AMD-8151™ HyperTransport™ AGP3.0 Graphics Tunnel Data Sheet

1 Overview

The *AMD-8151™ HyperTransport™ AGP3.0 Graphics Tunnel* (referred to as *the IC* in this document) is a HyperTransport™ technology (referred to as *link* in this document) tunnel developed by AMD that provides an AGP 3.0 compliant (8x transfer rate) bridge.

1.1 Device Features

- HyperTransport technology tunnel with side A and side B.
  - Side A is 16 bits (input and output); side B is 8 bits.
  - Either side may connect to the host or to a downstream HyperTransport technology compliant device.
  - Each side supports HyperTransport technology-defined reduced bit widths: 8-bit, 4-bit, and 2-bit.
  - Side A supports transfer rates of 1600, 1200, 800, and 400 mega-transfers per second. Side B supports transfer rates of 800 and 400 mega-transfers per second.
  - Maximum bandwidth is 6.4 gigabytes per second across side A (half upstream and half downstream) and 1.6 gigabytes per second across side B.
  - Independent transfer rate and bit width selection for each side.
  - Link disconnect protocol supported.
- AGP 8x bridge.
  - Compliance with AGP 3.0 specification signaling, supporting 4x and 8x transfer rates.
  - Compliance with AGP 2.0 specification 1.5-volt signaling, supporting 1x, 2x, and 4x data-transfer modes.
  - Supports up to 32 outstanding requests.
- 31 x 31 millimeter, 564-ball BGA package.
- 1.5 volt AGP signaling; some 3.3 volt IO; 1.2 volt link signaling; 1.8 volt core.

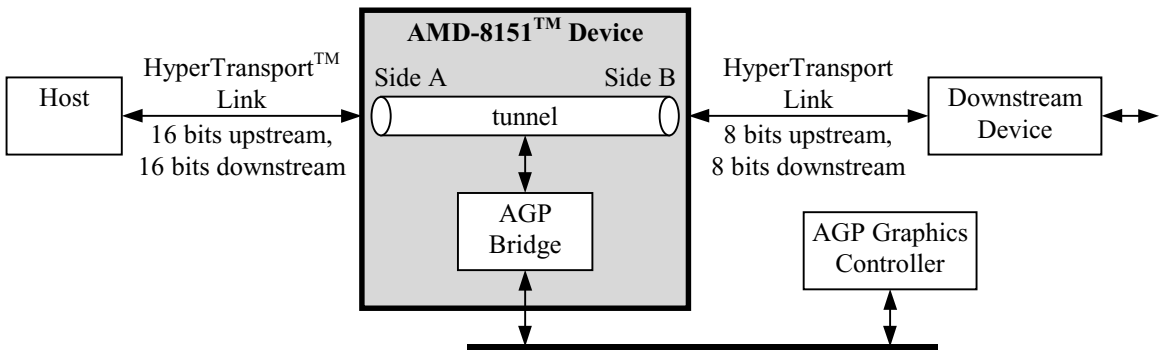

Figure 1: System block diagram.

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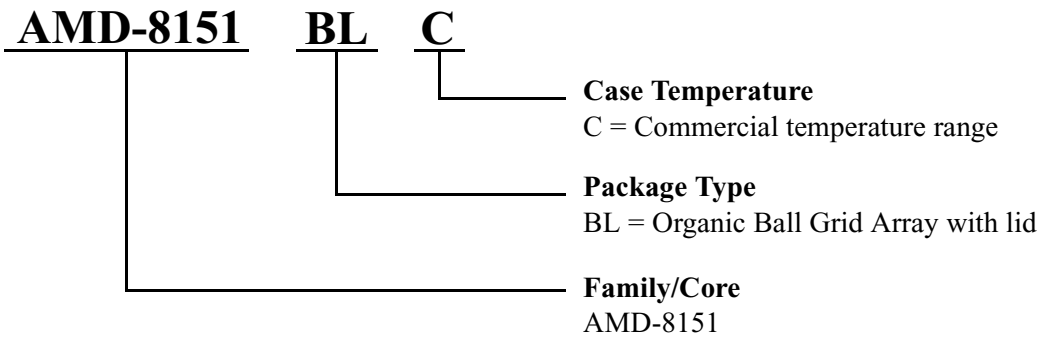


3 Signal Descriptions

3.1 Terminology

See section 5.1.2 for a description of the register naming convention used in this document. See the AMD-8151™ HyperTransport™ AGP3.0 Graphics Tunnel Design Guide for additional information.

Signals with a # suffix are active low.

Signals described in this chapter utilize the following IO cell types:

Name	Notes
Input	Input signal only.
Output	Output signal only. This includes outputs that are capable of being in the high-impedance state.
OD	Open drain output. These signals are driven low and expected to be pulled high by external circuitry.
IO	Input or output signal.
IOD	Input or open-drain output.
Analog	Analog signal.
w/PU	With pullup. The signal includes a pullup resistor to the signal's power plane. The resistor value is nominally 8K ohms.

Table 1: IO signal types.

The following provides definitions and reference data about each of the IC's pins. "During Reset" provides the state of the pin while RESET# is asserted. "After Reset" provides the state of the pin immediately after RESET# is deasserted. "Func." means that the pin is functional and operating per its defined function.

3.2 Tunnel Link Signals

The following are signals associated with the HyperTransport™ links. [B, A] in the signal names below refer to the A and B sides of the tunnel. [P, N] are the positive and negative sides of differential pairs.

Pin name and description	IO cell type	Power plane*	During reset	After reset
LDTCOMP[3:0]. Link compensation pins for both sides of the tunnel. These are designed to be connected through resistors as follows: Bit / Function / External Connection [0] Positive receive compensation — Resistor to VDD12B [1] Negative receive compensation — Resistor to VSS [3, 2] Transmit compensation — Resistor from bit [2] to bit [3] These resistors are used by the compensation circuit. The output of this circuit is combined with DevA:0x[E8, E4, E0] to determine compensation values that are passed to the link PHYs.	Analog	VDD-12B		
LRACAD_[P, N][15:0]; LRBCAD_[P, N][7:0]. Receive link command-address-data bus.	Link input	VDD12		
LRACLK[1, 0]_[P, N]; LRBCLK0_[P, N]. Receive link clock.	Link input	VDD12		
LR[B, A]CTL_[P, N]. Receive link control signal.	Link input	VDD12		
LTACAD_[P, N][15:0]; LTBCAD_[P, N][7:0]. Transmit link command-address-data bus.	Link output	VDD12	Diff High**	Func.
LTACLK[1, 0]_[P, N]; LTBCLK0_[P, N]. Transmit link clock.	Link output	VDD12	Func.	Func.
LT[B, A]CTL_[P, N]. Transmit link control signal.	Link output	VDD12	Diff Low**	Func.

* The signals connected to the A side of the tunnel are powered by VDD12A and the signals connected to the B side of the tunnel are powered by VDD12B.
** Diff High and Diff Low for these link pins specifies differential high and low; e.g., Diff High specifies that the _P signal is high and the _N signal is low.

If one of the sides of the tunnel is not used on a platform then the unconnected link should be treated as follows, for every 10 differential pairs: connect all of the _P differential inputs together and through a resistor to VSS; connect all the _N differential inputs together and through a resistor to VDD12; leave the differential outputs unconnected. If there are unused link signals on an active link (because the IC is connected to a device with a reduced bit width), then the unused differential inputs and outputs should also be connected in this way.

3.3 AGP Signals

In the table below, "Term" indicates the standard AGP 3.0 termination impedance to ground; "PU" indicates a weak pullup resistor; "PD" indicates a weak pulldown resistor.

Pin name and description	IO cell type	Power plane	AGP 3.0 Signaling		AGP 2.0 Signaling	
			During reset	After reset	During reset	After reset
A_ADSTB0_[P, N]. AGP differential strobe for A_AD[15:0] and A_CBE_L[1:0]. When AGP 3.0 signaling is enabled, A_ADSTB0_P is the first strobe and A_ADSTB0_N is the second strobe.	IO	VDD15	Term	Term	_P: PU _N: PD	_P: PU _N: PD
A_ADSTB1_[P, N]. AGP differential strobe for AD[31:16], A_CBE_L[3:2], and A_DBI[H,L]. When AGP 3.0 signaling is enabled, A_ADSTB1_P is the first strobe and A_ADSTB1_N is the second strobe.	IO	VDD15	Term	Term	_P: PU _N: PD	_P: PU _N: PD
A_AD[31:0]. AGP address-data bus.	IO	VDD15	Term	Term	PU	Low
A_CBE_L[3:0]. AGP command-byte enable bus.	IO	VDD15	Term	Term	PU	Low
A_CAL[D, S] and A_CAL[D, S]#. Compensation pins for matching impedance of system board AGP traces. See DevA:0x[54, 50] for more information. These are designed to be connected through resistors as follows: Signal — Compensation Function — External Connection A_CALD — Rising edge of data signals — Resistor to VSS A_CALD# — Falling edge of data signals — Resistor to VDD15 A_CALS — Rising edge of strobe signals — Resistor to VSS A_CALS# — Falling edge of strobe signals — Resistor to VDD15 These resistors are used by the compensation circuit. The output of this circuit is combined with DevA:0x[54, 50] to determine compensation values that are passed to the link PHYs.	Analog	VDD15				
A_DBI[H, L]. Data bus inversion [high, low]. When DevA:0xA4[AGP3MD]=1, A_DBIL applies to AD[15:0]; A_DBIH applies to AD[31:16]. 1=AD signals are inverted. 0=A_AD signals are not inverted. The IC uses these signals in determining the polarity of the A_AD signals when they are inputs. These may also be enabled to support the DBI function of the IC output signals by DevA:0x40[DBIEN]. Both A_DBIH and A_DBIL are strobed with A_ADSTB1_[P, N]. When DevA:0xA4[AGP3MD]=0: A_DBIL is pulled low with the AGP termination value and not used by the IC; A_DBIH is pulled up to VDD15 through a weak resistor and becomes the AGP 2.0 PIPE# input signal.	IO	VDD15	Term	Term	PU	PU
A_DEVSEL#. AGP device select.	IO	VDD15	Term	Term	PU	PU
A_FRAME#. AGP frame signal.	IO	VDD15	Term	Term	PU	PU
A_GC8XDET#. 0=Specifies that the graphics device supports AGP 3.0 signaling. The state of this signal is latched on the rising edge of A_RESET# before being passed to internal logic.	Input w/PU	VDD15	PU	PU	PU	PU

Pin name and description	IO cell type	Power plane	AGP 3.0 Signaling		AGP 2.0 Signaling	
			During reset	After reset	During reset	After reset
A_GNT#. AGP master grant signal.	Output	VDD15	Term	Low	PU	High
A_IRDY#. AGP master ready signal.	IO	VDD15	Term	Term	PU	PU
A_MB8XDET#. This pin is controlled by DevA:0x40[8XDIS]. It is designed to be connected to the AGP connector to indicate support for AGP 3.0 signaling.	Output	VDD15	Low	Low	Low	Low
A_PAR. AGP parity signal.	IO	VDD15	Term	Term	PU	Low
A_PCLK. 66 MHz AGP clock.	Output	VDD33	Func.	Func.	Func.	Func.
A_PLLCLKO. PLL clock output. See section 4.3 for details.	Output	VDD33	Func.	Func.	Func.	Func.
A_PLLCLKI. PLL clock input. See section 4.3 for details.	Input	VDD33				
A_REFCG. AGP signal reference output.	Analog output	VDD15				
A_REFGC. AGP signal reference input.	Analog input	VDD15				
A_REQ#. AGP master request signal.	Input	VDD15	Term	Term	PU	PU
A_RESET#. AGP bus reset signal. This is asserted whenever RESET# is asserted or when programmed by DevB:0x3C[SBRST]. Assertion of this pin does not reset any logic internal to the IC.	Output	VDD33	Low	High	Low	High
A_RBF#. AGP read buffer full signal.	Input	VDD15	Term	Term	PU	PU
A_SBSTB_[P, N]. AGP differential side band address strobe. In AGP 3.0 signaling mode, A_SBSTB_P is the first strobe and A_SBSTB_N is the second strobe.	Input	VDD15	Term	Term	_P: PU _N: PD	_P: PU _N: PD
A_SBA[7:0]. AGP side band address signals.	Input	VDD15	Term	Term	PU	PU
A_ST[2:0]. AGP status signals.	Output	VDD15	Term	Low	PU	Low
A_STOP#. AGP target abort signal.	IO	VDD15	Term	Term	PU	PU
A_TRDY#. AGP target ready signal.	IO	VDD15	Term	Term	PU	PU
A_TYPEDET#. AGP IO voltage level type detect. 0=1.5 volts; 1=3.3 volts (not supported by the IC). The state of this pin is provided in DevA:0x40[TYPEDET]. This pin is also used for test-mode selection; see section 9. This signal requires an external pullup resistor to VDD33 on the systemboard.	Input	VDD33				
A_WBF#. AGP write buffer full signal.	Input	VDD15	Term	Term	PU	PU

The SERR# and PERR# signals are not supported on the AGP bridge.

3.4 Test and Miscellaneous Signals

Pin name and description	IO cell type	Power plane	During reset	After reset
CMPOVR. Link automatic compensation override. 0=Link automatic compensation is enabled. 1=The compensation values stored in DevA:0x[E0, E4, E8] control the compensation circuit. The state of this signal determines the default value for DevA:0x[E0, E4, E8][ACTL and BCTL] at the rising edge of PWROK.	Input	VDD33		
FREE[7:1]. These should be left unconnected.				
LDTSTOP#. Link disconnect control signal. This pin is also used for test-mode selection; see section 9.	Input	VDD33		
NC[1:0]. These should be left unconnected.				
PWROK. Power OK. 1=All power planes are valid. The rising edge of this signal is deglitched; it is not observed internally until it is high for more than 6 consecutive REFCLK cycles. See section 4.2 for more details about this signal.	Input	VDD33		
REFCLK. 66 MHz reference clock. This is required to be operational and valid for a minimum of 200 microseconds prior to the rising edge of PWROK and always while PWROK is high.	Input	VDD33		
RESET#. Reset input. See section 4.2 for details.	Input	VDD33		
STRAPL[19:13, 11:0]. Strapping option to be tied low. These pins should be tied to ground. STRAPL0 is used for test-mode selection; see section 9.	IO	VDD15	3-State	3-State
STRAPL[22:20]. Strapping option to be tied low. These pins should be tied to ground.	IO	VDD33	3-State	3-State
TEST. This is required to be tied low for functional operation. See section 9 for details.	Input	VDD33		

3.5 Power and Ground

VDD12[B, A]. 1.2 volt power plane for the HyperTransport™ technology pins. VDD12A provides power to the A side of the tunnel. VDD12B provides power to the B side of the tunnel.

VDD15. 1.5 volt power plane for AGP.

VDD18. 1.8-volt power plane for the core of the IC.

VDDA18. Analog 1.8-volt power plane for the PLLs in the core of the IC. This power plane is required to be filtered from digital noise.

VDD33. 3.3-volt power plane for IO.

VSS. Ground.

3.5.1 Power Plane Sequencing

The following are power plane requirements that may imply power supply sequencing requirements.
- VDD33 is required to always be higher than VDD18, VDDA18, VDD15, and VDD12[B, A].
- VDD18 and VDDA18 are required to always be higher than VDD15 and VDD12[B, A].
- VDD15 is required to always be higher than VDD12[B, A].

4 Functional Operation

4.1 Overview

The IC connects to the host through either the side A or side B HyperTransport™ link interface. The other side of the tunnel may or may not be connected to another device. Host-initiated transactions that do not target the IC or the bridge flow through the tunnel to the downstream device. Transactions claimed by the device are passed to internal registers or to the AGP bridge.

See section 5.1 for details about the software view of the IC. See section 5.1.2 for a description of the register naming convention. See the AMD-8151™ HyperTransport™ AGP3.0 Graphics Tunnel Design Guide for additional information.

4.2 Reset And Initialization

RESET# and PWROK are both required to be low while the power planes to the IC are invalid and for at least 1 millisecond after the power planes are valid. Deassertion of PWROK is referred to as a *cold reset*. After PWROK is brought high, RESET# is required to stay low for at least 1 additional millisecond. After RESET# is brought high, the links go through the initialization sequence.

After a cold reset, the IC may be reset by asserting RESET# while PWROK remains high. This is referred to as a *warm reset*. RESET# must be asserted for no less than 1 millisecond during a warm reset.

4.3 Clocking

It is required that REFCLK be valid in order for the IC to operate. Also, the LR[B, A]CLK inputs from the operation links must also be valid at the frequency defined DevA:0xCC[FREQA] and DevA:0xD0[FREQB]. The IC provides A_PCLK as the clock to the AGP device.

The systemboard is required to include a connection from A_PLLCLKO to A_PLLCLKI. The length of this connection is required to be approximately the same as length of the A_PCLK trace from the IC to the external AGP devices (including approximately 2.5 inches of etch on the AGP card). The IC uses this loopback to help match the external trace delay.

4.3.1 Clock Gating

Internal clocks may be disabled during power-managed system states such as power-on suspend. It is required that all upstream requests initiated by the IC be suspended while in this state.

To enable clock gating, DevA:0xF0[ICGSMAF] is programmed to the values in which clock gating will be enabled. Stop Grant cycles and STPCLK deassertion link broadcasts interact to define the window in which the IC is enabled for clock gating during LDTSTOP# assertions. The system is placed into power managed states by steps that include a broadcast over the links of the Stop Grant cycle that includes the System Management Action Field (SMAF) followed by the assertion of LDTSTOP#. When the IC detects the Stop Grant broadcast which is enabled for clock gating, it enables clock gating for the next assertion of LDTSTOP#. While exiting the power-managed state, the system is required to broadcast a STPCLK deassertion message. The IC uses this message to disable clock gating during LDTSTOP# assertions. This is important because an LDTSTOP# assertion is not guaranteed to occur after the Stop Grant broadcast is received. The clock gating window must be closed to insure that clock gating does not occur during Stop Grant for LDTSTOP# assertions that are not associated with the power states specified by DevA:0xF0[ICGSMAF].

In summary, Stop Grant broadcasts with SMAF fields specified by DevA:0xF0[ICGSMAF] enable the clock gating window and STPCLK deassertion broadcasts disable the window. If LDTSTOP# is asserted while the clock gating window is enabled, then clock gating occurs.

Also, DevA:0xF0[ECGSMAF] may be used in a similar way to disable A_PCLK and the internal clock grids associated with the AGP bridge. The same rules for the clock gating window that apply to DevA:0xF0[ICGSMAF] also apply to DevA:0xF0[ECGSMAF]. If clock gating is enabled, then A_PCLK is forced low within two clock periods after LDTSTOP# is asserted. It becomes active again within two clock periods after LDTSTOP# is deasserted. It is required that there be no AGP-card-initiated upstream or downstream traffic while A_PCLK is gated. In addition, it is required that there be no host accesses to the bridge or internal registers in progress from the time that LDTSTOP# is asserted for clock gating until the link reconnects after LDTSTOP# is deasserted.

4.4 Tunnel Links

HyperTransport link A supports CLK receive and transmit frequencies of 200, 400, 600, and 800 MHz. Link B supports frequencies of 200 and 400 MHz. The side A and side B frequencies are independent of each other.

4.4.1 Link PHY

The PHY includes automatic compensation circuitry and a software override mechanism, as specified by DevA:0x[E8, E4, E0]. The IC only implements synchronous mode clock forwarding FIFOs. So only the link receive and transmit frequencies specified in DevA:0x[D0, CC][FREQB, FREQA] are allowed.

4.5 AGP

The AGP bridge supports AGP 3.0 signaling at 8x and 4x data rates and 1.5-volt AGP 2.0 signaling at 4x, 2x, and 1x data rates. 64-bit upstream and 32-bit downstream addressing is supported. AGP 3.0 dynamic bus inversion is supported on output signals in 8X mode only, not in 4X mode; dynamic bus inversion on input signals is supported in both 4X and 8X modes.

4.5.1 Tags, UnitIDs, And Ordering

The IC requires three HyperTransport™ technology-defined UnitIDs. They are allocated as follows:

- First UnitID is not used. This is to avoid a potential conflict with the host (because it may be zero; see DevA:0xC0[BUID]).
- Second UnitID is used for PCI-mode upstream requests and responses to host requests.
- Third UnitID is used for AGP (high priority and low priority) upstream requests.

The SrcTag value that is assigned to upstream non-posted AGP requests increments with each request from 0 to 27 and then rolls over to 0 again; the first SrcTag assigned after reset is 0. Up to 28 non-posted link requests may be outstanding at a time. The SrcTag value that is assigned to non-posted PCI requests is always 28.

All AGP transactions are compliant to AGP ordering rules. APG transactions are translated into link transactions as follows:

AGP transaction	Link transaction
High priority write	WrSized, posted channel, PassPW = 1
High priority read	RdSized, PassPW = 1, response PassPW = 1
Low priority write	WrSized, posted channel, PassPW = 0
Low priority read	RdSized, PassPW = 0, response PassPW = 1
Low priority flush	Flush, PassPW = 0
Low priority fence	None (wait for all outstanding read responses)

Table 2: Translation from AGP requests to link requests.

4.5.2 Various Behaviors

- The AGP bridge does not claim link special cycles. However, special cycles that are encoded in configuration cycles to device 31 of the AGP secondary bus number (per the PCI-to-PCI bridge specification) are translated to AGP bus special cycles.
- AGP and PCI read transactions that receive NXA responses from the host complete onto the AGP bus with the data provided by the host (which is required to be all 1's, per the link specification).
- In the translation from type 1 link configuration cycles to secondary bus type 0 configuration cycles, the IC converts the device number to IDSEL AD signal as follows: device 0 maps to AD[16]; device 1 maps to AD[17]; and so forth. Device numbers 16 through 31 are not valid.
- The compensation values for drive strength and input impedance that are assigned to non-clock forwarded AGP signals are automatically determined and set by the IC during the first compensation cycle after RESET#. Once set, they do not change until the next RESET# assertion.
- Per the link protocol, when the COMPAT bit is set in the transaction, the IC does not ever claim the transaction. Such transactions are automatically passed to the other side of the tunnel (or master aborted if the IC is at the end of the chain). This is true of all transactions within address space that is otherwise claimed by the IC, including the space defined by DevB:0x3C[VGAEN].

4.5.2.1 AGP Compensation And Calibration Cycles

The AGP PHY includes one compensation circuit for the clock forwarded data signals, A_AD[31:0], A_CBE_L[3:0], and A_DBI[H, L], and one compensation circuit for the strobes, A_ADSTB[1:0]. Each compensation circuit calculates the required rising-edge (P) and falling-edge (N) signal drive strength through a free-running state machine that generates a new value approximately every four microseconds. These values are provided in DevA:0x[50, 54][NCOMP, PCOMP].

Programmable skew values between data signals and strobes are also provided in DevA:0x58.

The compensation values provided to the AGP PHY are software selectable between the calculated compensation values, fixed programmable bypass values, or fixed programmable offsets from the calculated values. Regardless of which value is selected, the value presented to the PHY is never updated until there is a calibration cycle.

Calibration cycles consist of taking control of the AGP bus, updating the AGP PHY compensation values, and then releasing (see DevA:0xA8[PCALCYC]). If enabled by DevA:0xB0[CALDIS], they occur periodically with the period specified by DevA:0xA8[PCALCYC].

The first calibration cycle occurs approximately 4 milliseconds after the deassertion of RESET# (whether AGP 2.0 or 3.0 signaling is enabled).

5 Registers

5.1 Register Overview

The IC includes several sets of registers accessed through a variety of address spaces. IO address space refers to register addresses that are accessed through x86 IO instructions such as IN and OUT. PCI configuration space is typically accessed by the host through IO cycles to CF8h and CFCh. There is also memory space and indexed address space in the IC.

5.1.1 Configuration Space

The address space for the IC configuration registers is broken up into *busses*, *devices*, *functions*, and, *offsets*, as defined by the link specification. It is accessed by HyperTransport™ technology-defined type 0 configuration cycles. The device number is mapped into bits[15:11] of the configuration address. The function number is mapped into bits[10:8] of the configuration address. The offset is mapped to bits[7:2] of the configuration address.

The following diagram shows the devices in configuration space as viewed by software.

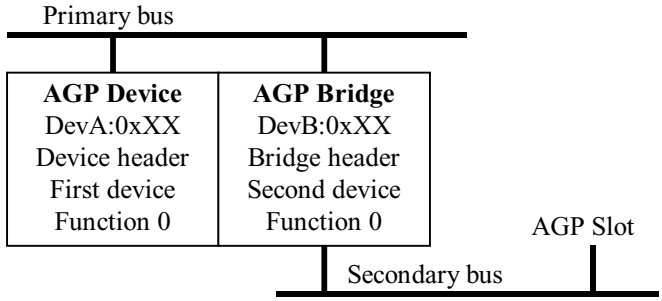


Figure 2: Configuration space.

Device A, above, is programmed to be the link base UnitID and device B is the link base UnitID plus 1.

5.1.2 Register Naming and Description Conventions

Configuration register locations are referenced with mnemonics that take the form of Dev[A|B]:[7:0]x[FF:0], where the first set of brackets contain the device number, the second set of brackets contain the function number, and the last set of brackets contain the offset.

Other register locations (e.g. memory mapped registers) are referenced with an assigned mnemonic that specifies the address space and offset. These mnemonics start with two or three characters that identify the space followed by characters that identify the offset within the space.

Register fields within register locations are also identified with a name or bit group in brackets following the register location mnemonic.

The following are configuration spaces:

Device	Function	Mnemonic	Registers
"A"	0	DevA:0xXX	AGP device header; link and AGP capabilities blocks
"B"	0	DevB:0xXX	PCI-PCI bridge registers for AGP

Table 3: Configuration spaces.

The IC does not claim configuration-register accesses to unimplemented functions within its devices (they are forwarded to the other side of the tunnel). Accesses to unimplemented register locations within implemented functions are claimed; such writes are ignored and reads always respond with all zeros.

The following are memory mapped spaces:

Base address register	Size (bytes)	Mnemonic	Registers
DevA:0x10	Variable	None	Graphic virtual memory aperture; minimum of 32 megabytes.
DevA:0xB8	4K	None	GART block in physical memory.

Table 4: Memory mapped address spaces.

The following are register attributes found in the register descriptions.

Type	Description
Read or read-only	Capable of being read by software. Read-only implies that the register cannot be written to by software.
Write	Capable of being written by software.
Set by hardware	Register bit is set high by hardware.
Write once	After RESET#, these registers may be written to once. After being written, they become read only until the next RESET# assertion. The write-once control is byte based. So, for example, software may write each byte of a write-once DWORD as four individual transactions. As each byte is written, that byte becomes read only.
Write 1 to clear	Software must write a 1 to the bit in order to clear it. Writing a 0 to these bits has no effect.
Write 1 only	Software can set the bit high by writing a 1 to it. However subsequent writes of 0 will have no effect. RESET# must be asserted in order to clear the bit.

Table 5: Register attributes.

5.2 AGP Device Configuration Registers

These registers are located in PCI configuration space, in the first device (device A), function 0. See section 5.1.2 for a description of the register naming convention.

AGP Vendor And Device ID Register **DevA:0x00**

Default: 7454 1022h Attribute: Read only.

Bits	Description
31:16	AGP device ID.
15:0	Vendor ID.

AGP Device Status And Command Register **DevA:0x04**

Default: 0210 0000h Attribute: See below.

Bits	Description
31	**DPE: detected parity error.** Read only. This bit is fixed in the low state.
30	**SSE: signaled system error.** Read; set by hardware; write 1 to clear. 1=A system error was signaled (both links were flooded with sync packets) as a result of a CRC error (see DevA:0x[C8:C4][CRCFEN, CRCERR]). Note: this bit is cleared by PWROK reset but not by RESET#.
29	**RMA: received master abort.** Read; set by hardware; write 1 to clear. 1=A request (AGP or PCI) sent to the host bus received a master abort (an NXA error response). Note: this bit is cleared by PWROK reset but not by RESET#.
28	**RTA: received target abort.** Read; set by hardware; write 1 to clear. 1=A request (AGP or PCI) sent to the host bus received a target abort (a non-NXA error response). Note: this bit is cleared by PWROK reset but not by RESET#.
27:21	Read only. These bits are fixed in their default state.
20	**Capabilities pointer.** Read only. This bit is fixed in the high state.
19:3	Read only. These bits are fixed in their default state.
2	**MASEN: PCI master enable.** Read-write. This bit controls no hardware in the IC.
1	**MEMEN: memory enable.** Read-write. 1=Enables access to the memory space specified by DevA:0x10. This bit controls no hardware in the IC.
0	**IO enable.** Read only. This bit is fixed in the low state.

AGP Device Revision and Class Code Register **DevA:0x08**

Default: 0600 00??h Attribute: See below.

Bits	Description
31:8	**CLASSCODE.** Read; write once. Provides the AGP bridge class code.
7:0	**REVISION.** Read only.

AGP Device BIST-Header-Latency-Cache Register **DevA:0x0C**

Default: 0000 0000h Attribute: Read only.

Bits	Description
31:24	**BIST.** These bits fixed at their default values.
23:16	**HEADER.** These bits fixed at their default values.
15:8	**LATENCY.** These bits fixed at their default values.
7:0	**CACHE.** These bits fixed at their default values.

AGP Device Graphic Virtual Memory Aperture Register — DevA:0x10

It is expected that the state of this register is copied into the host by software. This register controls no hardware in the IC.

Default: 0000 0000 0000 0008h Attribute: See below.

Bits	Description
63:32	**APBARHI.** Read-write. Aperture base address register high. Note: bits[63:40] are required to be programmed low; setting any of these bits high results in undefined behavior. Note: if DevA:0x10[64BIT]=0, then these bits are read only, all zero.
31:22	**APBARLO.** Aperture base address register low. These bits are a combination of read-write and read-only zero, based on the state of DevA:0xB4[APSIZE]; see that register for details.
21:4	Reserved.
3	Read only. This bit is fixed at its default value to indicate that this register points prefetchable space.
2	**64BIT: 64-bit pointer.** Read; write once. 1=DevA:0x10 is a 64-bit pointer. 0=DevA:0x10 is a 32-bit pointer; bits[63:32] are reserved.
1:0	Read only. These bits are fixed at their default value to indicate that this register points memory space.

AGP Device Subsystem ID and Subsystem Vendor ID Register — DevA:0x2C

Default: 0000 0000h Attribute: Read; write once.

Bits	Description
31:16	**Subsystem ID.** This field controls no hardware.
15:0	**Subsystem vendor ID.** This field controls no hardware.

AGP Capabilities Pointer — DevA:0x34

Default: 0000 00A0h Attribute: Read only.

Bits	Description
31:8	Reserved.
7:0	**Capabilities pointer.** Specifies the offset in DevA:0 address space for the AGP capabilities block.

AGP Miscellaneous Control Register **DevA:0x40**

Default: 0000 0000h Attribute: See below.

Bits	Description
31:8	Reserved.
7	**Must be low.** This bit is required to be low at all times; setting it high results in undefined behavior.
6	**Must be low.** This bit is required to be low at all times; setting it high results in undefined behavior.
5	**Must be low.** This bit is required to be low at all times; setting it high results in undefined behavior.
4	**Must be low.** This bit is required to be low at all times; setting it high results in undefined behavior.
3	**FWDIS: fast write disable.** Read-write. 1=DevA:0xA4[FWSUP] is low. 0=DevA:0xA4[FWSUP] is high.
2	**8XDIS: AGP 3.0 signaling mode disable.** Read-write. 0=The IC drives A_MB8XDET# low to indicate support for AGP 3.0 signaling. 1=The IC does not drive A_MB8XDET low. This bit may be used in conjunction with DevB:0x3C[SBRST] to revert back to AGP 2.0 signaling. To do this, software should (1) set DevB:0x3C[SBRST] in order to reset the AGP card, (2) set 8XDIS to cause A_MB8XDET# to float high, and (3) clear DevB:0x3C[SBRST].
1	**TYPEDET: AGP voltage type detection.** Read only. This bit reflects the state of the A_TYPEDET# pin. 0=The AGP master supports 1.5 volt signaling. 1=The AGP master requires 3.3 volt signaling and is therefore not compatible with the IC. If this bit is detected high by BIOS, an error should be signaled.
0	**DBIEN: dynamic bus inversion enable.** Read-write. 1= A_DBI[H, L] enabled to dynamically invert the state of the A_AD signals when the IC is driving these. This only applies to AGP 3.0 transfers in the downstream direction (fast writes and read responses to AGP master requests). For PCI transfers in the downstream direction, A_DBI[H, L] are held inactive and no inversion takes place. 0=When the IC drives the A_AD lines, A_DBI[H, L] are driven low. Note: this bit is only valid when 8x transfer rates are enabled; if (1) DevA:0xA4[AGP3MD]=0 or (2) DevA:0xA4[AGP3MD]=1 and DevA:0xA8[DRATE] is not 010b, then this field is ignored and the DBI is not enabled.

AGP PHY Control Register **DevA:0x[54, 50]**

These registers apply to the compensation values of AGP clock-forwarded data and strobe signals as follows:
- DevA:0x50: data signals A_AD[31:0], A_CBE_L[3:0], A_DBI[H, L], and A_SBA[7:0].
- DevA:0x54: strobe signals A_ADSTB[1:0]_[P, N] and A_SBSTB_[P, N].

NCTL, NDATA, and NCOMP are related to (1) the falling edge drive strength of the signals as outputs and (2) the impedance of the signals as inputs. PCTL, PDATA, and PCOMP are related to the rising edge drive strength of the signals as outputs only. For the [N, P]DATA and [N, P]COMP fields of these registers, 00h corresponds to the weakest drive strength and the highest receive impedance. For the [N, P]DATA and [N, P]COMP fields of these registers, the highest values corresponds to the strongest drive strength and lowest receive impedance.

External compensation resistors are used by the IC to determine the proper drive strength values. The resistors correlate the calculated values as follows:
- A_CALD is used to calculate DevA:0x50[PCOMP] (data signal rising edge drive strength).
- A_CALD# is used to calculate DevA:0x50[NCOMP] (data signal falling edge drive strength and receive impedance).
- A_CALS is used to calculate DevA:0x54[PCOMP] (strobe rising edge drive strength).
- A_CALS# is used to calculate DevA:0x54[NCOMP] (strobe falling edge drive strength and receive impedance).

Note: when new values are written to these registers, new compensation values are not updated to the AGP PHY automatically; the periodic calibration cycle specified by DevA:0xA8[PCALCYC] must pass in order for the AGP PHY calibration values to take effect.

Default: 000? 000?h Attribute: See below.

Bits	Description
31:30	**NCTL: AGP PHY N (falling edge) compensation control.** Read-write. These two bits combine to specify the PHY falling edge compensation value that is applied to AGP signals as follows: NCTL — Description 00b — Apply NCOMP directly as the compensation value. 01b — Apply NDATA directly as the compensation value. 10b — Apply the sum of NCOMP and NDATA as the compensation value. If the sum exceeds 3Fh, then 3Fh is applied. 11b — Apply the difference of NCOMP minus NDATA as the compensation value. If the difference is less than 00h, then 00h is applied.
29:28	Reserved.
27:22	**NDATA: AGP falling edge drive strength control.** Read-write. This value is applied to the falling-edge (N transistor) PHY compensation as described in NCTL.
21:16	**NCOMP: AGP falling edge drive strength.** Read only. This provides the calculated value of the falling-edge (N transistor) drive strength of the AGP signals. The default for this field varies. This field is updated by the hardware approximately every 8 microseconds.

15:14	**PCTL: AGP PHY P (rising edge) compensation control.** Read-write. These two bits combine to specify the PHY rising edge compensation value that is applied to AGP signals as follows: PCTL — Description 00b — Apply PCOMP directly as the compensation value. 01b — Apply PDATA directly as the compensation value. 10b — Apply the sum of PCOMP and PDATA as the compensation value. If the sum exceeds 1Fh, then 1Fh is applied. 11b — Apply the difference of PCOMP minus PDATA as the compensation value. If the difference is less than 00h, then 00h is applied.
13:12	Reserved.
11	**RW: read-write bit.** Read-write. This controls no logic.
10:6	**PDATA: AGP rising edge drive strength control.** Read-write. This value is applied to the rising-edge (P transistor) PHY compensation as described in PCTL.
5	Reserved.
4:0	**PCOMP: AGP rising edge drive strength.** Read only. This provides the calculated value of the rising-edge (P transistor) drive strength of the AGP signals. The default for this field varies. This field is updated by the hardware approximately every 8 microseconds.

AGP PHY Skew Control Register **DevA:0x58**

DSKEW and SSKEW are designed such that when they are both programmed to the same value, the AGP output strobes transition near the center of the data eye. To move the strobe to a later point in the data eye, the value of SSKEW is increased. To move the strobe to an earlier point in the data eye, DSKEW is increased. These values translate into skew approximately as follows:

For values 0h to 8h, the skew is about: [D, S]SKEW x 80 picoseconds.

For values 9h to Fh, the skew is about: 800 + ([D, S]SKEW - 8) x 400 picoseconds.

However, these values vary with process, temperature, and voltage. Note that the lower values provide fine resolution and the upper values provide coarse resolution.

Default: 0000 0000h. Attribute: Read-write.

Bits	Description
31:8	Reserved.
7:4	**DSKEW: AGP data skew.** Read-write. This specifies the alignment of the AGP data signal outputs, A_AD[31:0], A_CBE_L[3:0], and A_DBI[H, L], relative internal clocks. 0h=The strobe transitions earliest. Fh=The strobe transitions latest.
3:0	**SSKEW: AGP strobe skew.** Read-write. This specifies the alignment of the AGP strobe signal outputs, A_ADSTB[1:0], relative internal clocks. 0h=The strobe transitions earliest. Fh=The strobe transitions latest.

AGP Most Recent Request Register — DevA:0x60

As each PIPE mode or SBA mode AGP request is transferred into the IC, the fields are placed into this register. Thus, this register provides the fields of the most recent AGP requests. Any sticky bits from prior requests that have not been updated in the current request are also valid. Note: fences are not captured by this register.

Default: 0000 0000 0000 0000h Attribute: Read only.

Bits	Description
63:44	Reserved.
43:40	**MRC: most recent command field.** Specifies the command field of the most recent AGP request. 0h=LP (low priority) read. 1h=HP (high priority) read. 4h=LP write. 5h=HP write. 8h=LP long read. 9h=HP long read. Ah=Flush.
39:3	**MRA: most recent address.** Specifies address bits[39:3] of the most recent AGP request.
2:0	**MRL: most recent length field.** Specifies the length field of the most recent AGP request.

AGP Revision and Capability Register — DevA:0xA0

Default: 0030 C002h Attribute: Read only.

Bits	Description
31:24	Reserved.
23:16	**AGP specification.** This field is hardwired to indicate that the IC conforms to AGP specification revision 3.
15:8	**Next capabilities block.** Specifies the offset to the next capabilities block.
7:0	**Capabilities type.** Specifies the AGP capabilities block.

AGP Status Register — DevA:0xA4

Default: 1F00 0B2?h (see bit descriptions for bits[3:0])Attribute: Read only.

Bits	Description
31:24	**RQ: maximum number of outstanding requests.** This field is set to indicate support for 32 outstanding requests.
23:18	Reserved.
17	**Isochronous support.** This bit fixed in the low state to indicate that the IC does not support isochronous modes.
16:13	Reserved.
12:10	**Calibration cycle.** This field is set to indicate a requirement for calibration cycles every 64 milliseconds.
9	**SBA support.** This field is set to indicate support for SBA.
8	**Coherency.** This bit fixed high.
7	**64-bit GART support.** This bit fixed low.
6	**Host translation#.** This bit fixed low.
5	**Greater-than 4 gigabyte support.** This bit fixed high.

4	**FWSUP: fast write support flag.** 0=Fast writes are not supported. 1=Fast writes are supported. The state of this bit is controlled by DevA:0x40[FWDIS].
3	**AGP3MD: AGP 3.0 signaling mode detected.** 1=The IC detected connection to an AGP 3.0-capable master and is programmed for AGP 3.0 signaling. 0=The IC detected connection to an AGP 2.0 or earlier capable master or is not programmed for 1.5-volt, AGP 2.0 signaling. If DevA:0x40[8XDIS]=0 and the pin A_GC8XDET#=0, then this bit is high. Otherwise, it is low.
2:0	**RATE: data rate.** When AGP3MD=1, then this field defaults to 011b to indicate support for 4x and 8x data rates. When AGP3MD=0, this field defaults to 111b to indicate support for 4x, 2x, and 1x data rates.

AGP Command Register **DevA:0xA8**

Default: 0000 0000h Attribute: Read-write.

Bits	Description
31:13	Reserved.
12:10	**PCALCYC: periodic calibration cycle.** Specifies the period between calibration cycles as follows: 000b=4 milliseconds; 001b=16 milliseconds; 010=64 milliseconds; 011b=256 milliseconds; all other values are reserved. When DevA:0xA4[AGP3MD]=1, calibration cycles are as specified in the AGP 3.0 specification. When DevA:0xA4[AGP3MD]=0, calibration cycles consist of (1) the internal calibration logic requests the bus; (2) once granted, the calibration values are update in less than 6 A_PCLK cycles while the AGP bus is in a quiescent state. Note: after changing this value, the IC may not perform another calibration cycle until the internal counter rolls over as much as 256 microseconds later; in order to avoid this, DevA:0xB0[CALDIS] should be set high before changing PCALCYC and then DevA:0xB0[CALDIS] should be cleared afterward.
9	**SBA_EN: side band address enable.** 1=SBA addressing is enabled. Note: when DevA:0xA4[AGP3MD]=1, SBA addressing is enabled and the state of this bit is ignored.
8	**AGPEN: AGP operation enable.** 1=The IC accepts master-initiated AGP commands. 0=AGP commands are ignored.
7:6	Reserved.
5	**R4GEN: receive greater-than 4-gigabyte access enable.** 1=The IC accepts AGP accesses to addresses greater than 4 gigabytes.
4	**FWEN: fast write enable.** 1=Fast writes are enabled. When DevA:0xA4[FWSUP]=0, this bit is required to be programmed low; if, in this case, this bit is programmed high, then undefined behavior results.
3	Reserved.

2:0	**DRATE: data transfer mode rate.** This field is combined with DevA:0xA4[AGP3MD] to specify the AGP data rate as follows: AGP3MD / DRATE X / 000 — No AGP mode selected. 0 / 001 — 1x AGP rate; AGP 2.0 signaling. 0 / 010 — 2x AGP rate; AGP 2.0 signaling. 0 / 100 — 4x AGP rate; AGP 2.0 signaling. 1 / 001 — 4x AGP rate; AGP 3.0 signaling. 1 / 010 — 8x AGP rate; AGP 3.0 signaling. 1 / 100 — Reserved.

AGP Control Register **DevA:0xB0**

Default: 0000 0000h Attribute: Read-write.

Bits	Description
31:10	Reserved.
9	**CALDIS: calibration cycle disable.** 1=Calibration cycles (as defined in DevA:0xA8[PCALCYC]) are disabled.
8	**APEREN: graphics aperture enable.** This bit controls no hardware in the IC. It is expected that the state of this bit is copied into the host by software.
7	**GTLBEN: graphics translation look-aside buffer enable.** This bit controls no hardware in the IC. It is expected that the state of this bit is copied into the host by software.
6:0	Reserved.

AGP Aperture Size Register **DevA:0xB4**

Default: 0001 0F00h Attribute: See below.

Bits	Description
31:28	**PGSZSEL: page size select.** Read-write. The only legal value for these bits is 0000b, which specifies a 4-kilobyte page.
27	Reserved.
26:16	**Page size support.** Read only. These bits are fixed in their default state to indicate that the IC supports 4-kilobyte pages.
15:12	Reserved.

11:0	**APSIZE: graphic virtual memory aperture size.** Read-write (except bits[11, 7:6, and 2:0] which are read only, fixed at the default value). This field specifies the size of the aperture pointed to by DevA:0x10. This field also controls read only versus read-write control over several bits in DevA:0x10. It is encoded as follows:

Bits[10, 9, 8, 5, 4, 3]	Aperture size	DevA:0x10 read-write bits	DevA:0x10 read-only bits
1 1 1 1 1 1	32 MB	[63:25]	[24:0]
1 1 1 1 1 0	64 MB	[63:26]	[25:0]
1 1 1 1 0 0	128 MB	[63:27]	[26:0]
1 1 1 0 0 0	256 MB	[63:28]	[27:0]
1 1 0 0 0 0	512 MB	[63:29]	[28:0]
1 0 0 0 0 0	1024 MB	[63:30]	[29:0]
0 0 0 0 0 0	2048 MB	[63:31]	[30:0]

It is expected that the state of this field is copied into the host by software. Note: DevA:0x10[2] is "read; write once," even though it is shown as read-only above. Also, based on the state of DevA:0x10[2], DevA:0x10[63:32] may be read-only, all zeros.

AGP Device GART Pointer — DevA:0xB8

This register controls no hardware in the IC. It is expected that the state of this register is copied into the host by software.

Default: 0000 0000 0000 0000h Attribute: Read-write.

Bits	Description
63:32	**GARTHI: GART base address register high.**
31:12	**GARTLO: GART base address register low.**
11:0	Reserved.

Link Command Register — DevA:0xC0

Default: 0060 0008h Attribute: See below.

Bits	Description
31:29	**Slave/primary interface type.** Read only.
28	**DOUI: drop on uninitialized link.** Read-write. This specifies the behavior of transactions that are sent to uninitialized links. 0=Transactions that are received by the IC and forwarded to a side of the tunnel, when DevA:0x[C4/C8][INITCPLT and ENDOCH] for that side of the tunnel are both low, remain in buffers awaiting transmission indefinitely (waiting for INITCPLT to be set high). 1=Transactions that are received by the IC and forwarded to a side of the tunnel, when DevA:0x[C4/C8][INITCPLT and ENDOCH] for that side of the tunnel are both low, behave as if ENDOCH were high. Note: this bit is cleared by PWROK reset but not by RESET#.
27	**DEFDIR: default direction.** Read-write. 0=Send AGP master requests to the master link host as specified by DevA:0xC0[MASHST]. 1=Send AGP master requests to the opposite side of the tunnel.

26	**MASHST: master host.** Read; set and cleared by hardware. This bit indicates which link is the path to the master (or only) host bridge on the HyperTransport™ technology chain. 1=The hardware set this bit as a result of a write command from the B side of the tunnel to any of the bytes of DevA:0xC0[31:16]. 0=The hardware cleared this bit as a result of a write command from the A side of the tunnel to any of the bytes of DevA:0xC0[31:16]. This bit, along with DEFDIR, is used to determine the side of the tunnel to which AGP master requests are sent.
25:21	**UnitID count.** Read only. Specifies the number of UnitIDs used by the IC (three).
20:16	**BUID: base UnitID.** Read-write. This specifies the link-protocol base UnitID. The IC's logic uses this value to determine the UnitIDs for link request and response packets. When a new value is written to this field, the response includes a UnitID that is based on the new value in this register. Note: some legacy operating systems may require that this value be set to zero for normal operation so that the AGP capability block is part of device 0. Since the IC does not use the base unit ID in any link transactions, there is no conflict with the host unit ID. However, at boot, BIOS is required to temporarily change the BUID value of the IC so that the BUID values in downstream devices may be initialized. After downstream BUID values are initialized, this field may be set to zero to be compatible with legacy operating systems.
15:8	Reserved.
7:0	**Capabilities ID.** Read only. Specifies the capabilities ID for link configuration space.

Link Configuration And Control Register **DevA:0xC4 and DevA:0xC8**

DevA:0xC4 applies side A of the tunnel and DevA:0xC8 applies to side B of the tunnel. The default value for bit[5] may vary (see the definition).

Default: ??11 0020h for DevA:0xC4 and ??00 0020h for DevA:0xC8.Attribute: See below.

Bits	Description
31	Reserved.
30:28	**LWO: link width out.** Read-write. Specifies the operating width of the outgoing link. Legal values are 001b (16 bits; DevA:0xC4 only), 000b (8 bits), 101b (4 bits), 100b (2 bits), and 111b (not connected). Note: this field is cleared by PWROK reset but not by RESET#; the default value of this field depends on the widths of the links of the connecting device, per the link specification. Note: after this field is updated, the link width does not change until either RESET# is asserted or a link disconnect sequence occurs through or LDTSTOP#.
27	Reserved.
26:24	**LWI: link width in.** Read-write. Specifies the operating width of the incoming link. Legal values are 001b (16 bits; DevA:0xC4 only), 000b (8 bits), 101b (4 bits), 100b (2 bits), and 111b (not connected). Note: this field is cleared by PWROK reset but not by RESET#; the default value of this field depends on the widths of the links of the connecting device, per the link specification. Note: after this field is updated, the link width does not change until either RESET# is asserted or a link disconnect sequence occurs through an LDTSTOP# assertion.
23	Reserved.
22:20	**Max link width out.** Read only. This specifies the width of the outgoing link to be 16 bits wide for side A and 8 bits wide for side B.
19	Reserved.

18:16	**Max link width in.** Read only. This specifies the width of the incoming link to be 16 bits wide for side A and 8 bits wide for side B.
15	Reserved.
14	**EXTCTL: extended control time during initialization.** Read-write. This specifies the time in which LT[B, A]CTL is held asserted during the initialization sequence that follows an LDTSTOP# deassertion, after LR[B, A]CTL is detected asserted. 0=At least 16 bit times. 1=About 50 microseconds. Note: this bit is cleared by PWROK reset but not by RESET#.
13	**LDT3SEN: link three-state enable.** Read-write. 1=During the LDTSTOP# disconnect sequence, the link transmitter signals are placed into the high impedance state and the receivers are prepared for the high impedance mode. For the receivers, this includes cutting power to the receiver differential amplifiers and ensuring that there are no resultant high-current paths in the circuits. 0=During the LDTSTOP# disconnect sequence, the link transmitter signals are driven, but in an undefined state, and the link receiver signals are assumed to be driven. Note: this bit is cleared by PWROK reset but not by RESET#. AMD recommends that this bit be set high in single-processor systems and be low in multi-processor systems.
12:10	Reserved.
9:8	**CRCERR: CRC Error.** Read; set by hardware; write 1 to clear. Bit[9] applies to the upper byte of the link (DevA:0xC4 only) and bit[8] applies to the lower byte. 1=The hardware detected a CRC error on the incoming link. Note: this bit is cleared by PWROK reset but not by RESET#.
7	**TXOFF: transmitter off.** Read; write 1 only. 1=No output signals on the link toggle; the input link receivers are disabled and the pins may float.
6	**ENDOCH: end of chain.** Read; write 1 only or set by hardware. 1=The link is not part of the logical HyperTransport technology chain; packets which are issued or forwarded to this link are either dropped or result in an NXA error response, as appropriate; packets received from this link are ignored and CRC is not checked; if the transmitter is still enabled (TXOFF), then it drives only NOP packets with good CRC. ENDOCH may be set by writing a 1 to it or it may be set by hardware if the link is determined to be disconnected at the rising edge of RESET#.
5	**INITCPLT: initialization complete.** Read only. This bit is set by hardware when low-level link initialization has successfully completed. If there is no device on the other end of the link, or if the device on the other side of the link is unable to properly perform link initialization, then the bit is not set. This bit is cleared when RESET# is asserted or after the link disconnect sequence completes after the assertion of LDTSTOP#.
4	**LKFAIL: link failure.** Read; set by hardware; write 1 to clear. This bit is set high by the hardware when a CRC error is detected on the link (if enabled by CRCFEN) or if the link is not used in the system. Note: this bit is cleared by PWROK reset, not by RESET#.
3	**CRCERRCMD: CRC error command.** Read-write. 1=The link transmission logic generates erroneous CRC values. 0=Transmitted CRC values match the values calculated per the link specification. This bit is intended to be used to check the CRC failure detection logic of the device on the other side of the link.
2	Reserved.
1	**CRCFEN: CRC flood enable.** Read-write. 1=CRC errors (in link A for DevA:0xC4[CRCFEN]; in link B for DevA:0xC8[CRCFEN]) result in sync packets to both outgoing links, DevA:0x04[SSE] is set, and the LKFAIL bit is set. 0=CRC errors do not result in sync packets, setting of DevA:0x04[SSE] or the LKFAIL bit.
0	Reserved.

Link Frequency Capability 0 Register **DevA:0xCC**

Default: 0035 0022h. Attribute: See below.

Bits	Description
31:16	**FREQCAPA: link A frequency capability.** Read only. These bits indicate that A side of the tunnel supports 200, 400, 600, and 800 MHz link frequencies.
15:12	Reserved.
11:8	**FREQA: link A frequency.** Read-write. Specifies the link side A frequency. Legal values are 0h (200 MHz), 2h (400 MHz), 4h (600 MHz), and 5h (800 MHz). Note: this bit is cleared by PWROK reset, not by RESET#. Note: after this field is updated, the link frequency does not change until either RESET# is asserted or a link disconnect sequence occurs through LDTSTOP#.
7:0	**REVISION.** Read only. Revision A of the IC is designed to version 1.02 of the link specification.

Link Frequency Capability 1 Register **DevA:0xD0**

Default: 0035 0002h. Attribute: See below.

Bits	Description
31:16	**FREQCAPB: link B frequency capability.** Read only. These bits indicate that that B side of the tunnel supports 200, 400, 600, and 800 MHz link frequencies.
15:12	Reserved.
11:8	**FREQB: link B frequency.** Read-write. Specifies the link side B frequency. Legal values are 0h (200 MHz), and 2h (400 MHz), 4h (600 MHz), and 5h (800 MHz). Note: although it is possible to program this field for higher frequencies, the B link of the IC is only designed to support 200 and 400 MHz operation. Note: this bit is cleared by PWROK reset, not by RESET#. Note: after this field is updated, the link frequency does not change until either RESET# is asserted or a link disconnect sequence occurs through LDTSTOP#.
7:0	**Link device feature capability indicator.** Read only. These bits are set to indicate that the IC supports LDTSTOP#.

Link Enumeration Scratchpad Register **DevA:0xD4**

Default: 0000 0000h. Attribute: See below.

Bits	Description
31:16	Reserved.
15:0	**ESP: enumeration scratchpad.** Read-write. This field controls no hardware within the IC. Note: this bit is cleared by PWROK reset, not by RESET#.

Link PHY Compensation Control Registers **DevA:0x[E8, E4, E0]**

The link PHY circuitry includes automatic compensation that is used to adjust the electrical characteristics for the link transmitters and receivers on both sides of the tunnel. There is one compensation circuit for the receivers and one for each polarity of the transmitters. These registers provide visibility into the calculated output of the compensation circuits, the ability to override the calculated value with software-controlled values, and the ability to offset the calculated values with a fixed difference. The overrides and difference values may be different between sides A and B of the tunnel. These registers specify the compensation parameters as follows:

- DevA:0xE0: transmitter rising edge (P) drive strength compensation.
- DevA:0xE4: transmitter falling edge (N) drive strength compensation.
- DevA:0xE8: receiver impedance compensation.

For DevA:0x[E4, E0], higher values represent higher drive strength; the values range from 01h to 13h (19 steps). For DevA:0xE8, higher values represent lower impedance; the values range from 00h to 1Fh (32 steps).

Note: the default state of these registers is set by PWROK reset; assertion of RESET# does not alter any of the fields.

Default: See below. Attribute: See below.

Bits	Description
31	**Must be low.** Read-write. This bit is required to be low at all times; setting it high results in undefined behavior.
30:21	Reserved.
20:16	**CALCCOMP: calculated compensation value.** Read only. This provides the calculated value from the auto compensation circuitry. The default value of this field is not predictable.
15	Reserved.
14:13	**BCTL: link side B PHY control value.** Read-write. These two bits combine to specify the PHY compensation value that is applied to side B of the tunnel as follows: BCTL — Description 00b — Apply CALCCOMP directly as the compensation value. 01b — Apply BDATA directly as the compensation value. 10b — Apply the sum of CALCCOMP and BDATA as the compensation value. In DevA:0x[E4, E0], if the sum exceeds 13h, then 13h is applied. In DevA:0x[E8], if the sum exceeds 1Fh, then 1Fh is applied. 11b — Apply the difference of CALCCOMP minus BDATA as the compensation value. If the difference is less than 01h, then 01h is applied. The default value of this field (from PWROK reset) is controlled by the CMPOVR signal. If CMPOVR = 0, the default is 00b. If CMPOVR = 1, the default is 01b.
12:8	**BDATA: link side B data value.** Read-write. This value is applied to the side B of the tunnel PHY compensation as described in BCTL. The default for DevA:0x[E4, E0] is 08h. The default for DevA:0xE8 is 0Fh.
7	Reserved.

6:5	**ACTL: link side A PHY control value.** Read-write. These two bits combine to specify the PHY compensation value that is applied to side A of the tunnel as follows: ACTL — Description 00b — Apply CALCCOMP directly as the compensation value. 01b — Apply ADATA directly as the compensation value. 10b — Apply the sum of CALCCOMP and ADATA as the compensation value. In DevA:0x[E4, E0], if the sum exceeds 13h, then 13h is applied. In DevA:0x[E8], if the sum exceeds 1Fh, then 1Fh is applied. 11b — Apply the difference of CALCCOMP minus ADATA as the compensation value. If the difference is less than 01h, then 01h is applied. The default value of this field (from PWROK reset) is controlled by the CMPOVR signal. If CMPOVR = 0, the default is 00b. If CMPOVR = 1, the default is 01b.
4:0	**ADATA: link side A data value.** Read-write. This value is applied to the side A of the tunnel PHY compensation as described in ACTL. The default for DevA:0x[E4, E0] is 08h. The default for DevA:0xE8 is 0Fh.

Clock Control Register **DevA:0xF0**

See section 4.3.1 for details on clock gating. AMD system recommendations for System Management Action Field (SMAF) codes are: 0=ACPI C2; 1=ACPI C3; 2=FID/VID change; 3=ACPI S1; 4=ACPI S3; 5=Throttling; 6=ACPI S4/S5. For server and desktop platforms, AMD recommends setting this register to 0004_0008h (to gate clocks during S1). For mobile platforms, AMD recommends setting this register to 0004_0A0Ah (to gate clocks during C3 and S1).

Default: 0000 0000h. Attribute: Read-write.

Bits	Description
31:19	Reserved.
18	**CGEN: clock gate enable.** 1=Internal clock gating, as specified by bits[7:0] of this register, is enabled.
17	**Must be low.** This bit is required to be low at all times; setting it high results in undefined behavior.
16	**Must be low.** This bit is required to be low at all times; setting it high results in undefined behavior.
15:8	**ECGSMAF: external clock gating system management action fields.** Each of the bits of this field correspond to SMAF values that are captured in Stop Grant cycles from the host. For each bit, 1=When LDTSTOP# is asserted prior to a Stop Grant cycle in which the SMAF field matches the ECGSMAF bit that is asserted, then A_PCLK and internal clock grids associated with the AGP bridges are forced low. 0=A_PCLK and the internal clock grids are active while LDTSTOP# is asserted. For example, if A_PCLK gating is required for SMAF values of 3 and 5, then ECGSMAF[3, 5] must be high. See section 4.3.1 for details.
7:0	**ICGSMAF: internal clock gating system management action fields.** Each of the bits of this field correspond to SMAF values that are captured in Stop Grant cycles from the host. For each bit, 1=When LDTSTOP# is asserted prior to a Stop Grant cycle in which the SMAF field matches the ICGSMAF bit that is asserted, then the IC power is reduced through gating of internal clocks. 0=No power reduction while LDTSTOP# is asserted. For example, if clock gating is required for SMAF values of 3 and 5, then ICGSMAF[3, 5] must be high. See section 4.3.1 for details.

5.3 AGP Bridge Configuration Registers

These registers are located in PCI configuration space, in the second device (device B), function 0. See section 5.1.2 for a description of the register naming convention.

AGP Bridge Vendor And Device ID Register — DevB:0x00

Default: 7455 1022h Attribute: See below.

Bits	Description
31:16	AGP bridge device ID. Bits[31:20] are read only; bits[19:16] are write-once. When the LSBs are left at the default value, some operating systems may load a generic graphics driver. System BIOS should program the LSBs to 6h in order to circumvent the loading of such a driver.
15:0	Vendor ID. Read only.

AGP Bridge Status And Command Register — DevB:0x04

Default: 0220 0000h Attribute: See below.

Bits	Description
31:9	Read only. These bits are fixed in their default state.
8	**SERREN: SERR# enable.** Read-write. This bit controls no hardware.
7:3	**Special cycle enable.** Read only. This bit is hardwired low.
2	**MASEN: PCI master enable.** Read-write. 1=Enables the AGP bus master to initiate PCI cycles to the host.
1	**MEMEN: memory enable.** Read-write. 1=Enables access to the AGP bus memory space.
0	**IOEN: IO enable.** Read-write. 1=Enables access to the AGP bus IO space.

AGP Bridge Revision and Class Code Register — DevB:0x08

Default: 0604 00??h Attribute: Read only.

Bits	Description
31:8	**CLASSCODE.**
7:0	**REVISION.**

AGP Bridge BIST-Header-Latency-Cache Register — DevB:0x0C

Default: 0001 0000h Attribute: See below.

Bits	Description
31:24	**BIST.** Read only. These bits fixed at their default values.
23:16	**HEADER.** Read only. These bits fixed at their default values.

15:8	**LATENCY.** Read-write. These bits control no hardware.
7:0	**CACHE.** Read only. These bits fixed at their default values.

AGP Bridge Bus Numbers And Secondary Latency Register — DevB:0x18

Default: 0000 0000h Attribute: Read-write.

Bits	Description
31:24	**SECLAT.** Secondary latency timer. These bits control no hardware.
23:16	**SUBBUS.** Subordinate bus number.
15:8	**SECBUS.** Secondary bus number.
7:0	**PRIBUS.** Primary bus number.

AGP Bridge Memory Base-Limit Registers — DevB:0x[30:1C]

These registers specify the IO-space (DevB:0x1C and DevB:0x30), non-prefetchable memory-space (DevB:0x20), and prefetchable memory-space (DevB:0x24) address windows for transactions that are mapped from the 40-bit link address space to the AGP bus.

The links support 25 bits of IO space. AGP supports 32 bits of IO space. Host accesses to the link-defined IO region are mapped to the AGP IO window with the 7 MSB always zero. AGP IO accesses in which any of the 7 MSBs are other than zero are ignored. The AGP IO space window is defined as follow:

```
AGP IO window =
  {7'h00, DevB:30[24:16], DevB:0x1C[15:12], 12'hFFF} >= address >=
  {7'h00, DevB:30[8:0],   DevB:0x1C[7:4],  12'h000};
```

The links support 40 bits of memory space. AGP supports 32 bits of non-prefetchable memory space. The AGP non-prefetchable window is defined to be within the lowest 4 gigabytes of link address space. AGP accesses above 4 gigabytes cannot access non-prefetchable memory space. The AGP non-prefetchable memory space window is defined as follows:

```
AGP non-prefetchable memory window =
  {32'h00, DevB:0x20[31:20], 20'hF_FFFF} >= address >=
  {32'h00, DevB:0x20[15:4],  20'h0_0000};
```

The links support 40 bits of memory space. AGP supports 32 bits of prefetchable memory space. The AGP prefetchable window is defined to be within the lowest 4 gigabytes of link address space. The AGP prefetchable memory space window is defined as follows:

```
AGP prefetchable memory window =
  {32'h00, DevB:0x24[31:20], 20'hF_FFFF} >= address >=
  {32'h00, DevB:0x24[15:4],  20'h0_0000};
```

These windows may also be altered by DevB:0x3C[VGAEN, ISAEN]. When the address (from either the host or from an AGP bus master) is inside one of the windows, then the transaction targets the AGP bus. Therefore, the following transactions are possible:

- Host-initiated transactions inside the windows are routed to the AGP bus.
- PCI transactions initiated on the AGP bus inside the windows are not claimed by the IC.
- Host initiated transactions outside the windows are passed through the tunnel or master aborted if the IC is at the end of a HyperTransport technology chain.
- PCI transactions initiated on the AGP bus outside the windows are claimed by the IC using medium decoding and passed to the host.

So, for example, if IOBASE > IOLIM, then no host-initiated IO-space transactions are forwarded to the AGP bus and all AGP-bus-initiated IO-space (not configuration) transactions are forwarded to the host. If MEMBASE > MEMLIM and PMEMBASE > PMEMLIM, then no host-initiated memory-space transactions are forwarded to the AGP bus and all AGP-bus-initiated memory-space (not configuration) transactions are forwarded to the host.

DevB:0x1C. Default: 0220 01F1h Attribute: See below.

Bits	Description
31:30	Reserved.
29	**RMA: received master abort.** Read; set by hardware; write 1 to clear. 1=The IC received a master abort as a PCI master on the AGP bus. Note: this bit is cleared by PWROK reset but not by RESET#.
28	**RTA: received target abort.** Read; set by hardware; write 1 to clear. 1=The IC received a target abort as a PCI master on the AGP bus. Note: this bit is cleared by PWROK reset but not by RESET#.
27	**STA: signaled target abort.** Read; set by hardware; write 1 to clear. 1=The IC generated a target abort as a PCI target on the AGP bus. The IC generates target aborts if it receives a target abort (a non-NXA error) response from the host to an AGP bus PCI master transaction request. Note: this bit is cleared by PWROK reset but not by RESET#.
26:16	Read only. These bits are fixed in their default state.
15:12	**IOLIM.** IO limit address bits[15:12]. See DevB:0x[30:1C] above.
11:8	Reserved.
7:4	**IOBASE.** IO base address bits[15:12]. See DevB:0x[30:1C] above.
3:0	Reserved.

DevB:0x20. Default: 0000 FFF0h Attribute: Read-write.

Bits	Description
31:20	**MEMLIM.** Non-prefetchable memory limit address bits[31:20]. See DevB:0x[30:1C] above.
19:16	Reserved.
15:4	**MEMBASE.** Non-prefetchable memory base address bits[31:20]. See DevB:0x[30:1C] above.
3:0	Reserved.

DevB:0x24. Default: 0000 FFF0h Attribute: Read-write.

Bits	Description
31:20	**PMEMLIM.** Prefetchable memory limit address bits[31:20]. See DevB:0x[30:1C] above.
19:16	Reserved.
15:4	**PMEMBASE.** Prefetchable memory base address bits[31:20]. See DevB:0x[30:1C] above.
3:0	Reserved.

DevB:0x30. Default: 0000 FFFFh Attribute: Read-write.

Bits	Description
31:16	**IOLIM.** IO limit address bits[31:16]. See DevB:0x[30:1C] above.
15:0	**IOBASE.** IO base address bits[31:16]. See DevB:0x[30:1C] above.

AGP Bridge Interrupt and Bridge Control Register **DevB:0x3C**

Default: 0000 00FFh Attribute: See below.

Bits	Description
31:23	Reserved.
22	**SBRST: AGP bus reset.** Read-write. 1=A_RESET# asserted; AGP bus placed into reset state. 0=A_RESET# not asserted.
21:20	Reserved.
19	**VGAEN: VGA decoding enable.** Read-write. 1=Host-initiated commands targeting VGA-compatible address ranges are routed to the AGP bus. These include memory accesses from A0000h to BFFFFh (within the bottom megabyte of memory space only), IO accesses in which address bits[9:0] range from 3B0h to 3BBh or 3C0h to 3DFh (address bits[15:10] are not decoded, regardless of DevB:0x3C[ISAEN]; also this only applies to the first 64K of IO space; i.e., address bits[31:16] must be low). 0=The IC does not decode VGA-compatible address ranges.
18	**ISAEN: ISA decoding enable.** Read-write. 1=The IO address window specified by DevB:0x1C[15:0] and DevB:0x30 is limited to the first 256 bytes of each 1K byte block specified; this only applies to the first 64K bytes of IO space. 0=The PCI IO window is the whole range specified by DevB:0x1C[15:0] and DevB:0x30.
17:16	Reserved.
15:8	**INTERRUPT_PIN.** Read; write once. These bits control no internal logic.
7:0	**INTERRUPT_LINE.** Read-write. These bits control no internal logic.

6 Electrical Data

6.1 Absolute Ratings

The IC is not designed to operate beyond the parameters shown in the following table.

Parameter	Minimum	Maximum	Comments
VDD12[B, A]	–0.5 V	1.7 V	
VDD15	–0.5 V	2.0 V	
VDD18, VDDA18	–0.5 V	2.3 V	
VDD33	–0.5 V	3.6 V	
T_{CASE} (Under Bias)		85 °C	
$T_{STORAGE}$	-65 °C	150 °C	

Table 6: Absolute maximum ratings.

6.2 Operating Ranges

The IC is designed to provide functional operation if the voltage and temperature parameters are within the limits defined in the following table.

Parameter	Minimum	Typical	Maximum	Units	Comments
VDD12[B, A]	1.14	1.2	1.26	V	
VDD15	1.425	1.5	1.575	V	
VDD18, VDDA18	1.71	1.8	1.89	V	
VDD33	3.135	3.3	3.465 V	V	
T_{CASE} (Under Bias)			85	deg C	

Table 7: Operating ranges.

6.3 DC Characteristics

See the HyperTransport™ Technology Electrical Specification for the DC characteristics of link signals.

The following table shows current consumption in amps and power in watts for each power plane.

		Typical		Max		
Supply	**Parameter Description**	**Current**	**Power**	**Current**	**Power**	**Comments**
VDD12	VDD12[B, A] current, power	0.21 A	0.25 W	0.27 A	0.34 W	
VDD15	VDD15 current, power	0.05 A	0.08 W	0.08 A	0.13 W	
VDD18	VDD18 current, power; operational	1.30 A	2.34 W	1.75 A	3.30 W	
VDD18	VDD18 current, power; internal clock gating enabled (DevA:0xF0[ICGSMAF])	0.40 A	0.72 W	0.50 A	0.95 W	
VDD18	VDD18 current, power; internal and external clock gating enabled (DevA:0xF0[I/ECGSMAF])	0.21 A	0.38 W	0.30 A	0.57 W	
VDDA18	VDDA18 current, power	0.02 A	0.04 W	0.03 A	0.06 W	
VDD33	VDD33 current, power	0.05 A	0.17 W	0.07 A	0.24 W	
	Total power (no clock gating enabled)		2.88 W		4.07 W	

Table 8: Current and power consumption.

The following table shows DC characteristics for signals on the VDD33 power plane.

Symbol	**Parameter Description**	**Min**	**Max**	**Units**	**Comments**
V_{IL}	Input low voltage	-0.5	0.3 VDD33	V	
V_{IH}	Input high voltage	0.6 VDD33	0.5 + VDD33	V	
V_{OL}	Output low voltage; I_{OUT} = 1.5 mA		0.1 VDD33	V	
V_{OH}	Output high voltage; I_{OUT} = -0.5 mA	0.9 VDD33		V	
I_{LI}	Input leakage current		+/- 10	uA	
C_{IN}	Input capacitance		8	pF	

Table 9: DC characteristics for signals on the VDD33 power plane.

The following table shows DC characteristics for signals on the VDD15 power plane when AGP 2.0 signaling is enabled.

Symbol	Parameter Description	Min	Max	Units	Comments
V_{IL}	Input low voltage	-0.5	0.4 VDD15	V	
V_{IH}	Input high voltage	0.6 VDD15	0.5 + VDD15	V	
V_{OL}	Output low voltage; I_{OUT} = 1.0 mA		0.15 VDD15	V	
V_{OH}	Output high voltage; I_{OUT} = 0.2 mA	0.85 VDD15		V	
V_{REFI}	Input reference voltage on A_REFGC	0.48 VDD15	0.52 VDD15	V	
V_{REFO}	Output reference voltage on A_REFCG	0.48 VDD15	0.52 VDD15	V	
I_{IL}	Input leakage current		+/- 10	uA	
C_{IN}	Input capacitance		8	pF	

Table 10: DC characteristics for signals on the VDD15 power plane, AGP 2.0 signaling.

The following table shows DC characteristics for signals on the VDD15 power plane when AGP 3.0 signaling is enabled.

Symbol	Parameter Description	Min	Max	Units	Comments
V_{IL}	Input low voltage	-0.3	V_{REFI} - 0.1	V	
V_{IH}	Input high voltage	V_{REFI} + 0.1	VDD15 + 0.3	V	
V_{OL}	Output low voltage; I_{OUT} = 1.5 mA		0.05	V	
V_{OH}	Output high voltage; 50 ohm load to ground	0.750	0.850	V	
V_{REFI}	Input reference voltage on A_REFGC	0.34	0.36	V	
V_{REFO}	Output reference voltage on A_REFCG	0.226 VDD15	0.240 VDD15	V	
C_{DIE}	Input die capacitance		8	pF	
Z_{TERM}	Terminator equivalent impedance; V_{OH} = 0.8V; Z_{TARG} = 50 Ohm	45	55	Ohms	
Z_{PU}	Pull-up equivalent impedance; V_{OH} = 0.8V; Z_{TARG} = 50 Ohm	39.3	46.2	Ohms	

Table 11: DC characteristics for signals on the VDD15 power plane, AGP 3.0 signaling.

6.4 AC Characteristics

See the HyperTransport Technology Electrical Specification for the AC characteristics of link signals.

The following table shows AC specification data for clocks.

Symbol	Parameter Description	Min	Max	Units	Comments
t_{REF}	REFCLK cycle time	15	18	ns	
t_{CYC}	A_PCLK cycle time	15		ns	Matches REFCLK
t_{HIGH}	A_PCLK high time	6		ns	
t_{LOW}	A_PCLK low time	6		ns	
t_{SLEW}	A_PCLK slew rate	1	4	V/ns	

Table 12: AC data for clocks.

The following table shows AC specification data for common clock (A_PCLK) operation of AGP signals.

Symbol	Parameter Description	Min	Max	Units	Notes
t_{VAL}	A_PCLK to signal valid delay	1	5.5	ns	
t_{ON}	A_PCLK to signal float-to-active delay	1	6	ns	
t_{OFF}	A_PCLK to signal active-to-float delay	1	14	ns	
t_{SU}	Signal input setup time to A_PCLK	6		ns	
t_{H}	AGP signal input hold time after A_PCLK	0		ns	
t_{RF}	Signal output rise and fall slew rate	2	3.5	V/ns	

Table 13: AC data for common clock operation of AGP signals.

The following table shows AC specification data for clock-forwarded operation of AGP signals.

Symbol	Parameter Description	AGP 2X		AGP 4X		AGP 8X		Units	Notes
		Min	Max	Min	Max	Min	Max		
t_{TSF}	A_PCLK to transmit strobe first strobe edge	2	12	1.9	8	1.5		ns	
t_{TSR}	A_PCLK to transmit strobe final strobe edge		20		20		19.5	ns	
t_{DVB}	Data valid before strobe	1.7		-0.95		0.527		ns	
t_{DVA}	Data valid after strobe	1.9		1.15		0.477		ns	
t_{OND}	A_PCLK to float-to-active delay	-1	9	-1	7	-1	7	ns	
t_{OFFD}	A_PCLK to active-to-float delay	1	12	1	14	1	14	ns	
t_{ONS}	Strobe active to first edge delay	6	10	4	9	4	9	ns	
t_{OFFS}	Strobe final edge to float delay	6	10	4	9	4	9	ns	
t_{RSSU}	Receive requirement for last strobe setup time to next A_PCLK	6		6		6		ns	
t_{RSH}	Receive requirement for first strobe hold time after A_PCLK	1		0.5		0.5		ns	
t_{DSU}	Receive data setup time to strobe	1		0.4		0.085		ns	
t_{DH}	Receive data hold time after strobe	1		0.7		0.210		ns	
t_{RF}	Transmit rise and fall slew rate	2	3.5	2	3.5	2	3.5	V/ns	

Table 14: AC data for clock-forwarded operation of AGP signals.

7 Ball Designations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
A			LTACAD_P0	LTACAD_N0	LTACAD_P2	LTACAD_N2	LTACLK0_P	LTACLK0_N	LTACAD_P5	LTACAD_N5	LTACAD_P7	LTACAD_N7	LRACTL_N	LRACTL_P	LRACAD_N6	LRACAD_P6	LRACAD_N4	LRACAD_P4	LRACAD_N3	LRACAD_P3	LRACAD_N1	LRACAD_P1			A
B		VDD12A	VSS	LTACAD_P1	VDD18	LTACAD_P3	VSS	LTACAD_P4	VDD18	LTACAD_P6	VSS	LTACTL_P	VDD18	LRACAD_N7	VSS	LRACAD_N5	VDD18	LRACLK0_N	VSS	LRACAD_N2	VDD18	LRACAD_N0	VDD12A		B
C	VDD12A	VSS	LTACAD_N8	LTACAD_N1	LTACAD_N10	LTACAD_N3	LTACLK1_N	LTACAD_N4	LTACAD_N13	LTACAD_N6	LTACAD_N15	LTACTL_N	FREE4	LRACAD_P7	LRACAD_P14	LRACAD_P5	LRACAD_P12	LRACLK0_P	LRACAD_P11	LRACAD_P2	LRACAD_P9	LRACAD_P0	VSS	VDD12A	C
D	VSS	VDD12A	LTACAD_P8	VDD18	LTACAD_P10	VSS	LTACLK1_P	VDD18	LTACAD_P13	VSS	LTACAD_P15	VDD18	FREE5	VSS	LRACAD_N14	VDD18	LRACAD_N12	VSS	LRACAD_N11	VDD18	LRACAD_N9	VSS	VSS	VDD12A	D
E	VDD12A	VSS	LTACAD_P9	LTACAD_N9	LTACAD_P11	LTACAD_N11	LTACAD_P12	LTACAD_N12	LTACAD_P14	LTACAD_N14	FREE7	FREE6	LRACAD_N15	LRACAD_P15	LRACAD_N13	LRACAD_P13	LRACLK1_N	LRACLK1_P	LRACAD_N10	LRACAD_P10	LRACAD_N8	LRACAD_P8	VDD12A	VSS	E
F	A_DBIH	VDD12A	VSS	VDD12A	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD12A	VSS	VDD12B	F
G	A_SBA0	A_DBIL	VDD12A	VDD12A	VDD12A	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD12A	VSS	VDD12B	VDD12B	G
H	A_SBA2	A_SBA1	STRAPL0	VDD15	VSS	VDD12A	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD12A	VDD12A	VDD12A	VSS	VDD12B	VSS	VSS	H
J	A_SBA3	VSS	STRAPL10	STRAPL1	STRAPL8	VSS	VDD12A	VDD12A	VDD12A	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD12A	VSS	VDD12B	VDD12B	VDD12B	VSS	VDD18	LTBCAD_P0	J
K	A_SB STB_P	A_SB STB_N	FREE1	A_GC8X DET#	VSS	VDD15	VSS	VDD15	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD12B	VSS	VSS	VDD18	LTBCAD_N1	LTBCAD_P1	LTBCAD_N0	K
L	A_SBA5	A_SBA4	VSS	A_GNT#	STRAPL9	VSS	VDD15	VSS	VDD15	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	LTBCAD_P5	LTBCAD_P4	LTBCAD_N4	VSS	LTBCAD_P2	L
M	A_SBA6	VSS	STRAPL11	VDD15	VSS	VDD15	VSS	VDD15	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	LTBCAD_N5	VSS	LTBCAD_N3	LTBCAD_P3	LTBCAD_N2	M
N	A_AD31	A_SBA7	NC1	A_REQ#	VSS	VSS	VDD15	VSS	VDD15	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	LTBCAD_P7	LTBCAD_P6	LTBCAD_N6	VDD18	LTBCLK0_P	N
P	A_AD29	A_AD30	VSS	STRAPL13	STRAPL7	VDD15	VSS	VDD15	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	LTBCAD_N7	VDD18	LTBCTL_N	LTBCTL_P	LTBCLK0_N	P
R	A_AD28	VSS	FREE2	VDD15	VSS	VSS	VDD15	VSS	VDD15	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	VSS	VDD18	LRBCAD_N6	LRBCAD_N7	LRBCAD_P7	VSS	LRBCTL_N	R
T	A_AD26	A_AD27	FREE3	A_ST0	VSS	VDD15	VSS	VDD15	VSS	VDD15	VSS	VDD15	VSS	VDD15	VSS	VDD12B	VSS	VDD18	VSS	LRBCAD_P6	VSS	LRBCLK0_P	LRBCLK0_N	LRBCTL_P	T
U	A_AD25	A_AD24	VSS	A_ST1	VSS	VSS	VDD15	VSS	VDD15	VSS	VDD15	VSS	VDD15	VSS	VSS	VDD12B	VDD18	VSS	VDD18	LRBCAD_N4	LRBCAD_N5	LRBCAD_P5	VDD18	LRBCAD_N3	U
V	A_AD STB1_P	VSS	A_ST2	VDD15	VSS	VDD15	VSS	VDD15	VSS	VDD15	VSS	VDD15	VSS	VDD15	VSS	VDD12B	VSS	VDD18	VSS	LRBCAD_P4	VDD18	LRBCAD_P2	LRBCAD_N2	LRBCAD_P3	V
W	A_AD23	A_AD STB1_N	A_CBE_L3	A_MB8X DET#	VSS	VSS	VDD15	VSS	VDD15	VSS	VDD15	VSS	VDD15	VSS	VDD15	VSS	VDD12B	VSS	VDD18	LDTCOMP0	LDTCOMP1	LDTCOMP2	VSS	LRBCAD_N1	W
Y	A_AD21	A_AD22	VSS	NC0	A_RBF#	VSS	A_CALS	STRAPL5	STRAPL6	VSS	STRAPL4	STRAPL18	STRAPL19	VDD15	STRAPL20	STRAPL21	VSS	VDD12B	VSS	LDTCOMP3	VSS	LRBCAD_P0	LRBCAD_N0	LRBCAD_P1	Y
AA	A_AD20	VSS	STRAPL14	VDD15	A_WBF#	A_CALD	VDD15	A_CALS#	A_FRAME#	VDD15	A_STOP#	A_PAR	VDD15	STRAPL3	A_PLL CLKO	STRAPL22	TEST	VSS	VDD12B	VSS	VDD12B	VSS	VDD12B	VSS	AA
AB	A_AD19	A_AD17	A_AD18	STRAPL15	VSS	A_CALD#	STRAPL16	A_IRDY#	A_DEVSEL#	A_TRDY#	VSS	A_AD5	STRAPL2	VSS	A_PLL CLKI	REFCLK	VSS	RESET#	VSS	VDD12B	VDD12B	VDD12B	VSS	VDD12B	AB
AC		VSS	A_AD16	VSS	A_CBE_L1	A_AD14	VSS	A_AD12	A_AD9	VSS	A_AD STB0_P	A_AD6	VSS	A_AD2	A_AD1	VSS	CMP OVR	LDT-STOP#	A_PCLK	VSS	VDD33	VSS	VDD12B		AC
AD			A_CBE_L2	STRAPL17	A_AD15	A_AD13	A_AD11	A_AD10	A_AD8	A_CBE_L0	A_AD STB0_N	A_AD7	A_AD4	A_AD3	A_AD0	A_REF GC	A_REF CG	PWROK	A_RESET#	A_TYPE DET#	VDD33	VDDA18			AD
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	

Top side view.

Figure 3: Ball designations.

Alphabetical listing of signals and corresponding BGA designators.

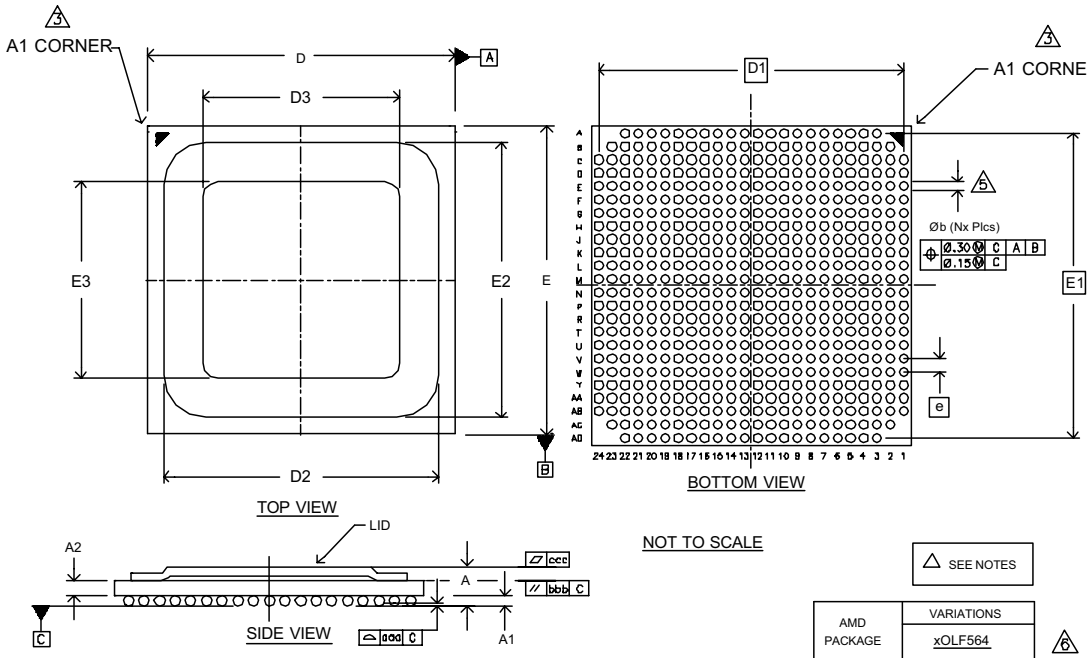
Signal name	Ball	Signal name	Ball	Signal name	Ball	Signal name	Ball	Signal name	Ball
A_AD0	15AD	A_PAR	12AA	LRACAD_N13	15E	LTACAD_N7	12A	NC1	3N
A_AD1	15AC	A_PCLK	19AC	LRACAD_N14	15D	LTACAD_N8	3C	PWROK	18AD
A_AD2	14AC	A_PLLCLKI	15AB	LRACAD_N15	13E	LTACAD_N9	4E	REFCLK	16AB
A_AD3	14AD	A_PLLCLKO	15AA	LRACAD_P0	22C	LTACAD_N10	5C	RESET#	18AB
A_AD4	13AD	A_RBF#	5Y	LRACAD_P1	22A	LTACAD_N11	6E	STRAPL0	3H
A_AD5	12AB	A_REFCG	17AD	LRACAD_P2	20C	LTACAD_N12	8E	STRAPL1	4J
A_AD6	12AC	A_REFGC	16AD	LRACAD_P3	20A	LTACAD_N13	9C	STRAPL2	13AB
A_AD7	12AD	A_REQ#	4N	LRACAD_P4	18A	LTACAD_N14	10E	STRAPL3	14AA
A_AD8	9AD	A_RESET#	19AD	LRACAD_P5	16C	LTACAD_N15	11C	STRAPL4	11Y
A_AD9	9AC	A_SBA0	1G	LRACAD_P6	16A	LTACAD_P0	3A	STRAPL5	8Y
A_AD10	8AD	A_SBA1	2H	LRACAD_P7	14C	LTACAD_P1	4B	STRAPL6	9Y
A_AD11	7AD	A_SBA2	1H	LRACAD_P8	22E	LTACAD_P2	5A	STRAPL7	5P
A_AD12	8AC	A_SBA3	1J	LRACAD_P9	21C	LTACAD_P3	6B	STRAPL8	5J
A_AD13	6AD	A_SBA4	2L	LRACAD_P10	20E	LTACAD_P4	8B	STRAPL9	5L
A_AD14	6AC	A_SBA5	1L	LRACAD_P11	19C	LTACAD_P5	9A	STRAPL10	3J
A_AD15	5AD	A_SBA6	1M	LRACAD_P12	17C	LTACAD_P6	10B	STRAPL11	3M
A_AD16	3AC	A_SBA7	2N	LRACAD_P13	16E	LTACAD_P7	11A	STRAPL13	4P
A_AD17	2AB	A_SBSTB_N	2K	LRACAD_P14	15C	LTACAD_P8	3D	STRAPL14	3AA
A_AD18	3AB	A_SBSTB_P	1K	LRACAD_P15	14E	LTACAD_P9	3E	STRAPL15	4AB
A_AD19	1AB	A_ST0	4T	LRACLK0_N	18B	LTACAD_P10	5D	STRAPL16	7AB
A_AD20	1AA	A_ST1	4U	LRACLK0_P	18C	LTACAD_P11	5E	STRAPL17	4AD
A_AD21	1Y	A_ST2	3V	LRACLK1_N	17E	LTACAD_P12	7E	STRAPL18	12Y
A_AD22	2Y	A_STOP#	11AA	LRACLK1_P	18E	LTACAD_P13	9D	STRAPL19	13Y
A_AD23	1W	A_TRDY#	10AB	LRACTL_N	13A	LTACAD_P14	9E	STRAPL20	15Y
A_AD24	2U	A_TYPEDET#	20AD	LRACTL_P	14A	LTACAD_P15	11D	STRAPL21	16Y
A_AD25	1U	A_WBF#	5AA	LRBCAD_N0	23Y	LTACLK0_N	8A	STRAPL22	16AA
A_AD26	1T	CMPOVR	17AC	LRBCAD_N1	24W	LTACLK0_P	7A	TEST	17AA
A_AD27	2T	FREE1	3K	LRBCAD_N2	23V	LTACLK1_N	7C		
A_AD28	1R	FREE2	3R	LRBCAD_N3	24U	LTACLK1_P	7D		
A_AD29	1P	FREE3	3T	LRBCAD_N4	20U	LTACTL_N	12C		
A_AD30	2P	FREE4	13C	LRBCAD_N5	21U	LTACTL_P	12B		
A_AD31	1N	FREE5	13D	LRBCAD_N6	20R	LTBCAD_N0	24K		
A_ADSTB0_N	11AD	FREE6	12E	LRBCAD_N7	21R	LTBCAD_N1	22K		
A_ADSTB0_P	11AC	FREE7	11E	LRBCAD_P0	22Y	LTBCAD_N2	24M		
A_ADSTB1_N	2W	LDTCOMP0	20W	LRBCAD_P1	24Y	LTBCAD_N3	22M		
A_ADSTB1_P	1V	LDTCOMP1	21W	LRBCAD_P2	22V	LTBCAD_N4	22L		
A_CALD	6AA	LDTCOMP2	22W	LRBCAD_P3	24V	LTBCAD_N5	20M		
A_CALD#	6AB	LDTCOMP3	20Y	LRBCAD_P4	20V	LTBCAD_N6	22N		
A_CALS	7Y	LDTSTOP#	18AC	LRBCAD_P5	22U	LTBCAD_N7	20P		
A_CALS#	8AA	LRACAD_N0	22B	LRBCAD_P6	20T	LTBCAD_P0	24J		
A_CBE_L0	10AD	LRACAD_N1	21A	LRBCAD_P7	22R	LTBCAD_P1	23K		
A_CBE_L1	5AC	LRACAD_N2	20B	LRBCLK0_N	23T	LTBCAD_P2	24L		
A_CBE_L2	3AD	LRACAD_N3	19A	LRBCLK0_P	22T	LTBCAD_P3	23M		
A_CBE_L3	3W	LRACAD_N4	17A	LRBCTL_N	24R	LTBCAD_P4	21L		
A_DBIH	1F	LRACAD_N5	16B	LRBCTL_P	24T	LTBCAD_P5	20L		
A_DBIL	2G	LRACAD_N6	15A	LTACAD_N0	4A	LTBCAD_P6	21N		
A_DEVSEL#	9AB	LRACAD_N7	14B	LTACAD_N1	4C	LTBCAD_P7	20N		
A_FRAME#	9AA	LRACAD_N8	21E	LTACAD_N2	6A	LTBCLK0_N	24P		
A_GC8XDET#	4K	LRACAD_N9	21D	LTACAD_N3	6C	LTBCLK0_P	24N		
A_GNT#	4L	LRACAD_N10	19E	LTACAD_N4	8C	LTBCTL_N	22P		
A_IRDY#	8AB	LRACAD_N11	19D	LTACAD_N5	10A	LTBCTL_P	23P		
A_MB8XDET#	4W	LRACAD_N12	17D	LTACAD_N6	10C	NC0	4Y		

Table 15: Signal BGA positions.

Signal name	Ball	Signal name	Ball	Signal name	Ball	Signal name	Ball	Signal name	Ball	Signal name	Ball	Signal name	Ball
VDD12A	1C	VDD15	6T	VDD18	12F	VDD18	23U	VSS	8R	VSS	14AB	VSS	21Y
VDD12A	1E	VDD15	6V	VDD18	12H	VDD33	21AC	VSS	8U	VSS	15B	VSS	22D
VDD12A	2B	VDD15	7L	VDD18	12K	VDD33	21AD	VSS	8W	VSS	15F	VSS	22G
VDD12A	2D	VDD15	7N	VDD18	12M	VDDA18	22AD	VSS	9F	VSS	15H	VSS	22J
VDD12A	2F	VDD15	7R	VDD18	12P	VSS	1D	VSS	9H	VSS	15K	VSS	22AA
VDD12A	3G	VDD15	7U	VDD18	13B	VSS	2C	VSS	9K	VSS	15M	VSS	22AC
VDD12A	4F	VDD15	7W	VDD18	13G	VSS	2E	VSS	9M	VSS	15P	VSS	23C
VDD12A	4G	VDD15	7AA	VDD18	13J	VSS	2J	VSS	9P	VSS	15T	VSS	23D
VDD12A	5G	VDD15	8K	VDD18	13L	VSS	2M	VSS	9T	VSS	15U	VSS	23F
VDD12A	6H	VDD15	8M	VDD18	13N	VSS	2R	VSS	9V	VSS	15V	VSS	23H
VDD12A	7J	VDD15	8P	VDD18	13R	VSS	2V	VSS	10D	VSS	16G	VSS	23L
VDD12A	8J	VDD15	8T	VDD18	14F	VSS	2AA	VSS	10G	VSS	16J	VSS	23R
VDD12A	9J	VDD15	8V	VDD18	14H	VSS	2AC	VSS	10J	VSS	16L	VSS	23W
VDD12A	17J	VDD15	9L	VDD18	14K	VSS	3B	VSS	10L	VSS	16N	VSS	23AB
VDD12A	18H	VDD15	9N	VDD18	14M	VSS	3F	VSS	10N	VSS	16R	VSS	24E
VDD12A	19H	VDD15	9R	VDD18	14P	VSS	3L	VSS	10R	VSS	16W	VSS	24H
VDD12A	20H	VDD15	9U	VDD18	15G	VSS	3P	VSS	10U	VSS	16AC	VSS	24AA
VDD12A	21G	VDD15	9W	VDD18	15J	VSS	3U	VSS	10W	VSS	17F		
VDD12A	22F	VDD15	10T	VDD18	15L	VSS	3Y	VSS	10Y	VSS	17H		
VDD12A	23B	VDD15	10V	VDD18	15N	VSS	4AC	VSS	10AC	VSS	17K		
VDD12A	23E	VDD15	10AA	VDD18	15R	VSS	5F	VSS	11B	VSS	17M		
VDD12A	24C	VDD15	11U	VDD18	16D	VSS	5H	VSS	11F	VSS	17P		
VDD12A	24D	VDD15	11W	VDD18	16F	VSS	5K	VSS	11H	VSS	17T		
VDD12B	16T	VDD15	12T	VDD18	16H	VSS	5M	VSS	11K	VSS	17V		
VDD12B	16U	VDD15	12V	VDD18	16K	VSS	5N	VSS	11M	VSS	17Y		
VDD12B	16V	VDD15	13U	VDD18	16M	VSS	5R	VSS	11P	VSS	17AB		
VDD12B	17W	VDD15	13W	VDD18	16P	VSS	5T	VSS	11T	VSS	18D		
VDD12B	18K	VDD15	13AA	VDD18	17B	VSS	5U	VSS	11V	VSS	18G		
VDD12B	18Y	VDD15	14T	VDD18	17G	VSS	5V	VSS	11AB	VSS	18J		
VDD12B	19J	VDD15	14V	VDD18	17L	VSS	5W	VSS	12G	VSS	18L		
VDD12B	19AA	VDD15	14Y	VDD18	17N	VSS	5AB	VSS	12J	VSS	18N		
VDD12B	20J	VDD15	15W	VDD18	17R	VSS	6D	VSS	12L	VSS	18R		
VDD12B	20AB	VDD18	4D	VDD18	17U	VSS	6G	VSS	12N	VSS	18U		
VDD12B	21J	VDD18	5B	VDD18	18F	VSS	6J	VSS	12R	VSS	18W		
VDD12B	21AA	VDD18	6F	VDD18	18M	VSS	6L	VSS	12U	VSS	18AA		
VDD12B	21AB	VDD18	7G	VDD18	18P	VSS	6N	VSS	12W	VSS	19B		
VDD12B	22H	VDD18	8D	VDD18	18T	VSS	6R	VSS	13F	VSS	19F		
VDD12B	22AB	VDD18	8F	VDD18	18V	VSS	6U	VSS	13H	VSS	19K		
VDD12B	23G	VDD18	8H	VDD18	19G	VSS	6W	VSS	13K	VSS	19M		
VDD12B	23AA	VDD18	9B	VDD18	19L	VSS	6Y	VSS	13M	VSS	19P		
VDD12B	23AC	VDD18	9G	VDD18	19N	VSS	7B	VSS	13P	VSS	19T		
VDD12B	24F	VDD18	10F	VDD18	19R	VSS	7F	VSS	13T	VSS	19V		
VDD12B	24G	VDD18	10H	VDD18	19U	VSS	7H	VSS	13V	VSS	19Y		
VDD12B	24AB	VDD18	10K	VDD18	19W	VSS	7K	VSS	13AC	VSS	19AB		
VDD15	4H	VDD18	10M	VDD18	20D	VSS	7M	VSS	14D	VSS	20G		
VDD15	4M	VDD18	10P	VDD18	20F	VSS	7P	VSS	14G	VSS	20K		
VDD15	4R	VDD18	11G	VDD18	21B	VSS	7T	VSS	14J	VSS	20AA		
VDD15	4V	VDD18	11J	VDD18	21K	VSS	7V	VSS	14L	VSS	20AC		
VDD15	4AA	VDD18	11L	VDD18	21P	VSS	7AC	VSS	14N	VSS	21F		
VDD15	6K	VDD18	11N	VDD18	21V	VSS	8G	VSS	14R	VSS	21H		
VDD15	6M	VDD18	11R	VDD18	23J	VSS	8L	VSS	14U	VSS	21M		
VDD15	6P	VDD18	12D	VDD18	23N	VSS	8N	VSS	14W	VSS	21T		

Table 16: Power and ground BGA positions.

8 Package Specification



GENERAL NOTES

1. All dimensions are specified in millimeters (mm).
2. Dimensioning and tolerancing per ASME-Y14.5M-1994.
3. This corner which consists of a triangle on both sides of the package identifies ball A1 corner and can be used for handling and orientation purposes.
4. Symbol "M" determines ball matrix size and "N" is number of balls.
5. Dimension "b" is measured at maximum solder ball diameter on a plane parallel to datum C.
6. "x" in front of package variation denotes non-qualified package per AMD 01-002.3.
7. The following features are not shown on drawings:
   a) Marking on die, label on package
   b) Laser elements
   c) Die and passive fudicials

△ SEE NOTES

AMD PACKAGE	VARIATIONS xOLF564	
SYMBOL	min.	max.
D/E	30.8	31.2
D1/E1	29.21 BSC.	
D2/E2	27.8	28.2
D3/E3	22.8	23.2
A	3.25	3.56
A1	0.5	0.7
A2	0.9	1.1
e	1.27 BSC	
Øb	0.6	0.9
M	24	
N	564	
aaa	0.2	
bbb	0.25	
ccc	0.125	

Figure 4: Package mechanical drawing.

9 Test

The IC includes the following test modes.

Mode	TEST	A_TYPEDET	LDTSTOP#	STRAPL0	Notes
Operational	0	X	X	X	
High impedance	1	0	0	0	
NAND tree	1	0	0	1	

Table 17: Test modes.

9.1 High Impedance Mode

In high-impedance mode, all the signals of the IC are placed into the high-impedance state.

9.2 NAND Tree Mode

There are several NAND trees in the IC. Some of the inputs are differential (e.g., LR[B, A] pins); for these, the _P and _N pairs of signals are converted into a single signal that is part of the NAND tree, as shown in Signal_3 in the following diagram.

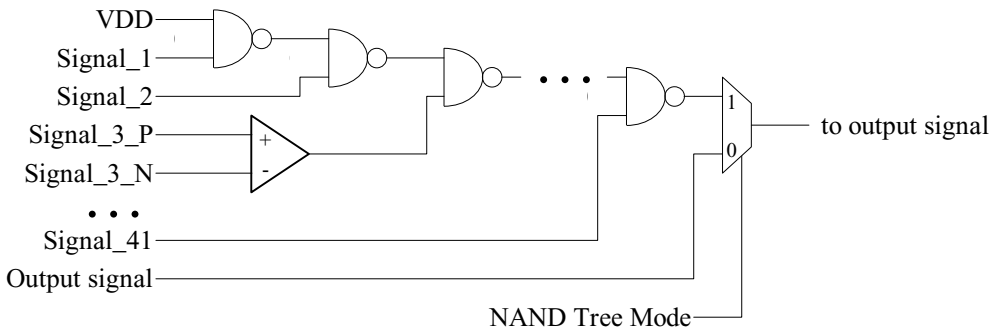


Figure 5: NAND tree.

NAND tree 1: output signal is STRAPL[5]. However, the gate connected to the last signal in this NAND tree (LDTCOMP[3]) is an AND gate rather than a NAND gate; so the expected output of this NAND tree is inverted compared to the other NAND trees.

1	LRBCLK0_[P,N]	11	LTBCLK0_P	21	LTBCAD_P[4]	31	LDTCOMP[2]
2	LRBCAD_[P,N][0]	12	LTBCLK0_N	22	LTBCAD_N[4]	32	LDTCOMP[3]
3	LRBCAD_[P,N][1]	13	LTBCAD_P[0]	23	LTBCAD_P[5]		
4	LRBCAD_[P,N][2]	14	LTBCAD_N[0]	24	LTBCAD_N[5]		
5	LRBCAD_[P,N][3]	15	LTBCAD_P[1]	25	LTBCAD_P[6]		
6	LRBCAD_[P,N][4]	16	LTBCAD_N[1]	26	LTBCAD_N[6]		
7	LRBCAD_[P,N][5]	17	LTBCAD_P[2]	27	LTBCAD_P[7]		
8	LRBCAD_[P,N][6]	18	LTBCAD_N[2]	28	LTBCAD_N[7]		
9	LRBCAD_[P,N][7]	19	LTBCAD_P[3]	29	LTBCTL_P		
10	LRBCTL_[P,N]	20	LTBCAD_N[3]	30	LTBCTL_N		

NAND tree 2: output signal is STRAPL[4].

1	LRACLK0_[P,N]	21	LTACLK0_N	41	LTACAD_N[4]
2	LRACLK1_[P,N]	22	LTACLK1_P	42	LTACAD_P[12]
3	LRACAD_[P,N][0]	23	LTACLK1_N	43	LTACAD_N[12]
4	LRACAD_[P,N][8]	24	LTACAD_P[0]	44	LTACAD_P[5]
5	LRACAD_[P,N][1]	25	LTACAD_N[0]	45	LTACAD_N[5]
6	LRACAD_[P,N][9]	26	LTACAD_P[8]	46	LTACAD_P[13]
7	LRACAD_[P,N][2]	27	LTACAD_N[8]	47	LTACAD_N[13]
8	LRACAD_[P,N][10]	28	LTACAD_P[1]	48	LTACAD_P[6]
9	LRACAD_[P,N][3]	29	LTACAD_N[1]	49	LTACAD_N[6]
10	LRACAD_[P,N][11]	30	LTACAD_P[9]	50	LTACAD_P[14]
11	LRACAD_[P,N][4]	31	LTACAD_N[9]	51	LTACAD_N[14]
12	LRACAD_[P,N][12]	32	LTACAD_P[2]	52	LTACAD_P[7]
13	LRACAD_[P,N][5]	33	LTACAD_N[2]	53	LTACAD_N[7]
14	LRACAD_[P,N][13]	34	LTACAD_P[10]	54	LTACAD_P[15]
15	LRACAD_[P,N][6]	35	LTACAD_N[10]	55	LTACAD_N[15]
16	LRACAD_[P,N][14]	36	LTACAD_P[3]	56	LTACTL_P
17	LRACAD_[P,N][7]	37	LTACAD_N[3]	57	LTACTL_N
18	LRACAD_[P,N][15]	38	LTACAD_P[11]		
19	LRACTL_[P,N]	39	LTACAD_N[11]		
20	LTACLK0_P	40	LTACAD_P[4]		

NAND tree 3: output signal is STRAPL[3].

1	STRAPL[1]	21	A_DBIL	41	A_CBE_L[2]	61	A_AD[12]		STRAPL[19]
2	STRAPL[8]	22	A_DBIH	42	A_CBE_L[3]	62	A_AD[13]		
3	STRAPL[10]	23	A_AD[31]	43	A_ST[0]	63	A_AD[11]		
4	STRAPL[9]	24	A_AD[30]	44	A_ST[1]	64	A_AD[10]		
5	A_GC8XDET#	25	A_AD[29]	45	A_ST[2]	65	A_AD[9]		
6	A_SBA[0]	26	A_AD[28]	46	A_MB8XDET#	66	A_AD[8]		
7	A_SBA[1]	27	A_AD[27]	47	A_RBF#	67	A_ADSTB0_N		
8	A_SBA[2]	28	A_AD[26]	48	A_WBF#	68	A_ADSTB0_P		
9	A_SBA[3]	29	A_AD[25]	49	STRAPL[14]	69	A_CBE_L[0]		
10	A_SBSTB_N	30	A_AD[24]	50	STRAPL[15]	70	A_AD[7]		
11	A_SBSTB_P	31	A_ADSTB1_N	51	STRAPL[17]	71	A_AD[6]		
12	A_SBA[4]	32	A_ADSTB1_P	52	STRAPL[16]	72	A_AD[5]		
13	A_SBA[5]	33	A_AD[23]	53	A_IRDY#	73	A_AD[4]		
14	A_SBA[6]	34	A_AD[22]	54	A_DEVSEL#	74	A_AD[3]		
15	A_SBA[7]	35	A_AD[21]	55	A_FRAME#	75	A_AD[1]		
16	A_GNT#	36	A_AD[20]	56	STRAPL[6]	76	A_AD[2]		
17	STRAPL[11]	37	A_AD[19]	57	A_TRDY#	77	A_AD[0]		
18	A_REQ#	38	A_AD[17]	58	A_CBE_L[1]	78	A_STOP#		
19	STRAPL[13]	39	A_AD[18]	59	A_AD[15]	79	A_PAR		
20	STRAPL[7]	40	A_AD[16]	60	A_AD[14]	80	STRAPL[18]		

Nand tree 4: output signal is STRAPL[2].

1	CMPOVR	6	A_PLLCLKI	11	A_PCLK
2	RESET#	7	STRAPL[20]		
3	PWROK	8	STRAPL[21]		
4	REFCLK	9	STRAPL[22]		
5	A_PLLCLKO	10	A_RESET#		

Notes:
- LDTSTOP#, A_TYPEDET#, TEST, STRAPL[0], A_REFCG, A_REFGC, A_CALD, A_CALD#, A_CALS, and A_CALS# are not in the NAND trees.
- While in NAND-tree mode, the link and AGP input compensation is placed at a “mid-band” value.
- While in NAND-tree mode, the AGP signals operate under AGP 2.0 signaling rules.

10 Appendix

10.1 Revision History

Revision 3.02
- Initial release.

Revision 3.03
- Removed Preliminary.