDC	AD17
VDDC	AD20
VDDC	AD21
VDDC	AD24
VDDC	AD25
VDDC	AD28
VDDC	AD29

Signal Name	Ball Reference
VDDC	AE16
VDDC	AE17
VDDC	AE20
VDDC	AE21
VDDC	AE24
VDDC	AE25
VDDC	AE28
VDDC	AE29
VDDC	AF16
VDDC	AF17
VDDC	AF20
VDDC	AF21
VDDC	AF24
VDDC	AF25
VDDC	AF28
VDDC	AF29
VDDC	AG17
VDDC	AG20
VDDC	AG21
VDDC	AG24
VDDC	AG25
VDDC	AG28
VDDC	AG29
VDDC	AH18
VDDC	AH19
VDDC	AH20
VDDC	AH21
VDDC	AH22
VDDC	AH23
VDDC	AH24
VDDC	AH25
VDDC	AH26
VDDC	AH27
VDDC	AH28
VDDC	AH29
VDDC	AJ19
VDDC	AJ20
VDDC	AJ21
VDDC	AJ22
VDDC	AJ23
VDDC	AJ24
VDDC	AJ25

Signal Name	Ball Reference
VDDC	AJ26
VDDC	AJ27
VDDC	AJ28
VDDCI	P21
VDDCI	P23
VDDCI	R16
VDDCI	R18
VDDCI	R19
VDDCI	R20
VDDCI	R24
VDDCI	R25
VDDCI	R26
VDDCI	R28
VDDCI	T15
VDDCI	T27
VDDCI	T29
VDDCI	U28
VDDCI	V15
VDDCI	V29
VDDCI	W15
VDDCI	Y15
VDDCI	AA14
VDDCI	AC14
VDDCI	AD15
VDDCI	AE15
VDDCI	AF15
VDDCI	AG16
VDDCI	AH15
VDDCI	AH17
VDDCI	AJ16
VDDCI	AJ18
VDD_08	AA34
VDD_08	AA35
VDD_08	AD36
VDD_08	AE35
VDD_08	AF35
VDD_08	AG36
VDD_08	AJ30
VDD_08	AJ35
VDD_08	AK35
VDD_08	AM36
VDD_08	AN35

Signal Name	Ball Reference
VDD_18	AM25
VDD_18	AN25
VDD_18	AN26
VDD_18	AP26
VDD_18	AP27
VDD_18	AR27
VDD_33	AL24
VDD_33	AM24
VMEMIO	E6
VMEMIO	E12
VMEMIO	E17
VMEMIO	E20
VMEMIO	E27
VMEMIO	E32
VMEMIO	F5
VMEMIO	G11
VMEMIO	G15
VMEMIO	G19
VMEMIO	G25
VMEMIO	G29
VMEMIO	G33
VMEMIO	J14
VMEMIO	J18
VMEMIO	J23
VMEMIO	J26
VMEMIO	J30
VMEMIO	L17
VMEMIO	L20
VMEMIO	L24
VMEMIO	L27
VMEMIO	L37
VMEMIO	M5
VMEMIO	M12
VMEMIO	M39
VMEMIO	N15
VMEMIO	N19
VMEMIO	N25
VMEMIO	N29
VMEMIO	P14
VMEMIO	P30
VMEMIO	P35
VMEMIO	R7

Signal Name	Ball Reference
VMEMIO	R13
VMEMIO	R31
VMEMIO	R37
VMEMIO	U5
VMEMIO	U11
VMEMIO	U33
VMEMIO	U39
VMEMIO	V9
VMEMIO	V35
VMEMIO	W7
VMEMIO	W13
VMEMIO	W31
VMEMIO	Y11
VMEMIO	Y33
VMEMIO	AC9
VMEMIO	AD11
VMEMIO	AE7
VMEMIO	AE13
VMEMIO	AF9
VMEMIO	AG5
VMEMIO	AG11
VMEMIO	AJ7
VMEMIO	AJ13
VMEMIO	AK9
VMEMIO	AK14
VMEMIO	AL15
VMEMIO	AL19
VMEMIO	AM5
VMEMIO	AN7
VMEMIO	AN17
VMEMIO	AN20
VMEMIO	AR14
VMEMIO	AR18
VMEMIO	AU11
VMEMIO	AU15
VMEMIO	AW12
VMEMIO	AW17
VSS	A2
VSS	A6
VSS	A11
VSS	A15
VSS	A19

Signal Name	Ball Reference
VSS	A25
VSS	A29
VSS	A33
VSS	A38
VSS	A42
VSS	B1
VSS	B2
VSS	B8
VSS	B12
VSS	B17
VSS	B20
VSS	B24
VSS	B27
VSS	B32
VSS	B36
VSS	B39
VSS	B42
VSS	B43
VSS	C5
VSS	C9
VSS	C14
VSS	C18
VSS	C21
VSS	C23
VSS	C26
VSS	C30
VSS	C35
VSS	C40
VSS	D6
VSS	D11
VSS	D15
VSS	D19
VSS	D25
VSS	D29
VSS	D33
VSS	D38
VSS	D41
VSS	E3
VSS	E5
VSS	E8
VSS	E24
VSS	E36

Signal Name	Ball Reference
VSS	E39
VSS	E42
VSS	F1
VSS	F4
VSS	F6
VSS	F9
VSS	F14
VSS	F18
VSS	F21
VSS	F23
VSS	F26
VSS	F30
VSS	F35
VSS	F38
VSS	F40
VSS	F43
VSS	H2
VSS	H5
VSS	H8
VSS	H12
VSS	H17
VSS	H20
VSS	H24
VSS	H26
VSS	H27
VSS	H32
VSS	H39
VSS	H42
VSS	J3
VSS	J6
VSS	J9
VSS	J21
VSS	J35
VSS	J38
VSS	J41
VSS	K15
VSS	K19
VSS	K25
VSS	K27
VSS	K29
VSS	L1
VSS	L4



Signal Name	Ball Reference
VSS	L7
VSS	L11
VSS	L12
VSS	L14
VSS	L32
VSS	L40
VSS	L43
VSS	M2
VSS	M8
VSS	M11
VSS	M18
VSS	M21
VSS	M23
VSS	M26
VSS	M30
VSS	M33
VSS	M36
VSS	M42
VSS	P3
VSS	P6
VSS	P9
VSS	P11
VSS	P17
VSS	P18
VSS	P24
VSS	P27
VSS	P29
VSS	P32
VSS	P38
VSS	P41
VSS	R1
VSS	R4
VSS	R10
VSS	R15
VSS	R17
VSS	R21
VSS	R22
VSS	R23
VSS	R27
VSS	R29
VSS	R30
VSS	R34

Signal Name	Ball Reference
VSS	R40
VSS	R43
VSS	T18
VSS	T19
VSS	T22
VSS	T23
VSS	T26
VSS	T28
VSS	U2
VSS	U8
VSS	U14
VSS	U15
VSS	U18
VSS	U19
VSS	U22
VSS	U23
VSS	U26
VSS	U27
VSS	U29
VSS	U30
VSS	U36
VSS	U42
VSS	V3
VSS	V6
VSS	V12
VSS	V18
VSS	V19
VSS	V22
VSS	V23
VSS	V26
VSS	V27
VSS	V30
VSS	V32
VSS	V37
VSS	W1
VSS	W4
VSS	W10
VSS	W18
VSS	W19
VSS	W22
VSS	W23
VSS	W26

Signal Name	Ball Reference
VSS	W27
VSS	W34
VSS	W36
VSS	W38
VSS	W39
VSS	W40
VSS	W41
VSS	Y2
VSS	Y5
VSS	Y8
VSS	Y18
VSS	Y19
VSS	Y22
VSS	Y23
VSS	Y26
VSS	Y27
VSS	Y30
VSS	Y35
VSS	Y36
VSS	Y37
VSS	Y40
VSS	AA3
VSS	AA6
VSS	AA9
VSS	AA12
VSS	AA15
VSS	AA18
VSS	AA19
VSS	AA22
VSS	AA23
VSS	AA26
VSS	AA27
VSS	AA32
VSS	AA33
VSS	AA36
VSS	AA40
VSS	AB15
VSS	AB18
VSS	AB19
VSS	AB22
VSS	AB23
VSS	AB26

Signal Name	Ball Reference
VSS	AB27
VSS	AC3
VSS	AC6
VSS	AC12
VSS	AC15
VSS	AC18
VSS	AC19
VSS	AC22
VSS	AC23
VSS	AC26
VSS	AC27
VSS	AC32
VSS	AC33
VSS	AC36
VSS	AC40
VSS	AC41
VSS	AD2
VSS	AD5
VSS	AD8
VSS	AD14
VSS	AD18
VSS	AD19
VSS	AD22
VSS	AD23
VSS	AD26
VSS	AD27
VSS	AD32
VSS	AD35
VSS	AD37
VSS	AD40
VSS	AE1
VSS	AE4
VSS	AE10
VSS	AE18
VSS	AE19
VSS	AE22
VSS	AE23
VSS	AE26
VSS	AE27
VSS	AE32
VSS	AE36
VSS	AE40

Signal Name	Ball Reference
VSS	AF3
VSS	AF6
VSS	AF8
VSS	AF12
VSS	AF18
VSS	AF19
VSS	AF22
VSS	AF23
VSS	AF26
VSS	AF27
VSS	AF32
VSS	AF36
VSS	AF40
VSS	AF41
VSS	AG2
VSS	AG8
VSS	AG10
VSS	AG14
VSS	AG15
VSS	AG18
VSS	AG19
VSS	AG22
VSS	AG23
VSS	AG26
VSS	AG27
VSS	AG32
VSS	AG35
VSS	AG37
VSS	AG40
VSS	AH16
VSS	AJ1
VSS	AJ4
VSS	AJ10
VSS	AJ14
VSS	AJ15
VSS	AJ17
VSS	AJ29
VSS	AJ32
VSS	AJ36
VSS	AJ40
VSS	AK3
VSS	AK6

Signal Name	Ball Reference
VSS	AK12
VSS	AK15
VSS	AK17
VSS	AK18
VSS	AK20
VSS	AK24
VSS	AK27
VSS	AK29
VSS	AK32
VSS	AK36
VSS	AK40
VSS	AK41
VSS	AL23
VSS	AL25
VSS	AL29
VSS	AM2
VSS	AM8
VSS	AM11
VSS	AM14
VSS	AM18
VSS	AM26
VSS	AM32
VSS	AM35
VSS	AM37
VSS	AM40
VSS	AN1
VSS	AN4
VSS	AN12
VSS	AN24
VSS	AN27
VSS	AN33
VSS	AN36
VSS	AN40
VSS	AP15
VSS	AP19
VSS	AP25
VSS	AP29
VSS	AP30
VSS	AR3
VSS	AR6
VSS	AR9
VSS	AR32

Signal Name	Ball Reference
VSS	AR33
VSS	AR35
VSS	AR36
VSS	AR40
VSS	AR41
VSS	AT2
VSS	AT5
VSS	AT12
VSS	AT17
VSS	AT21
VSS	AT26
VSS	AT27
VSS	AT35
VSS	AT38
VSS	AT39
VSS	AT40
VSS	AT41
VSS	AT42
VSS	AT43
VSS	AU18
VSS	AU19
VSS	AU23
VSS	AU24
VSS	AU25
VSS	AV1
VSS	AV4
VSS	AV6
VSS	AV9
VSS	AV14
VSS	AV20
VSS	AV29
VSS	AV30
VSS	AV32
VSS	AV33
VSS	AV38
VSS	AV39
VSS	AV40
VSS	AW2
VSS	AW5
VSS	AW8
VSS	AW26
VSS	AW27

Signal Name	Ball Reference
VSS	AW29
VSS	AW30
VSS	AW32
VSS	AW33
VSS	AW35
VSS	AW36
VSS	AW38
VSS	AW39
VSS	AW41
VSS	AW43
VSS	AY3
VSS	AY6
VSS	AY11
VSS	AY15
VSS	AY18
VSS	AY19
VSS	AY25
VSS	AY41
VSS	BA4
VSS	BA9
VSS	BA14
VSS	BA18
VSS	BA21
VSS	BA23
VSS	BA26
VSS	BA27
VSS	BA29
VSS	BA30
VSS	BA32
VSS	BA33
VSS	BA35
VSS	BA36
VSS	BA38
VSS	BA39
VSS	BA40
VSS	BB1
VSS	BB2
VSS	BB5
VSS	BB8
VSS	BB12
VSS	BB17
VSS	BB18



Signal Name	Ball Reference
VSS	BB42
VSS	BB43
VSS	BC2
VSS	BC6
VSS	BC11
VSS	BC15
VSS	BC18
VSS	BC42
VSYN	AR24
WAKEB	AV43
WCKA0B_0	L41
WCKA0B_1	L38
WCKA0_0	L42
WCKA0_1	L39
WCKA1B_0	C33
WCKA1B_1	E30
WCKA1_0	B33
WCKA1_1	D30
WCKB0B_0	H21
WCKB0B_1	B21
WCKB0_0	G21
WCKB0_1	A21
WCKB1B_0	G12
WCKB1B_1	B9
WCKB1_0	F12
WCKB1_1	A8
WCKC0B_0	J2
WCKC0B_1	M7
WCKC0_0	H1
WCKC0_1	M6
WCKC1B_0	AA2
WCKC1B_1	AA8
WCKC1_0	AA1
WCKC1_1	AA7
WCKD0B_0	AK5
WCKD0B_1	AN3
WCKD0_0	AK4
WCKD0_1	AN2
WCKD1B_0	AV11
WCKD1B_1	BA11
WCKD1_0	AW11
WCKD1_1	BB11

Signal Name	Ball Reference
WEA0B	V34
WEA1B	H30
WEB0B	J25
WEB1B	M15
WEC0B	R12
WEC1B	AE9
WED0B	AK8
WED1B	AP18
XTALIN	BA43
XTALOUT	AY42