

405GP

Data Sheet

Power PC 405GP Embedded Processor

Features

- PowerPC® 405 32-bit RISC processor core operating up to 266MHz
- Synchronous DRAM (SDRAM) interface operating up to 133MHz
 - 32-bit interface for non-ECC applications
 - 40-bit interface serves 32 bits of data plus 8 check bits for ECC applications
- 4KB on-chip memory (OCM)
- External peripheral bus
 - Flash ROM/Boot ROM interface
 - Direct support for 8-, 16-, or 32-bit SRAM and external peripherals
 - Up to eight devices
 - External Mastering supported
- DMA support for external peripherals, internal UART and memory
 - Scatter-gather chaining supported
 - Four channels
- PCI Revision 2.2 compliant interface (32-bit, up to 66MHz)
 - Synchronous or asynchronous PCI Bus interface
 - Internal or external PCI Bus Arbiter
- Ethernet 10/100Mbps (full-duplex) support with media independent interface (MII)
- Programmable interrupt controller supports seven external and 19 internal edge triggered or level-sensitive interrupts
- Programmable timers
- Two serial ports (16550 compatible UART)
- One IIC interface
- General purpose I/O (GPIO) available
- Supports JTAG for board level testing
- Internal processor local Bus (PLB) runs at SDRAM interface frequency
- Supports PowerPC processor boot from PCI memory

Description

Designed specifically to address embedded applications, the PowerPC 405GP (PPC405GP) provides a high-performance, low-power solution that interfaces to a wide range of peripherals by incorporating on-chip power management features and lower power dissipation requirements.

This chip contains a high-performance RISC processor core, SDRAM controller, PCI bus interface, Ethernet interface, control for external ROM and peripherals, DMA with scatter-gather support, serial

ports, IIC interface, and general purpose I/O.

Technology: CMOS SA-12E, 0.25 μm
(0.18 μm L_{eff})

Package: 456-ball (35mm or 27mm), or 413-ball (25mm) enhanced plastic ball grid array (E-PBGA)

Power (typical): TBDW at 133MHz, 1.5W at 200MHz, 2W at 266MHz

Contents

Ordering, PVR, and JTAG Information	4
Address Map Support	7
On-Chip Memory (OCM)	9
PLB to PCI Interface	9
SDRAM Memory Controller	10
External Peripheral Bus Controller (EBC)	10
DMA Controller	11
Serial Interface	11
IIC Bus Interface	12
General Purpose IO (GPIO) Controller	12
Universal Interrupt Controller (UIC)	13
10/100 Mbps Ethernet MAC	13
JTAG	13
Signal List	33
Spread Spectrum Clocking	48
Strapping	55

Tables

System Memory Address Map	7
DCR Address Map	8
Signals Listed Alphabetically	17
Signals Listed by Ball Assignment—413-Ball Package	27
Signals Listed by Ball Assignment—456-Ball Package	30
Pin Summary	33
Signal Functional Description	35
Absolute Maximum Ratings	43
Package Thermal Specifications	43
Recommended DC Operating Conditions	44
Input Capacitance	45
DC Electrical Characteristics	46
Clocking Specifications	47
Peripheral Interface Clock Timings	49
I/O Specifications—All speeds	51
I/O Specifications—133 and 200MHz	53
I/O Specifications—266MHz	54
PPC405GP Strapping Pin Assignments	55

Figures

PPC405GP Embedded Controller Functional Block Diagram	6
25mm, 413-Ball E-PBGA Package	14
27mm, 456-Ball E-PBGA Package	15
35mm, 456-Ball E-PBGA Package	16
5V-Tolerant Input Current	45
Input Setup and Hold Waveform	50
Output Delay and Float Timing Waveform	50

Ordering, PVR, and JTAG Information

Product Name	Order Part Number ^{1, 2}	Processor Frequency	Package	Rev Level	PVR Value	JTAG ID
PPC405GP	PPC405GP-3BE133C	133MHz	35mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3BE133CZ	133MHz	35mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3DE133C	133MHz	27mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3DE133CZ	133MHz	27mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3FE133C	133MHz	35mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3FE133CZ	133MHz	35mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3KE133C	133MHz	27mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3KE133CZ	133MHz	27mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3BE200C	200MHz	35mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3BE200CZ	200MHz	35mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3DE200C	200MHz	27mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3DE200CZ	200MHz	27mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3FE200C	200MHz	35mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3FE200CZ	200MHz	35mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3KE200C	200MHz	27mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3KE200CZ	200MHz	27mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3EE200C	200MHz	25mm, 413 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3EE200CZ	200MHz	25mm, 413 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3BE266C	266MHz	35mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3BE266CZ	266MHz	35mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3DE266C	266MHz	27mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3DE266CZ	266MHz	27mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3FE266C	266MHz	35mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3FE266CZ	266MHz	35mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3KE266C	266MHz	27mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3KE266CZ	266MHz	27mm, 456 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3EE266C	266MHz	25mm, 413 ball E-PBGA	E	0x40110145	0x42050049
PPC405GP	PPC405GP-3EE266CZ	266MHz	25mm, 413 ball E-PBGA	E	0x40110145	0x42050049

Notes

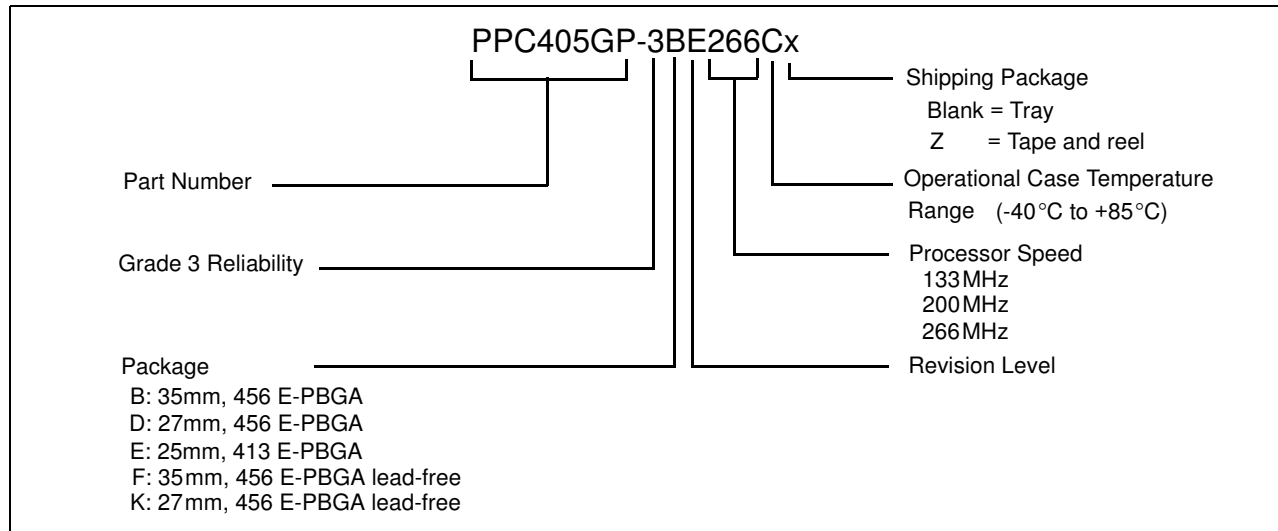
1. Z at the end of the Order Part Number indicates a tape-and-reel shipping package. Otherwise, the chips are shipped in a tray.
2. Package types F (35mm) and K (27mm) are lead-free.

The part number contains a revision code. This refers to the die mask revision number and is included in the part numbering scheme for identification purposes only.

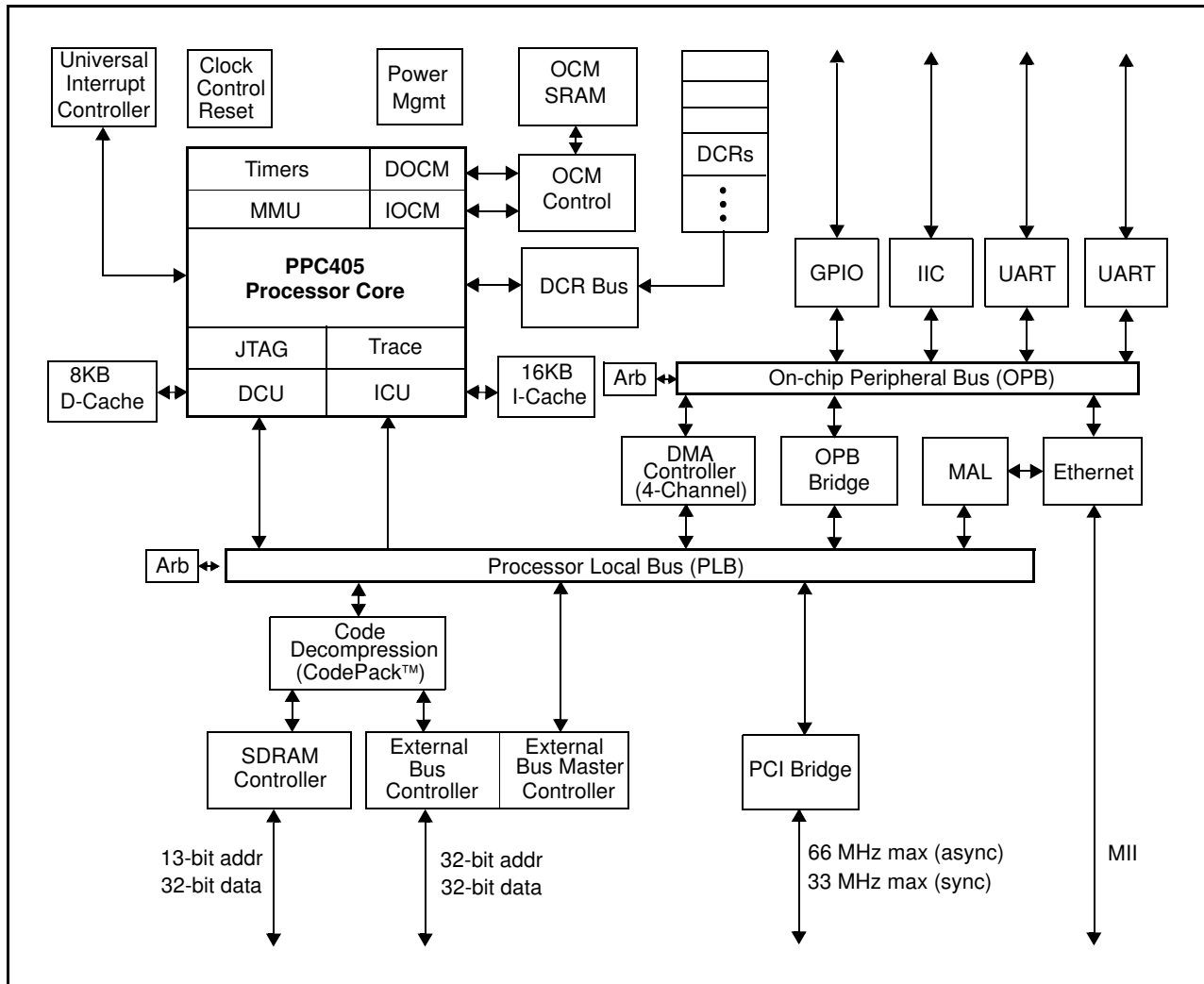
The PVR (Processor Version Register) is software accessible and contains additional information about the revision level of the part. Refer to the *PowerPC 405GP Embedded Processor User's Manual* for details on the register content.

Data Sheet

Order Part Number Key



PPC405GP Embedded Controller Functional Block Diagram



The PPC405GP is designed using the IBM® Microelectronics Blue Logic™ methodology in which major functional blocks are integrated together to create an application-specific ASIC product. This approach provides a consistent way to create complex ASICs using IBM CoreConnect™ Bus Architecture.

Data Sheet**Address Map Support**

The PPC405GP incorporates two simple and separate address maps. The first address map defines the possible use of address regions that the processor can access. The second address map is for Device Configuration Registers (DCRs). The DCRs are accessed by software running on the PPC405GP processor through the use of **mtdcr** and **mfdcr** instructions.

System Memory Address Map 4GB System Memory

Function	Subfunction	Start Address	End Address	Size
General Use	SDRAM, External Peripherals, and PCI Memory Note: Any of the address ranges listed at right may be use for any of the above functions.	0x00000000	0xE7FFFFFF	3712MB
		0xE8010000	0xE87FFFFFF	8MB
		0xEC000000	0xEEBFFFFFF	44MB
		0xEEE00000	0xEF3FFFFFF	6MB
		0xEF500000	0xEF5FFFFFF	1MB
		0xF0000000	0xFFFFFFFF	256MB
Boot-up	Peripheral Bus Boot ¹	0xFFE00000	0xFFFFFFFF	2MB
	PCI Boot ²	0xFFFE0000	0xFFFFFFFF	128KB
PCI	PCI I/O	0xE8000000	0xE800FFFF	64KB
	PCI I/O	0xE8800000	0xEBFFFFFF	56MB
	Configuration Registers	0xEEC00000	0xEEC00007	8B
	Interrupt Acknowledge and Special Cycle	0xEED00000	0xEED00003	4B
	Local Configuration Registers	0xEF400000	0xEF40003F	64B
Internal Peripherals	UART0	0xEF600300	0xEF600307	8B
	UART1	0xEF600400	0xEF600407	8B
	IIC0	0xEF600500	0xEF60051F	32B
	OPB Arbiter	0xEF600600	0xEF60063F	64B
	GPIO Controller Registers	0xEF600700	0xEF60077F	128B
	Ethernet Controller Registers	0xEF600800	0xEF6008FF	256B

Notes:

1. When peripheral bus boot is selected, peripheral bank 0 is automatically configured at reset to the address range listed above.
2. If PCI boot is selected, a PLB-to-PCI mapping is automatically configured at reset to the address range listed above.
3. After the boot process, software may reassign the boot memory regions for other uses.
4. All address ranges not listed above are reserved.

DCR Address Map 4KB Device Configuration Registers

Function	Start Address	End Address	Size
Total DCR Address Space¹	0x000	0x3FF	1KW (4KB) ¹
By function:			
Reserved	0x000	0x00F	16W
Memory Controller Registers	0x010	0x011	2W
External Bus Controller Registers	0x012	0x013	2W
Decompression Controller Registers	0x014	0x015	2W
Reserved	0x016	0x017	2W
On-Chip Memory Controller Registers	0x018	0x01F	8W
Reserved	0x020	0x07F	96W
PLB Registers	0x080	0x08F	16W
Reserved	0x090	0x09F	16W
OPB Bridge Out Registers	0x0A0	0x0A7	8W
Reserved	0x0A8	0x0AF	6W
Clock, Control, and Reset	0x0B0	0x0B7	8W
Power Management	0x0B8	0x0BF	8W
Interrupt Controller	0x0C0	0x0CF	16W
Reserved	0x0D0	0x0FF	48W
DMA Controller Registers	0x100	0x13F	64W
Reserved	0x140	0x17F	64W
Ethernet MAL Registers	0x180	0x1FF	128W
Reserved	0x200	0x3FF	512W

Notes:

1. DCR address space is addressable with up to 10 bits (1024 or 1K unique addresses). Each unique address represents a single 32-bit (word) register, or 1 kiloword (KW) (which equals 4 KB).

On-Chip Memory (OCM)

The OCM feature comprises a memory controller and a one-port 4KB static RAM (SRAM) accessed by the processor core.

Features include:

- Low-latency access to critical instructions and data
- Performance identical to cache hits without misses
- Contents change only under program control

PLB to PCI Interface

The PLB to PCI interface core provides a mechanism for connecting PCI devices to the local PowerPC processor and local memory. This interface is compliant with version 2.2 of the PCI Specification.

Features include:

- Internal PCI bus arbiter for up to six external devices at PCI bus speeds up to 66MHz. Internal arbiter use is optional and can be disabled for systems which employ an external arbiter.
- PCI bus frequency up to 66MHz
 - Synchronous operation at 1/n fractions of PLB speed (n = 1 to 4) to 33MHz maximum
 - Asynchronous operation from 1/8 PLB frequency to 66MHz maximum
- 32-bit PCI address/data bus
- Power Management:
 - PCI Bus Power Management v1.1 compliant
- Supports 1:1, 2:1, 3:1, 4:1 clock ratios from PLB to PCI
- Buffering between PLB and PCI:
 - PCI target 64-byte write post buffer
 - PCI target 96-byte read prefetch buffer
 - PLB slave 32-byte write post buffer
 - PLB slave 64-byte read prefetch buffer
- Error tracking/status
- Supports PCI target side configuration
- Supports processor access to all PCI address spaces:
 - Single-byte PCI I/O reads and writes
 - PCI memory single-beat and prefetch-burst reads and single-beat writes
 - Single-byte PCI configuration reads and writes (type 0 and type 1)
 - PCI interrupt acknowledge
 - PCI special cycle

- Supports PCI target access to all PLB address spaces
- Supports PowerPC processor boot from PCI memory

SDRAM Memory Controller

The PPC405GP Memory Controller core provides a low latency access path to SDRAM memory. A variety of system memory configurations are supported. The memory controller supports up to four physical banks. Up to 256MB per bank are supported, up to a maximum of 1 GB. Memory timings, address and bank sizes, and memory addressing modes are programmable.

Features include:

- 11x8 to 13x11 addressing for SDRAM (2- and 4-bank)
- 32-bit memory interface support
- Programmable address compare for each bank of memory
- Industry standard 168-pin DIMMS are supported (some configurations)
- 4MB to 256MB per bank
- Programmable address mapping and timing
- Auto refresh
- Page mode accesses with up to 4 open pages
- Power management (self-refresh)
- Error checking and correction (ECC) support
 - Standard single-error correct, double-error detect coverage
 - Aligned nibble error detect
 - Address error logging

External Peripheral Bus Controller (EBC)

- Supports eight banks of ROM, EPROM, SRAM, Flash memory, or slave peripherals
- Burst and non-burst devices
- 8-, 16-, 32-bit byte-addressable data bus width support
- Latch data on Ready
- Programmable 2K clock time-out counter with disable for Ready
- Programmable access timing per device
 - 0–255 wait states for non-bursting devices
 - 0–31 burst wait states for first access and up to 7 wait states for subsequent accesses
 - Programmable CSon, CSoff relative to address
 - Programmable OEon, WEon, WEOff (0 to 3 clock cycles) relative to CS
- Programmable address mapping

Data Sheet

- Peripheral Device pacing with external “Ready”
- External master interface
 - Write posting from external master
 - Read prefetching on PLB for external master reads
 - Bursting capable from external master
 - Allows external master access to all non-EBC PLB slaves
 - External master can control EBC slaves for own access and control

DMA Controller

- Supports the following transfers:
 - Memory-to-memory transfers
 - Buffered peripheral to memory transfers
 - Buffered memory to peripheral transfers
- Four channels
- Scatter/gather capability for programming multiple DMA operations
- 8-, 16-, 32-bit peripheral support (OPB and external)
- 32-bit addressing
- Address increment or decrement
- Internal 32-byte data buffering capability
- Supports internal and external peripherals
- Support for memory mapped peripherals
- Support for peripherals running on slower frequency buses

Serial Interface

- One 8-pin UART and one 4-pin UART interface provided
- Selectable internal or external serial clock to allow a wide range of baud rates
- Register compatibility with NS16550 register set
- Complete status reporting capability
- Transmitter and receiver are each buffered with 16-byte FIFOs when in FIFO mode
- Fully programmable serial-interface characteristics
- Supports DMA using internal DMA engine

IIC Bus Interface

- Compliant with Philips® Semiconductors I²C Specification, dated 1995
- Operation at 100kHz or 400kHz
- 8-bit data
- 10- or 7-bit address
- Slave transmitter and receiver
- Master transmitter and receiver
- Multiple bus masters
- Supports fixed V_{DD} IIC interface
- Two independent 4 x 1 byte data buffers
- Twelve memory-mapped, fully programmable configuration registers
- One programmable interrupt request signal
- Provides full management of all IIC bus protocol
- Programmable error recovery

General Purpose IO (GPIO) Controller

- Controller functions and GPIO registers are programmed and accessed via memory-mapped OPB bus master accesses
- 23 GPIOs are pin-shared with other functions. DCRs control whether a particular pin that has GPIO capabilities acts as a GPIO or is used for another purpose. The 23 GPIOs are multiplexed with:
 - 7 of 8 chip selects
 - All seven external interrupts
 - All nine instruction trace pins
- Each GPIO output is separately programmable to emulate an open-drain driver (i.e., drives to zero, three-stated if output bit is 1)

Universal Interrupt Controller (UIC)

The Universal Interrupt Controller (UIC) provides the control, status, and communications necessary between the various sources of interrupts and the local PowerPC processor.

Features include:

- Supports seven external and 19 internal interrupts
- Edge triggered or level-sensitive
- Positive or negative active
- Non-critical or critical interrupt to processor core
- Programmable critical interrupt priority ordering
- Programmable critical interrupt vector for faster vector processing

10/100 Mbps Ethernet MAC

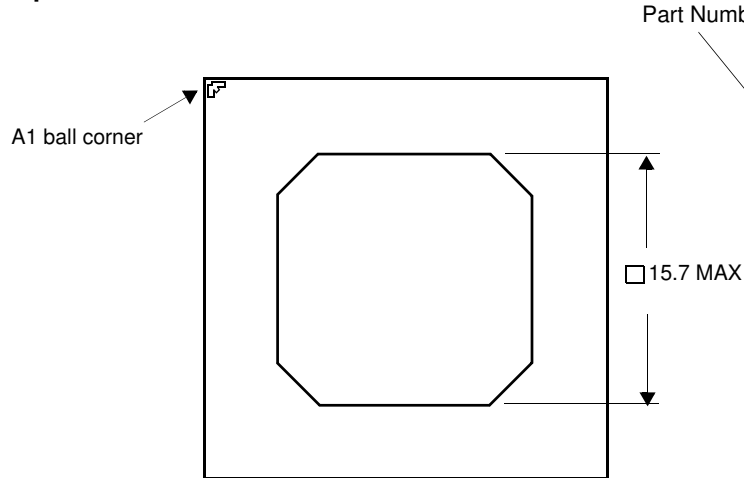
- Capable of handling full/half duplex 100Mbps and 10Mbps operation
- Uses the medium independent interface (MII) to the physical layer (PHY not included on chip)

JTAG

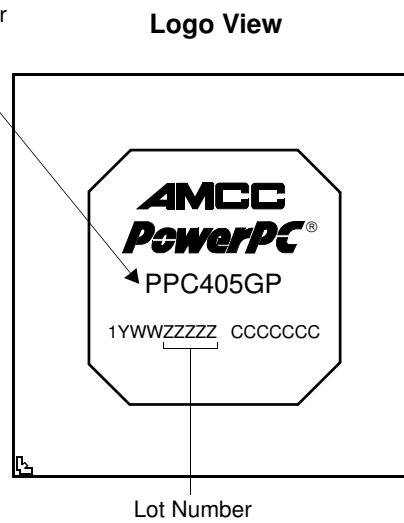
- IEEE 1149.1 test access port
- IBM RISCWatch debugger support
- JTAG Boundary Scan Description Language (BSDL)

25mm, 413-Ball E-PBGA Package

Top View

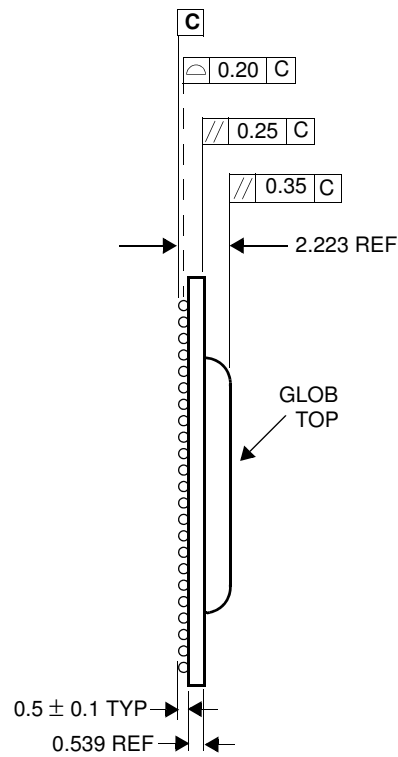
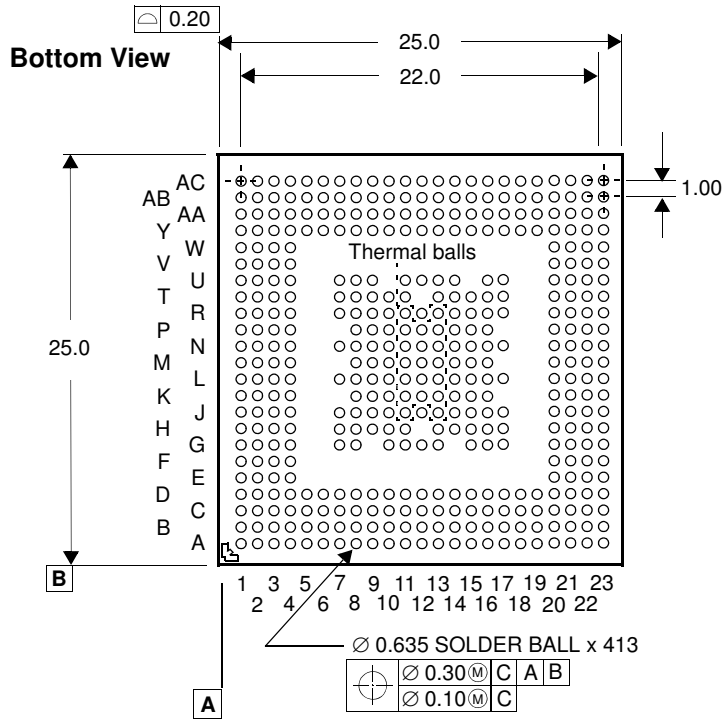


Logo View



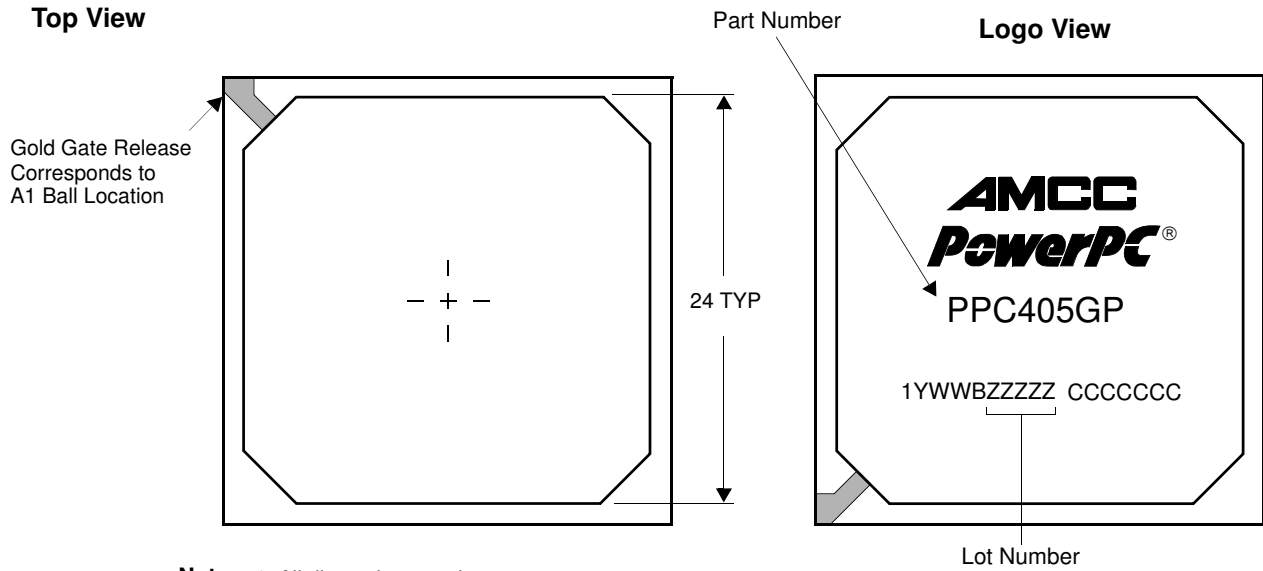
Note: All dimensions are in mm.

Bottom View

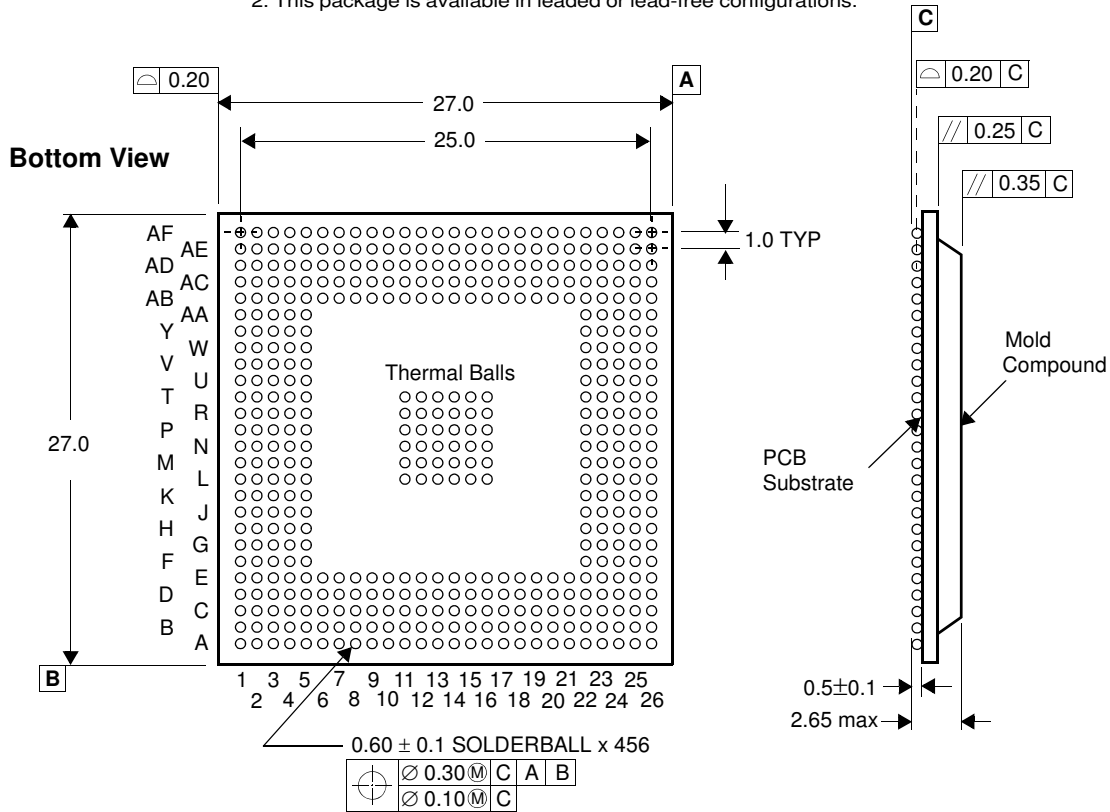


Data Sheet

27 mm, 456-Ball E-PBGA Package

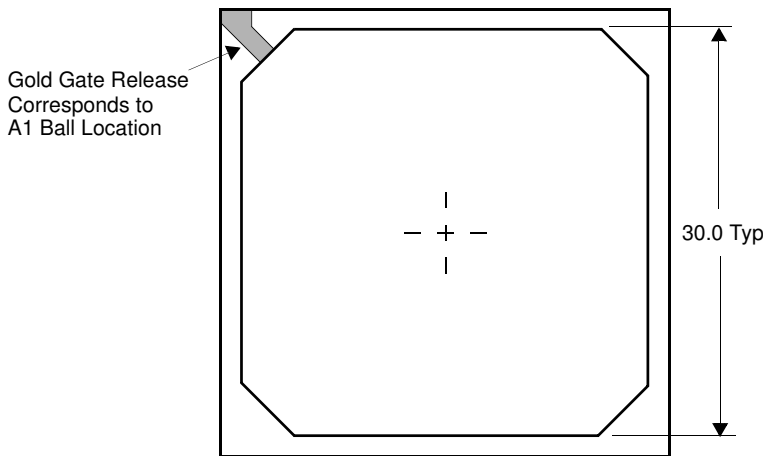


- Notes:** 1. All dimensions are in mm.
2. This package is available in leaded or lead-free configurations.



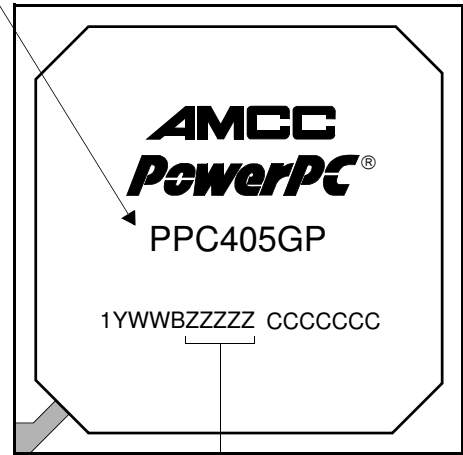
35mm, 456-Ball E-PBGA Package

Top View



Part Number

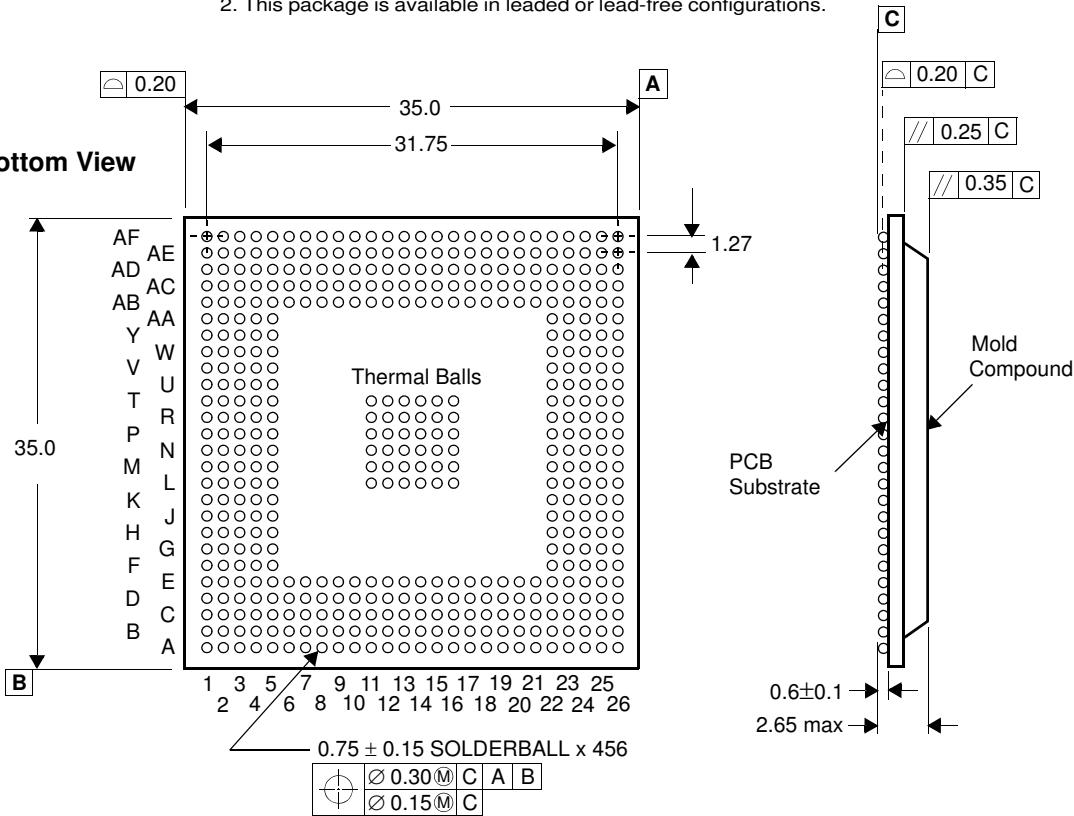
Logo View



Lot Number

- Notes: 1. All dimensions are in mm.
2. This package is available in leaded or lead-free configurations.

Bottom View



Data Sheet**Pin Lists**

The PPC405GP embedded controller is available as a 456-ball or a 413-ball E-PBGA. The 456-ball package is available in two sizes—35 millimeters and 27 millimeters. The 413-ball package size is 25 millimeters. In this section there are three tables that correlate the external signals to the physical package pin (ball) on which they appear.

The following table lists all the external signals in alphabetical order and shows the ball number on which the signal appears. Multiplexed signals are shown with the default signal (following reset) *not* in brackets and the alternate signal in brackets. Multiplexed signals appear alphabetically multiple times in the list—once for each signal name on the ball. The page number listed gives the page in “Signal Functional Description” on page 35 where the signals in the indicated interface group begin.

Signals Listed Alphabetically (Part 1 of 10)

Signal Name	413-Ball	456-Ball	Interface Group	Page
AV _{DD}	L21	D25	System	40
BA0 BA1	N16 N17	AB24 AC24	SDRAM	37
BankSel0 BankSel1 BankSel2 BankSel3	AC19 AB17 AC17 AB14	AD17 AF17 AE15 AC14	SDRAM	37
[BE0]PCIC0 [BE1]PCIC1 [BE2]PCIC2 [BE3]PCIC3	D16 C22 E23 P23	D19 F24 K24 R26	PCI	35
BusReq	T1	R3	External Master Peripheral	39
CAS	R15	AB23	SDRAM	37
ClkEn0 ClkEn1	AB22 Y20	AB25 AC25	SDRAM	37
DMAAck0 DMAAck1 DMAAck2 DMAAck3	A17 B14 A15 A8	D16 B15 B14 C12	External Slave Peripheral	37
DMAReq0 DMAReq1 DMAReq2 DMAReq3	C13 A16 B9 C6	C16 D14 C11 A7	External Slave Peripheral	37
DQM0 DQM1 DQM2 DQM3	U12 AC5 AC2 AA2	AC12 AC10 AC6 AA3	SDRAM	37
DQMCB	AB13	AC15	SDRAM	37
DrvrInh1 DrvrInh2	H17 G17	E24 E23	System	40
ECC0 ECC1 ECC2 ECC3 ECC4 ECC5 ECC6 ECC7	AA12 AC15 AB12 AC14 AC12 AC10 AC9 AB11	AE14 AF15 AF14 AD13 AF13 AF12 AE13 AD12	SDRAM	37
EMCMDCIk	J20	H24	Ethernet	36
EMCMDIO[PHYMDIO]	T17	AD26	Ethernet	36
EMCTxD0 EMCTxD1 EMCTxD2 EMCTxD3	F22 K21 J22 R23	J26 L25 L24 P25	Ethernet	36

Signals Listed Alphabetically (Part 2 of 10)

Signal Name	413-Ball	456-Ball	Interface Group	Page
EMCTxEn	J21	K23	Ethernet	36
EMCTxErr	K20	K25	Ethernet	36
EOT0/TC0 EOT1/TC1 EOT2/TC2 EOT3/TC3	C2 G4 U3 V3	F3 G2 V2 Y1	External Slave Peripheral	37
ExtAck	U4	Y3	External Master Peripheral	39
ExtReq	V4	Y4	External Master Peripheral	39
ExtReset	R2	T3	External Master Peripheral	39
GND	A1 A6 A18 A23 C14 D14 F1 F23 J11 J13 K11-K13 L1 L4 L11-L13 M4 M11-M13 M20 N11-N13 N20 N23 P11-P13 R11 R13 V1 V23 Y10 AA10 AC1 AC6 AC18 AC23	A1 A2 A6 A11 A16 A19 ¹ A21 A26 B2 B25 B26 C3 C24 D4 D23 E5 E9 E13 E14 E18 E22 F1 F26 H1 ¹ J5 J22 L1 L11-L16 L26 M11-M16 N5 N11-N16 N22 P5 P11-P16 P22 R11-R16 T1 T11-T16 T26 V5 V22 W26 ¹ AA1 AA26 AB5	Ground Notes: 1. Reserved on 27 mm package. GND on 35mm package. 2. On the 456-ball packages, L11-L16, M11-M16, N11-N16, P11-P16, R11-R16, and T11-T16 are also thermal balls. 3. On the 413-ball package, J11, J13, K11-K13, L11-L13, M11-N13, N11-N13, P11-P13, R11, and R13 are also thermal balls.	42

Data Sheet**Signals Listed Alphabetically** (Part 3 of 10)

Signal Name	413-Ball	456-Ball	Interface Group	Page
GND		AB9 AB13 AB14 AB18 AB22 AC4 AC23 AD3 AD24 AE1 AE2 AE25 AF1 AF6 AF8 ¹ AF11 AF16 AF21 AF25 AF26	Ground Notes: 1. Reserved on 27 mm package. GND on 35mm package. 2. On the 456-ball packages, L11-L16, M11-M16, N11-N16, P11-P16, R11-R16, and T11-T16 are also thermal balls. 3. On the 413-ball package, J11, J13, K11-K13, L11-L13, M11-N13, N11-N13, P11-P13, R11, and R13 are also thermal balls.	42
Gnt[PCIReq0]	D15	C19	PCI	35
GPIO1[TS1E] GPIO2[TS2E] GPIO3[TS1O] GPIO4[TS2O] GPIO5[TS3] GPIO6[TS4] GPIO7[TS5] GPIO8[TS6] GPIO9[TrcClk]	A20 C19 A21 AB18 AC4 AB4 AC3 Y6 T7	D18 C20 A22 AF18 AC9 AE8 AF5 AC7 AB3	System	40
[GPIO10]PerCS1 [GPIO11]PerCS2 [GPIO12]PerCS3 [GPIO13]PerCS4 [GPIO14]PerCS5 [GPIO15]PerCS6 [GPIO16]PerCS7	H11 G8 D5 C7 D10 B6 C10	C4 C5 A4 B9 B10 A9 B11	System	40
[GPIO17]IRQ0 [GPIO18]IRQ1 [GPIO19]IRQ2 [GPIO20]IRQ3 [GPIO21]IRQ4 [GPIO22]IRQ5 [GPIO23]IRQ6	U21 Y23 R20 Y22 W21 U20 AA22	V25 V23 W24 W25 Y24 Y25 AA24	System	40
Halt	AA23	AB26	System	40
HoldAck	P4	U2	External Master Peripheral	39
HoldPri	P3	T2	External Master Peripheral	39
HoldReq	V2	V1	External Master Peripheral	39
IIC_SCL	AB3	AD6	Internal Peripheral	39
IIC_SDA	Y7	AE7	Internal Peripheral	39
IRQ0[GPIO17] IRQ1[GPIO18] IRQ2[GPIO19] IRQ3[GPIO20] IRQ4[GPIO21] IRQ5[GPIO22] IRQ6[GPIO23]	U21 Y23 R20 Y22 W21 U20 AA22	V25 V23 W24 W25 Y24 Y25 AA24	Interrupts	40

Signals Listed Alphabetically (Part 4 of 10)

Signal Name	413-Ball	456-Ball	Interface Group	Page
MemAddr0	AA21	AE22	SDRAM Note: During a $\overline{\text{CAS}}$ cycle MemAddr0 is the least significant bit (lsb) on this bus.	37
MemAddr1	AC22	AC21		
MemAddr2	AA20	AE21		
MemAddr3	AB21	AD21		
MemAddr4	AA19	AF22		
MemAddr5	AB20	AE20		
MemAddr6	AC21	AC19		
MemAddr7	Y16	AE19		
MemAddr8	Y15	AD19		
MemAddr9	AB19	AC18		
MemAddr10	AC20	AF19		
MemAddr11	AA16	AD18		
MemAddr12	AA15	AC17		
MemClkOut0	W20	AC26	SDRAM	37
MemClkOut1	AB23	AA23		
MemData0	AC8	AC13	SDRAM Note: MemData0 is the most significant bit (msb) on this bus.	37
MemData1	AB10	AE12		
MemData2	AA11	AD11		
MemData3	AC7	AC11		
MemData4	AB7	AF10		
MemData5	AB9	AE11		
MemData6	AB8	AD10		
MemData7	AB6	AF9		
MemData8	AA9	AD9		
MemData9	AA7	AE9		
MemData10	Y9	AD8		
MemData11	AA6	AF7		
MemData12	Y8	AC8		
MemData13	AA5	AD7		
MemData14	AA4	AE6		
MemData15	AB2	AE5		
MemData16	Y4	AE4		
MemData17	T11	AD5		
MemData18	U11	AD4		
MemData19	R9	AC5		
MemData20	M9	AD1		
MemData21	AA3	AB2		
MemData22	AB1	AA4		
MemData23	Y3	AA2		
MemData24	W3	AB1		
MemData25	Y2	Y2		
MemData26	AA1	W4		
MemData27	T4	W2		
MemData28	R4	W3		
MemData29	W2	V4		
MemData30	Y1	W1		
MemData31	T3	V3		

Data Sheet**Signals Listed Alphabetically** (Part 5 of 10)

Signal Name	413-Ball	456-Ball	Interface Group	Page
OV _{DD}	A11	B17 ¹	Output driver voltage Note 1: Reserved on 27 mm package. OV _{DD} on 35 mm package.	42
	D11	C13 ¹		
	G10	E6		
	G15	E7		
	H9	E8		
	H10	E19		
	H14	E20		
	H15	E21		
	J7	F5		
	J8	F22		
	J10	G5		
	J14	G22		
	J16	H5		
	J17	H22		
	K3	K2 ¹		
	K4	N24 ¹		
	K8	P3 ¹		
	K16	U25 ¹		
	L23	W5		
	N1	W22		
	P8	Y5		
	P16	Y22		
	P20	AA5		
	P21	AA22		
	R7	AB6		
	R8	AB7		
	R10	AB8		
	R14	AB19		
	R16	AB20		
	R17	AB21		
	T9	AD14 ¹		
	T10	AE10 ¹		
	T14			
T15				
U9				
U14				
Y13				
AC13				

Signals Listed Alphabetically (Part 6 of 10)

Signal Name	413-Ball	456-Ball	Interface Group	Page
PCIAD0	B17	A17	PCI Note: PCIAD31 is the most significant bit (msb) on this bus.	35
PCIAD1	B15	B16		
PCIAD2	B16	C17		
PCIAD3	B18	A18		
PCIAD4	A19	D17		
PCIAD5	C15	C18		
PCIAD6	C17	B18		
PCIAD7	C18	A20		
PCIAD8	C20	B21		
PCIAD9	D19	A23		
PCIAD10	A22	D21		
PCIAD11	B22	B22		
PCIAD12	D20	B23		
PCIAD13	H13	C22		
PCIAD14	M15	C26		
PCIAD15	D21	F25		
PCIAD16	G22	K26		
PCIAD17	H22	L23		
PCIAD18	G23	M25		
PCIAD19	L22	M23		
PCIAD20	M21	N25		
PCIAD21	J23	M26		
PCIAD22	M22	N26		
PCIAD23	K23	P24		
PCIAD24	N22	R24		
PCIAD25	M16	R23		
PCIAD26	T23	P23		
PCIAD27	P22	R25		
PCIAD28	N21	T24		
PCIAD29	U22	U26		
PCIAD30	R22	T25		
PCIAD31	V22	V26		
PCIC0[BE0]	D16	D19	PCI	35
PCIC1[BE1]	C22	F24		
PCIC2[BE2]	E23	K24		
PCIC3[BE3]	P23	R26		
PCIClk	D17	B20	PCI	35
PCIDevSel	H20	H25	PCI	35
PCIFrame	H21	J24	PCI	35
PCI $\overline{\text{Gnt}}0[\text{Req}]$	W23	U23	PCI	35
PCI $\overline{\text{Gnt}}1$	U23	T23		
PCI $\overline{\text{Gnt}}2$	B23	F23		
PCI $\overline{\text{Gnt}}3$	D23	H26		
PCI $\overline{\text{Gnt}}4$	K22	N23		
PCI $\overline{\text{Gnt}}5$	H23	M24		
PCIIDSel	M23	P26	PCI	35
PCIINT[PerWE]	G13	C23	PCI	35
PCIIRDY	E22	J23	PCI	35
PCIParity	E21	E26	PCI	35
PCIPErr	D22	G25	PCI	35
PCIReq0[Gnt]	D15	C19	PCI	35
PCIReq1	B21	C21		
PCIReq2	B20	B19		
PCIReq3	G16	A24		
PCIReq4	F20	G23		
PCIReq5	G21	J25		
PCIReset	K14	B24	PCI	35
PCISErr	G20	G24	PCI	35
PCIS $\overline{\text{t}}\text{op}$	C23	H23	PCI	35
PCITRDY	F21	G26	PCI	35

Data Sheet**Signals Listed Alphabetically** (Part 7 of 10)

Signal Name	413-Ball	456-Ball	Interface Group	Page
PerAddr0	G7	D5	External Slave Peripheral Note: PerAddr0 is the most significant bit (msb) on this bus.	37
PerAddr1	J12	A3		
PerAddr2	C11	B4		
PerAddr3	C3	B5		
PerAddr4	A2	D6		
PerAddr5	C4	B6		
PerAddr6	B3	C6		
PerAddr7	D6	D7		
PerAddr8	C5	A5		
PerAddr9	B4	B7		
PerAddr10	D7	C7		
PerAddr11	A3	D8		
PerAddr12	D8	B8		
PerAddr13	D9	C8		
PerAddr14	B5	D9		
PerAddr15	A4	A8		
PerAddr16	C8	C9		
PerAddr17	C9	D10		
PerAddr18	A5	C10		
PerAddr19	B7	A10		
PerAddr20	B8	D11		
PerAddr21	A7	B12		
PerAddr22	B10	D13		
PerAddr23	B11	D12		
PerAddr24	C12	B13		
PerAddr25	A9	A12		
PerAddr26	B12	A13		
PerAddr27	A10	C14		
PerAddr28	A12	A14		
PerAddr29	A14	A15		
PerAddr30	B13	C15		
PerAddr31	G12	D15		
PerBLast	D3	F2	External Slave Peripheral	37
PerClk	J9	E4	External Master Peripheral	39
PerCS0	G11	B3	External Slave Peripheral	37
PerCS1[GPIO10]	H11	C4		
PerCS2[GPIO11]	G8	C5		
PerCS3[GPIO12]	D5	A4		
PerCS4[GPIO13]	C7	B9		
PerCS5[GPIO14]	D10	B10		
PerCS6[GPIO15]	B6	A9		
PerCS7[GPIO16]	C10	B11		

Signals Listed Alphabetically (Part 8 of 10)

Signal Name	413-Ball	456-Ball	Interface Group	Page
PerData0	R3	U4	External Slave Peripheral Note: PerData0 is the most significant bit (msb) on this bus.	37
PerData1	W1	U3		
PerData2	U2	U1		
PerData3	T2	T4		
PerData4	U1	R2		
PerData5	P2	P4		
PerData6	N2	R4		
PerData7	M3	P2		
PerData8	R1	R1		
PerData9	M2	P1		
PerData10	P1	N3		
PerData11	M1	N1		
PerData12	K1	M1		
PerData13	J1	N2		
PerData14	L2	M3		
PerData15	M8	M4		
PerData16	H1	N4		
PerData17	K2	M2		
PerData18	L3	L3		
PerData19	G1	L4		
PerData20	G2	K1		
PerData21	J2	L2		
PerData22	H2	K3		
PerData23	F2	J1		
PerData24	E1	K4		
PerData25	J3	J3		
PerData26	G3	J2		
PerData27	D1	J4		
PerData28	J4	H3		
PerData29	F3	G1		
PerData30	D2	H2		
PerData31	H4	H4		
PerErr	H8	B1	External Master Peripheral	39
PerOE	K10	C2	External Slave Peripheral	37
PerPar0	L7	D3	External Slave Peripheral	37
PerPar1	F4	G4		
PerPar2	E3	G3		
PerPar3	C1	E1		
PerReady	L8	E3	External Slave Peripheral	37
PerR/W	H7	C1	External Slave Peripheral	37
PerWBE0	D4	D2	External Slave Peripheral	37
PerWBE1	B2	E2		
PerWBE2	B1	F4		
PerWBE3	E4	D1		
[PerWE]PCIINT	G13	C23	External Slave Peripheral	37
PHYCol	Y21	AA25	Ethernet	36
PHYCrS	T20	W23	Ethernet	36
PHYRxClk	AA18	AF20	Ethernet	36
[PHYMDIO]EMCMDIO	T17	AD26	Ethernet	36
PHYRxD0	AA13	AE23	Ethernet	36
PHYRxD1	Y19	AF23		
PHYRxD2	Y18	AC20		
PHYRxD3	Y17	AD20		
PHYRxDV	R21	V24	Ethernet	36
PHYRxErr	T22	U24	Ethernet	36
PHYTxClk	C21	E25	Ethernet	36
RAS	R12	AF24	SDRAM	37
Rcvrlnh	L17	C25	System	40
[Req]PCIInt0	W23	U23	PCI	35

Data Sheet**Signals Listed Alphabetically** (Part 9 of 10)

Signal Name	413-Ball	456-Ball	Interface Group	Page
Reserved	B19 C16 D18 E2 H3 T21 V20 V21 W22 Y5 ¹ AA8 AB5	A19 ² B17 ³ C13 ³ D20 H1 ² K2 ³ N24 ³ P3 ³ U25 ³ W26 ² Y23 Y26 AF4 ¹ AF8 ² AD14 ³ AE10 ³	Other Notes: 1. Y5 (on the 413-ball package) and AF4 must be tied to OV _{DD} or GND. All other reserved pins should be left unconnected. 2. Reserved on 27 mm package. GND on 35 mm package. 3. Reserved on 27 mm package. OV _{DD} on 35 mm package.	42
SysClk	H16	A25	System	40
SysErr	P14	AD25	System	40
SysReset	J15	D22	System	40
TCK	U16	AD22	JTAG	40
TDI	U13	AE24	JTAG	40
TDO	T13	AD23	JTAG	40
TestEn	E20	D26	System	40
TmrClk	L16	D24	System	40
TMS	U17	AC22	JTAG	40
[TrcClk]GPIO9	T7	AB3	System	40
TRST	T16	AE26	JTAG	40
[TS1E]GPIO1 [TS2E]GPIO2 [TS1O]GPIO3 [TS2O]GPIO4 [TS3]GPIO5 [TS4]GPIO6 [TS5]GPIO7 [TS6]GPIO8	A20 C19 A21 AB18 AC4 AB4 AC3 Y6	D18 C20 A22 AF18 AC9 AE8 AF5 AC7	Trace	41
UART0_CTS	U7	AB4	Internal Peripheral	39
UART0_DCD	AA17	AE18	Internal Peripheral	39
UART0_DSR	P10	AE3	Internal Peripheral	39
UART0_DTR	T8	AF2	Internal Peripheral	39
UART0_RI	AC16	AD15	Internal Peripheral	39
UART0_RTS	AB15	AD16	Internal Peripheral	39
UART0_Rx	AA14	AE16	Internal Peripheral	39
UART0_Tx	U8	AF3	Internal Peripheral	39
UART1_CTS/UART1_DSR	N8	AC3	Internal Peripheral	39
UART1_DSR/UART1_CTS	N8	AC3	Internal Peripheral	39
UART1_DTR/UART1_RTS	N7	AD2	Internal Peripheral	39
UART1_RTS/UART1_DTR	N7	AD2	Internal Peripheral	39
UART1_Rx	W4	AC1	Internal Peripheral	39
UART1_Tx	N3	AC2	Internal Peripheral	39
UARTSerClk	Y14	AE17	Internal Peripheral	39

Signals Listed Alphabetically (Part 10 of 10)

Signal Name	413-Ball	456-Ball	Interface Group	Page
V _{DD}	A13	E10	Logic voltage	42
	D12	E11		
	D13	E12		
	K9	E15		
	K15	E16		
	L9	E17		
	L10	K5		
	L14	K22		
	L15	L5		
	L20	L22		
	M10	M5		
	M14	M22		
	N4	R5		
	N9	R22		
	N10	T5		
	N14	T22		
	N15	U5		
	P9	U22		
	P15	AB10		
	Y11	AB11		
Y12	AB12			
AC11	AB15			
	AB16			
	AB17			
\overline{WE}	AB16	AC16	SDRAM	37

Data Sheet**Signals Listed by Ball Assignment—413-Ball Package** (Part 1 of 3)

Ball	Signal Name	Ball	Signal Name	Ball	Signal Name	Ball	Signal Name
A1	GND	B17	PCIAD0	D10	PerCS5[GPIO14]	G13	PCIINT[PerWE]
A2	PerAddr4	B18	PCIAD3	D11	OV _{DD}	G15	OV _{DD}
A3	PerAddr11	B19	Reserved	D12	V _{DD}	G16	PCIReq3
A4	PerAddr15	B20	PCIReq2	D13	V _{DD}	G17	DrvrInh2
A5	PerAddr18	B21	PCIReq1	D14	GND	G20	PCISErr
A6	GND	B22	PCIAD11	D15	PCIReq0[Gnt]	G21	PCIReq5
A7	PerAddr21	B23	PCIgnt2	D16	PCIC0[BE0]	G22	PCIAD16
A8	DMAAck3	C1	PerPar3	D17	PCIClk	G23	PCIAD18
A9	PerAddr25	C2	EOT0/TC0	D18	Reserved	H1	PerData16
A10	PerAddr27	C3	PerAddr3	D19	PCIAD9	H2	PerData22
A11	OV _{DD}	C4	PerAddr5	D20	PCIAD12	H3	Reserved
A12	PerAddr28	C5	PerAddr8	D21	PCIAD15	H4	PerData31
A13	V _{DD}	C6	DMAReq3	D22	PCIPErr	H7	PerR \bar{W}
A14	PerAddr29	C7	PerCS4[GPIO13]	D23	PCIgnt3	H8	PerErr
A15	DMAAck2	C8	PerAddr16	E1	PerData24	H9	OV _{DD}
A16	DMAReq1	C9	PerAddr17	E2	Reserved	H10	OV _{DD}
A17	DMAAck0	C10	PerCS7[GPIO16]	E3	PerPar2	H11	PerCS1[GPIO10]
A18	GND	C11	PerAddr2	E4	PerWBE3	H13	PCIAD13
A19	PCIAD4	C12	PerAddr24	E20	TestEn	H14	OV _{DD}
A20	GPIO1[TS1E]	C13	DMAReq0	E21	PCIParity	H15	OV _{DD}
A21	GPIO3[TS1O]	C14	GND	E22	PCIIRDY	H16	SysClk
A22	PCIAD10	C15	PCIAD5	E23	PCIC2[BE2]	H17	DrvrInh1
A23	GND	C16	Reserved	F1	GND	H20	PCIDevSel
B1	PerWBE2	C17	PCIAD6	F2	PerData23	H21	PCIFrame
B2	PerWBE1	C18	PCIAD7	F3	PerData29	H22	PCIAD17
B3	PerAddr6	C19	GPIO2[TS2E]	F4	PerPar1	H23	PCIgnt5
B4	PerAddr9	C20	PCIAD8	F20	PCIReq4	J1	PerData13
B5	PerAddr14	C21	PHYTxClk	F21	PCITRDY	J2	PerData21
B6	PerCS6[GPIO15]	C22	PCIC1[BE1]	F22	EMCTxD0	J3	PerData25
B7	PerAddr19	C23	PCIStop	F23	GND	J4	PerData28
B8	PerAddr20	D1	PerData27	G1	PerData19	J7	OV _{DD}
B9	DMAReq2	D2	PerData30	G2	PerData20	J8	OV _{DD}
B10	PerAddr22	D3	PerBLast	G3	PerData26	J9	PerClk
B11	PerAddr23	D4	PerWBE0	G4	EOT1/TC1	J10	OV _{DD}
B12	PerAddr26	D5	PerCS3[GPIO12]	G7	PerAddr0	J11	GND
B13	PerAddr30	D6	PerAddr7	G8	PerCS2[GPIO11]	J12	PerAddr1
B14	DMAAck1	D7	PerAddr10	G10	OV _{DD}	J13	GND
B15	PCIAD1	D8	PerAddr12	G11	PerCS0	J14	OV _{DD}
B16	PCIAD2	D9	PerAddr13	G12	PerAddr31	J15	SysReset
J16	OV _{DD}	L20	V _{DD}	N22	PCIAD24	T1	BusReq
J17	OV _{DD}	L21	AV _{DD}	N23	GND	T2	PerData3
J20	EMCMDClk	L22	PCIAD19	P1	PerData10	T3	MemData31
J21	EMCTxEn	L23	OV _{DD}	P2	PerData5	T4	MemData27
J22	EMCTxD2	M1	PerData11	P3	HoldPri	T7	GPIO9[TrcClk]

Signals Listed by Ball Assignment—413-Ball Package (Part 2 of 3)

Ball	Signal Name	Ball	Signal Name	Ball	Signal Name	Ball	Signal Name
J23	PCIAD21	M2	PerData9	P4	HoldAck	T8	UART0_DTR
K1	PerData12	M3	PerData7	P8	OV _{DD}	T9	OV _{DD}
K2	PerData17	M4	GND	P9	V _{DD}	T10	OV _{DD}
K3	OV _{DD}	M8	PerData15	P10	UART0_DSR	T11	MemData17
K4	OV _{DD}	M9	MemData20	P11	GND	T13	TDO
K8	OV _{DD}	M10	V _{DD}	P12	GND	T14	OV _{DD}
K9	V _{DD}	M11	GND	P13	GND	T15	OV _{DD}
K10	PerOE	M12	GND	P14	SysErr	T16	TRST
K11	GND	M13	GND	P15	V _{DD}	T17	EMCMDIO [PHYMDIO]
K12	GND	M14	V _{DD}	P16	OV _{DD}	T20	PHYCrS
K13	GND	M15	PCIAD14	P20	OV _{DD}	T21	Reserved
K14	PCIReset	M16	PCIAD25	P21	OV _{DD}	T22	PHYRxErr
K15	V _{DD}	M20	GND	P22	PCIAD27	T23	PCIAD26
K16	OV _{DD}	M21	PCIAD20	P23	PCIC3[BE3]	U1	PerData4
K20	EMCTxErr	M22	PCIAD22	R1	PerData8	U2	PerData2
K21	EMCTxD1	M23	PCIIDSel	R2	ExtReset	U3	EOT2/TC2
K22	PCIGnt4	N1	OV _{DD}	R3	PerData0	U4	ExtAck
K23	PCIAD23	N2	PerData6	R4	MemData28	U7	UART0_CTS
L1	GND	N3	UART1_Tx	R7	OV _{DD}	U8	UART0_Tx
L2	PerData14	N4	V _{DD}	R8	OV _{DD}	U9	OV _{DD}
L3	PerData18	N7	UART1_RTS/ UART1_DTR	R9	MemData19	U11	MemData18
L4	GND	N8	UART1_DSR/ UART1_CTS	R10	OV _{DD}	U12	DQM0
L7	PerPar0	N9	V _{DD}	R11	GND	U13	TDI
L8	PerReady	N10	V _{DD}	R12	RAS	U14	OV _{DD}
L9	V _{DD}	N11	GND	R13	GND	U16	TCK
L10	V _{DD}	N12	GND	R14	OV _{DD}	U17	TMS
L11	GND	N13	GND	R15	CAS	U20	IRQ5[GPIO22]
L12	GND	N14	V _{DD}	R16	OV _{DD}	U21	IRQ0[GPIO17]
L13	GND	N15	V _{DD}	R17	OV _{DD}	U22	PCIAD29
L14	V _{DD}	N16	BA0	R20	IRQ2[GPIO19]	U23	PCIGnt1
L15	V _{DD}	N17	BA1	R21	PHYRxDV	V1	GND
L16	TmrClk	N20	GND	R22	PCIAD30	V2	HoldReq
L17	RcvrInh	N21	PCIAD28	R23	EMCTxD3	V3	EOT3/TC3
V4	ExtReq	Y15	MemAddr8	AA19	MemAddr4	AB23	MemClkOut1
V20	Reserved	Y16	MemAddr7	AA20	MemAddr2	AC1	GND
V21	Reserved	Y17	PHYRxD3	AA21	MemAddr0	AC2	DQM2
V22	PCIAD31	Y18	PHYRxD2	AA22	IRQ6[GPIO23]	AC3	GPIO7[TS5]
V23	GND	Y19	PHYRxD1	AA23	Half	AC4	GPIO5[TS3]
W1	PerData1	Y20	ClkEn1	AB1	MemData22	AC5	DQM1
W2	MemData29	Y21	PHYCoI	AB2	MemData15	AC6	GND
W3	MemData24	Y22	IRQ3[GPIO20]	AB3	IICsCL	AC7	MemData3
W4	UART1_Rx	Y23	IRQ1[GPIO18]	AB4	GPIO6[TS4]	AC8	MemData0

Data Sheet**Signals Listed by Ball Assignment—413-Ball Package** (Part 3 of 3)

Ball	Signal Name	Ball	Signal Name	Ball	Signal Name	Ball	Signal Name
W20	MemClkOut0	AA1	MemData26	AB5	Reserved	AC9	ECC6
W21	IRQ4[GPI021]	AA2	DQM3	AB6	MemData7	AC10	ECC5
W22	Reserved	AA3	MemData21	AB7	MemData4	AC11	V _{DD}
W23	PCIGnt0[Req]	AA4	MemData14	AB8	MemData6	AC12	ECC4
Y1	MemData30	AA5	MemData13	AB9	MemData5	AC13	OV _{DD}
Y2	MemData25	AA6	MemData11	AB10	MemData1	AC14	ECC3
Y3	MemData23	AA7	MemData9	AB11	ECC7	AC15	ECC1
Y4	MemData16	AA8	Reserved	AB12	ECC2	AC16	UART0_RI
Y5	Reserved	AA9	MemData8	AB13	DQMCB	AC17	BankSel2
Y6	GPIO8[TS6]	AA10	GND	AB14	BankSel3	AC18	GND
Y7	IICSDA	AA11	MemData2	AB15	UART0_RTS	AC19	BankSel0
Y8	MemData12	AA12	ECC0	AB16	WE	AC20	MemAddr10
Y9	MemData10	AA13	PHYRxD0	AB17	BankSel1	AC21	MemAddr6
Y10	GND	AA14	UART0_Rx	AB18	GPIO4[TS20]	AC22	MemAddr1
Y11	V _{DD}	AA15	MemAddr12	AB19	MemAddr9	AC23	GND
Y12	V _{DD}	AA16	MemAddr11	AB20	MemAddr5		
Y13	OV _{DD}	AA17	UART0_DCD	AB21	MemAddr3		
Y14	UARTSerClk	AA18	PHYRxClk	AB22	ClkEn0		

Signals Listed by Ball Assignment—456-Ball Package (Part 1 of 3)

Ball	Signal Name	Ball	Signal Name	Ball	Signal Name	Ball	Signal Name
A1	GND	B14	DMAAck2	D1	PerWBE3	E14	GND
A2	GND	B15	DMAAck1	D2	PerWBE0	E15	V _{DD}
A3	PerAddr1	B16	PCIAD1	D3	PerPar0	E16	V _{DD}
A4	PerCS3[GPIO12]	B17	Res – 27/OV _{DD} – 35	D4	GND	E17	V _{DD}
A5	PerAddr8	B18	PCIAD6	D5	PerAddr0	E18	GND
A6	GND	B19	PCIReq2	D6	PerAddr4	E19	OV _{DD}
A7	DMAReq3	B20	PCIClk	D7	PerAddr7	E20	OV _{DD}
A8	PerAddr15	B21	PCIAD8	D8	PerAddr11	E21	OV _{DD}
A9	PerCS6[GPIO15]	B22	PCIAD11	D9	PerAddr14	E22	GND
A10	PerAddr19	B23	PCIAD12	D10	PerAddr17	E23	DrvInh2
A11	GND	B24	PCIReset	D11	PerAddr20	E24	DrvInh1
A12	PerAddr25	B25	GND	D12	PerAddr23	E25	PHYTxClk
A13	PerAddr26	B26	GND	D13	PerAddr22	E26	PCIParity
A14	PerAddr28	C1	PerR/W	D14	DMAReq1	F1	GND
A15	PerAddr29	C2	PerOE	D15	PerAddr31	F2	PerBLast
A16	GND	C3	GND	D16	DMAAck0	F3	EOT0/TC0
A17	PCIAD0	C4	PerCS1[GPIO10]	D17	PCIAD4	F4	PerWBE2
A18	PCIAD3	C5	PerCS2[GPIO11]	D18	GPIO1[TS1E]	F5	OV _{DD}
A19	Res – 27/GND – 35	C6	PerAddr6	D19	PCIC0[BE0]	F22	OV _{DD}
A20	PCIAD7	C7	PerAddr10	D20	Reserved	F23	PCIGnt2
A21	GND	C8	PerAddr13	D21	PCIAD10	F24	PCIC1[BE1]
A22	GPIO3[TS1O]	C9	PerAddr16	D22	SysReset	F25	PCIAD15
A23	PCIAD9	C10	PerAddr18	D23	GND	F26	GND
A24	PCIReq3	C11	DMAReq2	D24	TmrClk	G1	PerData29
A25	SysClk	C12	DMAAck3	D25	AV _{DD}	G2	EOT1/TC1
A26	GND	C13	Res – 27/OV _{DD} – 35	D26	TestEn	G3	PerPar2
B1	PerErr	C14	PerAddr27	E1	PerPar3	G4	PerPar1
B2	GND	C15	PerAddr30	E2	PerWBE1	G5	OV _{DD}
B3	PerCS0	C16	DMAReq0	E3	PerReady	G22	OV _{DD}
B4	PerAddr2	C17	PCIAD2	E4	PerClk	G23	PCIReq4
B5	PerAddr3	C18	PCIAD5	E5	GND	G24	PCISErr
B6	PerAddr5	C19	PCIReq0[Gnt]	E6	OV _{DD}	G25	PCIPErr
B7	PerAddr9	C20	GPIO2[TS2E]	E7	OV _{DD}	G26	PCITRDY
B8	PerAddr12	C21	PCIReq1	E8	OV _{DD}	H1	Res – 27/GND – 35
B9	PerCS4[GPIO13]	C22	PCIAD13	E9	GND	H2	PerData30
B10	PerCS5[GPIO14]	C23	PCIINT[PerWE]	E10	V _{DD}	H3	PerData28
B11	PerCS7[GPIO16]	C24	GND	E11	V _{DD}	H4	PerData31
B12	PerAddr21	C25	RcvrInh	E12	V _{DD}	H5	OV _{DD}
B13	PerAddr24	C26	PCIAD14	E13	GND	H22	OV _{DD}
H23	PCIStop	M1	PerData12	P14	GND	U1	PerData2
H24	EMCMDClk	M2	PerData17	P15	GND	U2	HoldAck
H25	PCIDevSel	M3	PerData14	P16	GND	U3	PerData1
H26	PCIGnt3	M4	PerData15	P22	GND	U4	PerData0

Data Sheet**Signals Listed by Ball Assignment—456-Ball Package** (Part 2 of 3)

Ball	Signal Name	Ball	Signal Name	Ball	Signal Name	Ball	Signal Name
J1	PerData23	M5	V _{DD}	P23	PCIAD26	U5	V _{DD}
J2	PerData26	M11	GND	P24	PCIAD23	U22	V _{DD}
J3	PerData25	M12	GND	P25	EMCTxD3	U23	PCI $\overline{\text{Gnt0}}$ [Req]
J4	PerData27	M13	GND	P26	PCIIDSel	U24	PHYRxErr
J5	GND	M14	GND	R1	PerData8	U25	Res – 27/OV _{DD} – 35
J22	GND	M15	GND	R2	PerData4	U26	PCIAD29
J23	PCIIRDY	M16	GND	R3	BusReq	V1	HoldReq
J24	PCIFrame	M22	V _{DD}	R4	PerData6	V2	EOT2/TC2
J25	PCIReq5	M23	PCIAD19	R5	V _{DD}	V3	MemData31
J26	EMCTxD0	M24	PCI $\overline{\text{Gnt5}}$	R11	GND	V4	MemData29
K1	PerData20	M25	PCIAD18	R12	GND	V5	GND
K2	Res – 27/OV _{DD} – 35	M26	PCIAD21	R13	GND	V22	GND
K3	PerData22	N1	PerData11	R14	GND	V23	IRQ1[GPIO18]
K4	PerData24	N2	PerData13	R15	GND	V24	PHYRxDV
K5	V _{DD}	N3	PerData10	R16	GND	V25	IRQ0[GPIO17]
K22	V _{DD}	N4	PerData16	R22	V _{DD}	V26	PCIAD31
K23	EMCTxEn	N5	GND	R23	PCIAD25	W1	MemData30
K24	PCIC2[BE2]	N11	GND	R24	PCIAD24	W2	MemData27
K25	EMCTxErr	N12	GND	R25	PCIAD27	W3	MemData28
K26	PCIAD16	N13	GND	R26	PCIC3[BE3]	W4	MemData26
L1	GND	N14	GND	T1	GND	W5	OV _{DD}
L2	PerData21	N15	GND	T2	HoldPri	W22	OV _{DD}
L3	PerData18	N16	GND	T3	ExtReset	W23	PHYCrS
L4	PerData19	N22	GND	T4	PerData3	W24	IRQ2[GPIO19]
L5	V _{DD}	N23	PCI $\overline{\text{Gnt4}}$	T5	V _{DD}	W25	IRQ3[GPIO20]
L11	GND	N24	Res – 27/OV _{DD} – 35	T11	GND	W26	Res – 27/GND – 35
L12	GND	N25	PCIAD20	T12	GND	Y1	EOT3/TC3
L13	GND	N26	PCIAD22	T13	GND	Y2	MemData25
L14	GND	P1	PerData9	T14	GND	Y3	ExtAck
L15	GND	P2	PerData7	T15	GND	Y4	ExtReq
L16	GND	P3	Res – 27/OV _{DD} – 35	T16	GND	Y5	OV _{DD}
L22	V _{DD}	P4	PerData5	T22	V _{DD}	Y22	OV _{DD}
L23	PCIAD17	P5	GND	T23	PCI $\overline{\text{Gnt1}}$	Y23	Reserved
L24	EMCTxD2	P11	GND	T24	PCIAD28	Y24	IRQ4[GPIO21]
L25	EMCTxD1	P12	GND	T25	PCIAD30	Y25	IRQ5[GPIO22]
L26	GND	P13	GND	T26	GND	Y26	Reserved
AA1	GND	AB26	Half	AD9	MemData8	AE18	UART0_DCD
AA2	MemData23	AC1	UART1_Rx	AD10	MemData6	AE19	MemAddr7
AA3	DQM3	AC2	UART1_Tx	AD11	MemData2	AE20	MemAddr5
AA4	MemData22	AC3	UART1_DSR/ UART1_CTS	AD12	ECC7	AE21	MemAddr2
AA5	OV _{DD}	AC4	GND	AD13	ECC3	AE22	MemAddr0
AA22	OV _{DD}	AC5	MemData19	AD14	Res – 27/OV _{DD} – 35	AE23	PHYRxD0
AA23	MemClkOut1	AC6	DQM2	AD15	UART0_RI	AE24	TDI
AA24	IRQ6[GPIO23]	AC7	GPIO8[TS6]	AD16	UART0_RTS	AE25	GND

Signals Listed by Ball Assignment—456-Ball Package (Part 3 of 3)

Ball	Signal Name	Ball	Signal Name	Ball	Signal Name	Ball	Signal Name
AA25	PHYCol	AC8	MemData12	AD17	BankSel0	AE26	TRST
AA26	GND	AC9	GPIO5[TS3]	AD18	MemAddr11	AF1	GND
AB1	MemData24	AC10	DQM1	AD19	MemAddr8	AF2	UART0_DTR
AB2	MemData21	AC11	MemData3	AD20	PHYRxD3	AF3	UART0_Tx
AB3	GPIO9[TrcClk]	AC12	DQM0	AD21	MemAddr3	AF4	Reserved
AB4	UART0_CTS	AC13	MemData0	AD22	TCK	AF5	GPIO7[TS5]
AB5	GND	AC14	BankSel3	AD23	TDO	AF6	GND
AB6	OV _{DD}	AC15	DQMCB	AD24	GND	AF7	MemData11
AB7	OV _{DD}	AC16	WE	AD25	SysErr	AF8	Res – 27/GND – 35
AB8	OV _{DD}	AC17	MemAddr12	AD26	EMCMDIO [PHYMDIO]	AF9	MemData7
AB9	GND	AC18	MemAddr9	AE1	GND	AF10	MemData4
AB10	V _{DD}	AC19	MemAddr6	AE2	GND	AF11	GND
AB11	V _{DD}	AC20	PHYRxD2	AE3	UART0_DSR	AF12	ECC5
AB12	V _{DD}	AC21	MemAddr1	AE4	MemData16	AF13	ECC4
AB13	GND	AC22	TMS	AE5	MemData15	AF14	ECC2
AB14	GND	AC23	GND	AE6	MemData14	AF15	ECC1
AB15	V _{DD}	AC24	BA1	AE7	IICSDA	AF16	GND
AB16	V _{DD}	AC25	ClkEn1	AE8	GPIO6[TS4]	AF17	BankSel1
AB17	V _{DD}	AC26	MemClkOut0	AE9	MemData9	AF18	GPIO4[TS20]
AB18	GND	AD1	MemData20	AE10	Res – 27/OV _{DD} – 35	AF19	MemAddr10
AB19	OV _{DD}	AD2	UART1_RTS/ UART1_DTR	AE11	MemData5	AF20	PHYRxClk
AB20	OV _{DD}	AD3	GND	AE12	MemData1	AF21	GND
AB21	OV _{DD}	AD4	MemData18	AE13	ECC6	AF22	MemAddr4
AB22	GND	AD5	MemData17	AE14	ECC0	AF23	PHYRxD1
AB23	CAS	AD6	IICSCSCL	AE15	BankSel2	AF24	RAS
AB24	BA0	AD7	MemData13	AE16	UART0_Rx	AF25	GND
AB25	ClkEn0	AD8	MemData10	AE17	UARTSerClk	AF26	GND

Signal List

The following table provides a summary of the number of package pins associated with each functional interface group.

Pin Summary

Group	No. of Pins		
	413-Ball package	456-Ball Package	
	25 mm	35 mm	27mm
PCI	60	60	60
Ethernet	18	18	18
SDRAM	71	71	71
External peripheral	96	96	96
External master	9	9	9
Internal peripheral	15	15	15
Interrupts	7	7	7
JTAG	5	5	5
System	19	19	19
Total Signal Pins	300	300	300
OV_{DD}	38	32	24
V_{DD}	22	24	24
Gnd	26	60	56
Thermal (and Gnd)	15	36	36
Reserved	12	4	16
Total Pins	413	456	456

Multiplexed Pins

In the table “Signal Functional Description” on page 35, each external signal is listed along with a description of the signal function. Some signals are multiplexed on the same pin (ball) so that the pin can be used for different functions. Multiplexed signals are shown as a default signal with a secondary signal in square brackets (for example, GPIO1[TS1E]). Active-low signals (for example, \overline{RAS}) are marked with an overline.

It is expected that in any single application a particular pin will always be programmed to serve the same function. The flexibility of multiplexing allows a single chip to offer a richer pin selection than would otherwise be possible.

In addition to multiplexing, many pins are also multi-purpose. For example, the EBC peripheral controller address pins are used as outputs by the PPC405GP to broadcast an address to external slave devices when the PPC405GP has control of the external bus. When, during the course of normal chip operation, an external master gains ownership of the external bus, these same pins are used as inputs which are driven by the external master and received by the EBC in the PPC405GP. In this example, the pins are also bidirectional, serving as both inputs and outputs.

Initialization Strapping

One group of pins is used as strapped inputs during system reset. These pins function as strapped inputs only during reset and are used for other functions during normal operation (see “Strapping” on page 55). Note that the use of these pins for strapping is not considered multiplexing since the strapping function is not programmable.

Pull-Up and Pull-Down Resistors

Pull-up and pull-down resistors are used for strapping during reset and to retain unused or undriven inputs in an appropriate state. The recommended pull-up value of 3k Ω to +3.3V (10k Ω to +5V can be used on 5V tolerant I/Os) and pull-down value of 1k Ω to GND, applies only to individually terminated signals. To prevent possible damage to the device, I/Os capable of becoming outputs *must never* be tied together and terminated through a common resistor.

If your system-level test methodology permits, input-only signals can be connected together and terminated through either a common resistor or directly to +3.3V or GND. When a resistor is used, its value must ensure that the grouped I/Os reach a valid logic zero or logic one state when accounting for the total input current into the PPC405GP.

Unused I/Os

Termination of some pins may be necessary when they are unused. Although the PPC405GP requires only the pull-up and pull-down terminations as specified in the “Signal Functional Description” on page 35, good design practice is to terminate all unused inputs or to configure I/Os such that they always drive. If unused, the peripheral, SDRAM, and PCI buses should be configured and terminated as follows:

- Peripheral interface—PerAddr0:31, PerData0:31, and all of the control signals are driven by default. Terminate PerReady high and PerError low.
- SDRAM—Program SDRAM0_CFG[EMDULR]=1 and SDRAM0_CFG[DCE]=1. This causes the PPC405GP to actively drive all of the SDRAM address, data, and control signals.
- PCI—The PCI pull-up requirements given in the Signal Functional Description apply only when the PCI interface is being used. When the PCI bridge is unused, configure the PCI controller to park on the bus and actively drive PCIAD31:0, PCIC3:0[BE3:0], and the remaining PCI control signals by doing the following:
 - Strap the PPC405GP to disable the internal PCI arbiter and to operate the PCI interface in synchronous mode.
 - Individually connect $\overline{\text{PCISerr}}$, $\overline{\text{PCIPerr}}$, $\overline{\text{PCITRDY}}$, and $\overline{\text{PCIStop}}$ through 3k Ω resistors to +3.3V.
 - Terminate $\overline{\text{PCIReq1:5}}$ to +3.3V.
 - Terminate $\overline{\text{PCIReq0[Gnt]}}$ to GND.

External Bus Control Signals

All peripheral bus control signals ($\overline{\text{PerCS0:7}}$, $\overline{\text{PerR/W}}$, $\overline{\text{PerWBE0:3}}$, $\overline{\text{PerOE}}$, $\overline{\text{PerWE}}$, $\overline{\text{PerBLast}}$, HoldAck, $\overline{\text{ExtAck}}$) are set to the high-impedance state when $\overline{\text{ExtReset}}=0$. In addition, as detailed in the *PowerPC 405GP Embedded Processor User's Manual*, the peripheral bus controller can be programmed via EBC0_CFG to float some of these control signals between transactions and/or when an external master owns the peripheral bus. As a result, a pull-up resistor should be added to those control signals where an undriven state may affect any devices receiving that particular signal.

The following table lists all of the I/O signals provided by the PPC405GP. Please refer to “Signals Listed Alphabetically” on page 17 for the pin number to which each signal is assigned.

Data Sheet**Signal Functional Description** (Part 1 of 8)

Multiplexed signals are shown in brackets following the first signal name assigned to each multiplexed ball.

Notes:

1. Receiver input has hysteresis.
2. Must pull up. See “Pull-Up and Pull-Down Resistors” on page 34 for recommended termination values.
3. Must pull down. See “Pull-Up and Pull-Down Resistors” on page 34 for recommended termination values.
4. If not used, must pull up.
5. If not used, must pull down.
6. Strapping input during reset; pull up or pull down as required.
7. Pull-up may be required. See “External Bus Control Signals” on page 34.

Signal Name	Description	I/O	Type	Notes
PCI Interface				
PCIA0:31	PCI Address/Data Bus. Multiplexed address and data bus.	I/O	5V tolerant 3.3V PCI	
PCIC0:3[BE3:0]	PCI bus command and byte enables.	I/O	5V tolerant 3.3V PCI	
PCIParity	PCI parity. Parity is even across PCIA0:31 and PCIC0:3[BE0:3]. PCIParity is valid one cycle after either an address or data phase. The PCI device that drove PCIA0:31 is responsible for driving PCIParity on the next PCI bus clock.	I/O	5V tolerant 3.3V PCI	
PCIFrame	PCIFrame is driven by the current PCI bus master to indicate the beginning and duration of a PCI access.	I/O	5V tolerant 3.3V PCI	2
PCIIRDY	PCIIRDY is driven by the current PCI bus master. Assertion of PCIIRDY indicates that the PCI initiator is ready to transfer data.	I/O	5V tolerant 3.3V PCI	2
PCITRDY	The target of the current PCI transaction drives PCITRDY. Assertion of PCITRDY indicates that the PCI target is ready to transfer data.	I/O	5V tolerant 3.3V PCI	2
PCIStop	The target of the current PCI transaction can assert PCIStop to indicate to the requesting PCI master that it wants to end the current transaction.	I/O	5V tolerant 3.3V PCI	2
PCIDevSel	PCIDevSel is driven by the target of the current PCI transaction. A PCI target asserts PCIDevSel when it has decoded an address and command encoding and claims the transaction.	I/O	5V tolerant 3.3V PCI	2
PCIIDSel	PCIIDSel is used during configuration cycles to select the PCI slave interface for configuration.	I	5V tolerant 3.3V PCI	
PCISErr	PCISErr is used for reporting address parity errors or catastrophic failures detected by a PCI target.	I/O	5V tolerant 3.3V PCI	2
PCIPErr	PCIPErr is used for reporting data parity errors on PCI transactions. PCIPErr is driven active by the device receiving PCIA0:31, PCIC0:3[BE0:3], and PCIParity, two PCI clocks following the data in which bad parity is detected.	I/O	5V tolerant 3.3V PCI	2
PCIClk	PCIClk is used as the asynchronous PCI clock when in asynchronous mode. It is unused when the PCI interface is operated synchronously with the PLB bus.	I	5V tolerant 3.3V PCI	
PCIReset	PCI specific reset.	O	5V tolerant 3.3V PCI	
PCIINT[PerWE]	PCI interrupt. Open-drain output (two states; 0 or open circuit) or Peripheral write enable. Low when any of the four PerWBE0:3 write byte enables are low.	O	5V tolerant 3.3V PCI	
PCIReq0[Gnt]	Multipurpose signal, used as PCIReq0 when internal arbiter is used, and as Gnt when external arbiter is used.	I	5V tolerant 3.3V PCI	
PCIReq1:5	Used as PCIReq1:5 input when internal arbiter is used.	I	5V tolerant 3.3V PCI	

Signal Functional Description (Part 2 of 8)

Multiplexed signals are shown in brackets following the first signal name assigned to each multiplexed ball.

Notes:

1. Receiver input has hysteresis.
2. Must pull up. See “Pull-Up and Pull-Down Resistors” on page 34 for recommended termination values.
3. Must pull down. See “Pull-Up and Pull-Down Resistors” on page 34 for recommended termination values.
4. If not used, must pull up.
5. If not used, must pull down.
6. Strapping input during reset; pull up or pull down as required.
7. Pull-up may be required. See “External Bus Control Signals” on page 34.

Signal Name	Description	I/O	Type	Notes
$\overline{\text{PCIGnt0}}[\overline{\text{Req}}]$	$\overline{\text{Gnt0}}$ when internal arbiter is used or $\overline{\text{Req}}$ when external arbiter is used.	O	5V tolerant 3.3V PCI	
$\overline{\text{PCIGnt1:5}}$	Used as $\overline{\text{PCIGnt1:5}}$ output when internal arbiter is used.	O	5V tolerant 3.3V PCI	
Ethernet Interface				
PHYRxD3:0	Received data. This is a nibble wide bus from the PHY. The data is synchronous with the PHYRxClk.	I	5V tolerant 3.3V LVTTTL	1
EMCTxD3:0	Transmit data. A nibble wide data bus towards the net. The data is synchronous to the PHYTxClk.	O	5V tolerant 3.3V LVTTTL	6
PHYRxErr	Receive Error. This signal comes from the PHY and is synchronous to the PHYRxClk.	I	5V tolerant 3.3V LVTTTL	1
PHYRxClk	Receiver Medium clock. This signal is generated by the PHY.	I	5V tolerant 3.3V LVTTTL	1
PHYRxDV	Receive Data Valid. Data on the Data Bus is valid when this signal is activated. Deassertion of this signal indicates end of the frame reception.	I	5V tolerant 3.3V LVTTTL	1
PHYCrS	Carrier Sense signal from the PHY. This is an asynchronous signal.	I	5V tolerant 3.3V LVTTTL	1
EMCTxErr	Transmit Error. This signal is generated by the Ethernet controller, is connected to the PHY and is synchronous with the PHYTxClk. It informs the PHY that an error was detected.	O	5V tolerant 3.3V LVTTTL	6
EMCTxEn	Transmit Enable. This signal is driven by the EMAC to the PHY. Data is valid during the active state of this signal. Deassertion of this signal indicates end of frame transmission. This signal is synchronous to the PHYTxClk.	O	5V tolerant 3.3V LVTTTL	6
PHYTxClk	This clock comes from the PHY and is the Medium Transmit clock.	I	5V tolerant 3.3V LVTTTL	1
PHYCol	Collision signal from the PHY. This is an asynchronous signal.	I	5V tolerant 3.3V LVTTTL	1
EMCMDClk	Management Data Clock. The MDClk is sourced to the PHY. This clock has a period of 400ns, adjustable via EMAC0_STACR[OPBC]. Management information is transferred synchronously with respect to this clock.	O	5V tolerant 3.3V LVTTTL	
EMCMDIO[PHYMDIO]	Management Data Input/Output is a bidirectional signal between the Ethernet controller and the PHY. It is used to transfer control and status information.	I/O	5V tolerant 3.3V LVTTTL	1

Data Sheet**Signal Functional Description** (Part 3 of 8)

Multiplexed signals are shown in brackets following the first signal name assigned to each multiplexed ball.

Notes:

1. Receiver input has hysteresis.
2. Must pull up. See “Pull-Up and Pull-Down Resistors” on page 34 for recommended termination values.
3. Must pull down. See “Pull-Up and Pull-Down Resistors” on page 34 for recommended termination values.
4. If not used, must pull up.
5. If not used, must pull down.
6. Strapping input during reset; pull up or pull down as required.
7. Pull-up may be required. See “External Bus Control Signals” on page 34.

Signal Name	Description	I/O	Type	Notes
SDRAM Interface				
MemData0:31	Memory data bus. Notes: 1. MemData0 is the most significant bit (msb). 2. MemData31 is the least significant bit (lsb).	I/O	3.3V LVTTTL	
MemAddr12:0	Memory address bus. Notes: 1. MemAddr12 is the most significant bit (msb). 2. MemAddr0 is the least significant bit (lsb).	O	3.3V LVTTTL	
BA1:0	Bank Address supporting up to 4 internal banks.	O	3.3V LVTTTL	
$\overline{\text{RAS}}$	Row Address Strobe.	O	3.3V LVTTTL	
$\overline{\text{CAS}}$	Column Address Strobe.	O	3.3V LVTTTL	
DQM0:3	DQM for byte lane: 0 (MemData0:7), 1 (MemData8:15), 2 (MemData16:23), and 3 (MemData24:31)	O	3.3V LVTTTL	
DQM CB	DQM for ECC check bits.	O	3.3V LVTTTL	
ECC0:7	ECC check bits 0:7.	I/O	3.3V LVTTTL	
BankSel0:3	Select up to four external SDRAM banks.	O	3.3V LVTTTL	
$\overline{\text{WE}}$	Write Enable.	O	3.3V LVTTTL	
ClkEn0:1	SDRAM Clock Enable.	O	3.3V LVTTTL	
MemClkOut0:1	Two copies of an SDRAM clock allows, in some cases, glueless SDRAM attach without requiring this signal to be repowered by a PLL or zero-delay buffer.	O	3.3V LVTTTL	
External Slave Peripheral Interface				
PerData0:31	Peripheral data bus used by PPC405GP when not in external master mode, otherwise used by external master. Note: PerData0 is the most significant bit (msb) on this bus.	I/O	5V tolerant 3.3V LVTTTL	1
PerAddr0:31	Peripheral address bus used by PPC405GP when not in external master mode, otherwise used by external master. Note: PerAddr0 is the most significant bit (msb) on this bus.	I/O	5V tolerant 3.3V LVTTTL	1
PerPar0:3	Peripheral byte parity signals.	I/O	5V tolerant 3.3V LVTTTL	1
$\overline{\text{PerWBE0:3}}$	As outputs, these pins can act as byte-enables which are valid for an entire cycle or as write-byte-enables which are valid for each byte on each data transfer, allowing partial word transactions. As outputs, pins are used by either the peripheral controller or the DMA controller depending upon the type of transfer involved. Used as inputs when an external bus master owns the external interface.	I/O	5V tolerant 3.3V LVTTTL	1, 7
$\overline{[\text{PerWE}] \text{PCIINT}}$	Peripheral write enable. Low when any of the four $\overline{\text{PerWBE0:3}}$ write byte enables are low. or PCI interrupt. Open-drain output (two states; 0 or open circuit)	O	5V tolerant 3.3V PCI	

Signal Functional Description (Part 4 of 8)

Multiplexed signals are shown in brackets following the first signal name assigned to each multiplexed ball.

Notes:

1. Receiver input has hysteresis.
2. Must pull up. See “Pull-Up and Pull-Down Resistors” on page 34 for recommended termination values.
3. Must pull down. See “Pull-Up and Pull-Down Resistors” on page 34 for recommended termination values.
4. If not used, must pull up.
5. If not used, must pull down.
6. Strapping input during reset; pull up or pull down as required.
7. Pull-up may be required. See “External Bus Control Signals” on page 34.

Signal Name	Description	I/O	Type	Notes
$\overline{\text{PerCS0}}$	Peripheral chip select bank 0.	O	5V tolerant 3.3V LVTTTL	7
$\overline{\text{PerCS1:7}}[\text{GPIO10:16}]$	Seven additional peripheral chip selects or General Purpose I/O. To access this function, software must toggle a DCR bit.	O[I/O]	5V tolerant 3.3V LVTTTL	1, 7
$\overline{\text{PerOE}}$	Used by either the peripheral controller or the DMA controller depending upon the type of transfer involved. When the PPC405GP is the bus master, it enables the selected device to drive the bus.	O	5V tolerant 3.3V LVTTTL	7
$\text{PerR}/\overline{\text{W}}$	Used by the PPC405GP when not in external master mode, as output by either the peripheral controller or DMA controller depending upon the type of transfer involved. High indicates a read from memory, low indicates a write to memory. Otherwise it used by the external master as an input to indicate the direction of data transfer.	I/O	5V tolerant 3.3V LVTTTL	1
PerReady	Used by a peripheral slave to indicate it is ready to transfer data.	I	5V tolerant 3.3V LVTTTL	1
$\overline{\text{PerBLast}}$	Used by the PPC405GP when not in external master mode, otherwise used by external master. Indicates the last transfer of a memory access.	I/O	5V tolerant 3.3V LVTTTL	1, 7
DMAReq0:3	DMAReq0:3 are used by slave peripherals to indicate they are prepared to transfer data.	I	5V tolerant 3.3V LVTTTL	1
DMAAck0:3	DMAAck0:3 are used by the PPC405GP to cause the DMA peripheral to transfer data.	O	5V tolerant 3.3V LVTTTL	6
$\text{EOT0:3}/\text{TC0:3}$	End Of Transfer/Terminal Count.	I/O	5V tolerant 3.3V LVTTTL	1

Data Sheet**Signal Functional Description** (Part 5 of 8)

Multiplexed signals are shown in brackets following the first signal name assigned to each multiplexed ball.

Notes:

1. Receiver input has hysteresis.
2. Must pull up. See “Pull-Up and Pull-Down Resistors” on page 34 for recommended termination values.
3. Must pull down. See “Pull-Up and Pull-Down Resistors” on page 34 for recommended termination values.
4. If not used, must pull up.
5. If not used, must pull down.
6. Strapping input during reset; pull up or pull down as required.
7. Pull-up may be required. See “External Bus Control Signals” on page 34.

Signal Name	Description	I/O	Type	Notes
External Master Peripheral Interface				
PerClk	Peripheral clock to be used by an external master and by synchronous peripheral slaves.	O	5V tolerant 3.3V LVTTTL	
$\overline{\text{ExtReset}}$	Peripheral reset to be used by an external master and by synchronous peripheral slaves.	O	5V tolerant 3.3V LVTTTL	
HoldReq	Hold Request, used by an external master to request ownership of the peripheral bus.	I	5V tolerant 3.3V LVTTTL	1, 5
HoldAck	Hold Acknowledge, used by the PPC405GP to transfer ownership of peripheral bus to an external master.	O	5V tolerant 3.3V LVTTTL	6
$\overline{\text{ExtReq}}$	ExtReq is used by an external master to indicate it is prepared to transfer data.	I	5V tolerant 3.3V LVTTTL	1
$\overline{\text{ExtAck}}$	ExtAck is used by the PPC405GP to indicate a data transfer cycle.	O	5V tolerant 3.3V LVTTTL	6
HoldPri	Used by an external master to indicate the priority of a given external master tenure.	I	5V tolerant 3.3V LVTTTL	1
BusReq	Used when the PPC405GP needs to regain control of peripheral interface from an external master.	O	5V tolerant 3.3V LVTTTL	
PerErr	An input used to indicate to the PPC405GP that an external slave peripheral error occurred.	I	5V tolerant 3.3V LVTTTL	1, 5
Internal Peripheral Interface				
UARTSerClk	Serial Clock used to provide an alternate clock to the internally generated serial clock. Used in cases where the allowable internally generated baud rates are not satisfactory. This input can be individually connected to either UART.	I	5V tolerant 3.3V LVTTTL	1
UART0_Rx	UART0 Serial Data In.	I	5V tolerant 3.3V LVTTTL	1
UART0_Tx	UART0 Serial Data Out.	O	5V tolerant 3.3V LVTTTL	6
$\overline{\text{UART0_DCD}}$	UART0 Data Carrier Detect.	I	5V tolerant 3.3V LVTTTL	1
$\overline{\text{UART0_DSR}}$	UART0 Data Set Ready.	I	5V tolerant 3.3V LVTTTL	1
$\overline{\text{UART0_CTS}}$	UART0 Clear To Send.	I	5V tolerant 3.3V LVTTTL	1
$\overline{\text{UART0_DTR}}$	UART0 Data Terminal Ready.	O	5V tolerant 3.3V LVTTTL	6
$\overline{\text{UART0_RTS}}$	UART0 Request To Send.	O	5V tolerant 3.3V LVTTTL	6
$\overline{\text{UART0_RI}}$	UART0 Ring Indicator.	I	5V tolerant 3.3V LVTTTL	1
UART1_Rx	UART1 Serial Data In.	I	5V tolerant 3.3V LVTTTL	1

Signal Functional Description (Part 6 of 8)

Multiplexed signals are shown in brackets following the first signal name assigned to each multiplexed ball.

Notes:

1. Receiver input has hysteresis.
2. Must pull up. See “Pull-Up and Pull-Down Resistors” on page 34 for recommended termination values.
3. Must pull down. See “Pull-Up and Pull-Down Resistors” on page 34 for recommended termination values.
4. If not used, must pull up.
5. If not used, must pull down.
6. Strapping input during reset; pull up or pull down as required.
7. Pull-up may be required. See “External Bus Control Signals” on page 34.

Signal Name	Description	I/O	Type	Notes
UART1_Tx	UART1 Serial Data Out.	O	5V tolerant 3.3V LVTTTL	6
$\overline{\text{UART1_DSR}}$ / $\overline{\text{UART1_CTS}}$	UART1 Data Set Ready or UART1 Clear To Send. To access this function, software must toggle a DCR bit.	I	5V tolerant 3.3V LVTTTL	1
$\overline{\text{UART1_RTS}}$ / $\overline{\text{UART1_DTR}}$	UART1 Request To Send or UART1 Data Terminal Ready. To access this function, software must toggle a DCR bit.	O	5V tolerant 3.3V LVTTTL	6
IIC_SCL	IIC Serial Clock.	I/O	5V tolerant 3.3V LVTTTL	1, 2
IIC_SDA	IIC Serial Data.	I/O	5V tolerant 3.3V LVTTTL	1, 2
Interrupts Interface				
IRQ0:6[GPIO17:23]	Interrupt requests or General Purpose I/O. To access this function, software must toggle a DCR bit.	I/[I/O]	5V tolerant 3.3V LVTTTL	1
JTAG Interface				
TDI	Test data in.	I	5V tolerant 3.3V LVTTTL	1, 4
TMS	JTAG test mode select.	I	5V tolerant 3.3V LVTTTL	1, 4
TDO	Test data out.	O	5V tolerant 3.3V LVTTTL	
TCK	JTAG test clock. The frequency of this input can range from DC to 25MHz.	I	5V tolerant 3.3V LVTTTL	1, 4
$\overline{\text{TRST}}$	JTAG reset. $\overline{\text{TRST}}$ must be low at power-on to initialize the JTAG controller and for normal operation of the PPC405GP.	I	5V tolerant 3.3V LVTTTL	5
System Interface				
SysClk	Main system clock input.	I	5V tolerant 3.3V LVTTTL	
$\overline{\text{SysReset}}$	Main system reset. External logic can drive this bidirectional pin low (minimum of 16 cycles) to initiate a system reset. A system reset can also be initiated by software. Implemented as an open-drain output (two states; 0 or open circuit).	I/O	5V tolerant 3.3V LVTTTL	1, 2
AV _{DD}	Clean voltage input for the PLL.	I		
SysErr	Set to 1 when a Machine Check is generated.	O	5V tolerant 3.3V LVTTTL	
$\overline{\text{Halt}}$	Halt from external debugger.	I	5V tolerant 3.3V LVTTTL	1, 2

Data Sheet**Signal Functional Description** (Part 7 of 8)

Multiplexed signals are shown in brackets following the first signal name assigned to each multiplexed ball.

Notes:

1. Receiver input has hysteresis.
2. Must pull up. See “Pull-Up and Pull-Down Resistors” on page 34 for recommended termination values.
3. Must pull down. See “Pull-Up and Pull-Down Resistors” on page 34 for recommended termination values.
4. If not used, must pull up.
5. If not used, must pull down.
6. Strapping input during reset; pull up or pull down as required.
7. Pull-up may be required. See “External Bus Control Signals” on page 34.

Signal Name	Description	I/O	Type	Notes
GPIO1[TS1E] GPIO2[TS2E]	General Purpose I/O or Even Trace execution status. To access this function, software must toggle a DCR bit.	I/O[O]	5V tolerant 3.3V LVTTTL	1, 6
GPIO3[TS1O]	General Purpose I/O or Odd Trace execution status. To access this function, software must toggle a DCR bit.	I/O[O]	5V tolerant 3.3V LVTTTL	1
GPIO4[TS2O]	General Purpose I/O or Odd Trace execution status. To access this function, software must toggle a DCR bit.	I/O[O]	5V tolerant 3.3V LVTTTL	1, 6
GPIO5:8[TS3:6]	General Purpose I/O or Trace status. To access this function, software must toggle a DCR bit.	I/O[O]	5V tolerant 3.3V LVTTTL	1
GPIO9[TrcClk]	General Purpose I/O or Trace interface clock. A toggling signal that is always half of the CPU core frequency. To access this function, software must toggle a DCR bit.	I/O[O]	5V tolerant 3.3V LVTTTL	1
TestEn	Test Enable. Used only for manufacturing tests. Pull down for normal operation.	I	2.5V CMOS w/pull-down	
RcvrInh	Receiver Inhibit. Used only for manufacturing tests. Pull up for normal operation.	I	5V tolerant 3.3V LVTTTL	2
DrvrInh1:2	Driver Inhibit 1 and 2. Used only for manufacturing tests. Pull up for normal operation.	I	5V tolerant 3.3V LVTTTL	2
TmrClk	An external clock input that can be used to clock the timers in the CPU core.	I	5V tolerant 3.3V LVTTTL	1
Trace Interface				
[TS1E]GPIO1 [TS2E]GPIO2	Even Trace execution status. To access this function, software must toggle a DCR bit or General Purpose I/O.	O[I/O]	5V tolerant 3.3V LVTTTL	1, 6
[TS1O]GPIO3	Odd Trace execution status. To access this function, software must toggle a DCR bit or General Purpose I/O.	O[I/O]	5V tolerant 3.3V LVTTTL	1
[TS2O]GPIO4	Odd Trace execution status. To access this function, software must toggle a DCR bit or General Purpose I/O.	O[I/O]	5V tolerant 3.3V LVTTTL	1, 6

Signal Functional Description (Part 8 of 8)

Multiplexed signals are shown in brackets following the first signal name assigned to each multiplexed ball.

Notes:

1. Receiver input has hysteresis.
2. Must pull up. See “Pull-Up and Pull-Down Resistors” on page 34 for recommended termination values.
3. Must pull down. See “Pull-Up and Pull-Down Resistors” on page 34 for recommended termination values.
4. If not used, must pull up.
5. If not used, must pull down.
6. Strapping input during reset; pull up or pull down as required.
7. Pull-up may be required. See “External Bus Control Signals” on page 34.

Signal Name	Description	I/O	Type	Notes
[TS3:6]GPIO5:8	Trace status. To access this function, software must toggle a DCR bit or General Purpose I/O.	O[I/O]	5V tolerant 3.3V LVTTTL	1
[TrcClk]GPIO9	Trace interface clock. A toggling signal that is always half of the CPU core frequency. To access this function, software must toggle a DCR bit or General Purpose I/O.	O[I/O]	5V tolerant 3.3V LVTTTL	1
Ground pins				
GND	Ground Note: On the 456-ball packages, L11-L16, M11-M16, N11-N16, P11-P16, R11-R16, and T11-T16 are also thermal balls. On the 413-ball package, J11, J13, K11-K13, L11-L13, M11-N13, N11-N13, P11-P13, R11, and R13 are also thermal balls.			
OV_{DD} pins				
OV _{DD}	Output driver voltage—3.3V.			
V_{DD} pins				
V _{DD}	Logic voltage—2.5V.			
Other pins				
Reserved	Reserved—Except for Y5 (on the 413-ball package) or AF4, do not connect signals, voltage, or ground to these pins. Y5 (on the 413-ball package) and AF4 must be tied to OV _{DD} or GND.			

Data Sheet**Absolute Maximum Ratings**

The absolute maximum ratings below are stress ratings only. Operation at or beyond these maximum ratings can cause permanent damage to the device

Characteristic	Symbol	Value	Unit
Supply Voltage (Internal Logic)	V_{DD}	0 to +2.7	V
Supply Voltage (I/O Interface)	OV_{DD}	0 to +3.6	V
PLL Supply Voltage	AV_{DD}	0 to +2.7	V
Input Voltage (2.5V CMOS receivers)	V_{IN}	-0.6 to $V_{DD} + 0.6$	V
Input Voltage (3.3V LVTTTL receivers)	V_{IN}	-0.6 to $OV_{DD} + 0.6$	V
Input Voltage (5.0V LVTTTL receivers)	V_{IN}	-0.6 to $OV_{DD} + 2.4$	V
Storage Temperature Range	T_{STG}	-55 to +150	°C
Case temperature under bias	T_C	-40 to +120	°C

Notes:

- All specified voltages are with respect to GND.

Package Thermal Specifications

The PPC405GP is designed to operate within a case temperature range of -40°C to +85°C. Thermal resistance values for the E-PBGA packages (lead and lead-free) in a convection environment are as follows:

Package—Thermal Resistance	Symbol	Airflow ft/min (m/sec)			Unit
		0 (0)	100 (0.51)	200 (1.02)	
35 mm, 456-balls—Junction-to-Case	θ_{JC}	2	2	2	°C/W
35 mm, 456-balls—Case-to-Ambient ¹	θ_{CA}	14	13	12	°C/W
27 mm, 456-balls—Junction-to-Case	θ_{JC}	2	2	2	°C/W
27 mm, 456-balls—Case-to-Ambient ¹	θ_{CA}	18	16	15	°C/W
25 mm, 413-balls—Junction-to-Case	θ_{JC}	1.5	1.5	1.5	°C/W
25 mm, 413-balls—Case-to-Ambient ¹	θ_{CA}	17	15	13	°C/W

Notes:

- For a chip mounted on a JEDEC 2S2P card without a heat sink.
- For a chip mounted on a card with at least one signal and two power planes, the following relationships exist:
 - Case temperature, T_C , is measured at top center of case surface with device soldered to circuit board.
 - $T_A = T_C - P \times \theta_{CA}$, where T_A is ambient temperature and P is power consumption.
 - $T_{CMax} = T_{JMax} - P \times \theta_{JC}$, where T_{JMax} is maximum junction temperature and P is power consumption.

Recommended DC Operating Conditions

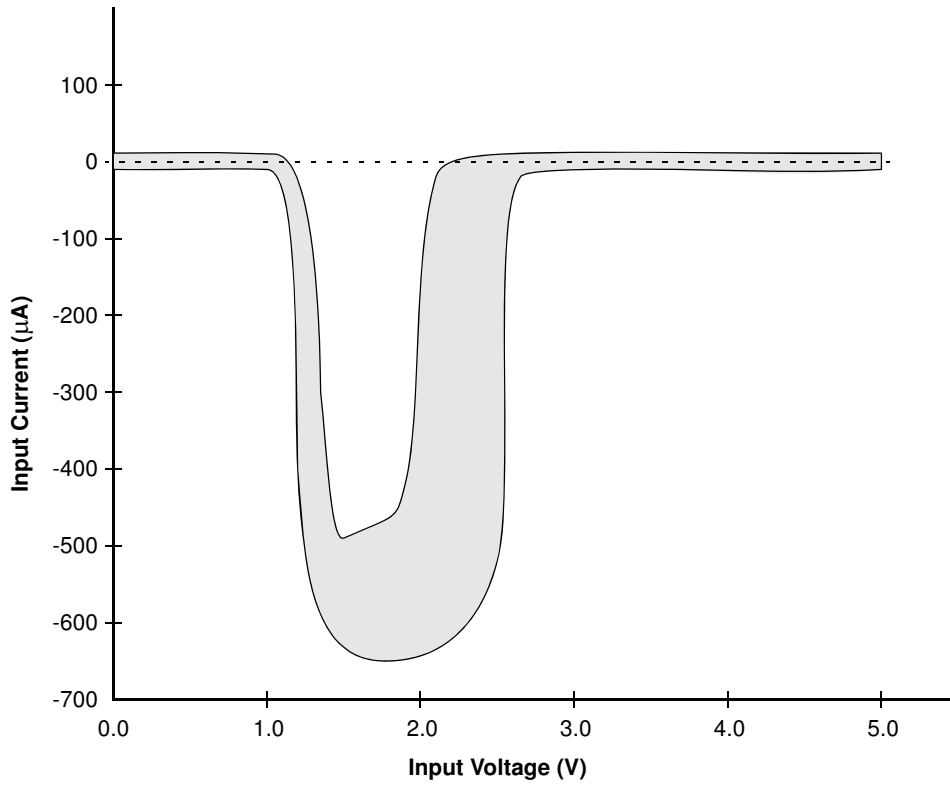
Device operation beyond the conditions specified is not recommended. Extended operation beyond the recommended conditions can affect device reliability.

Notes:

1. PCI drivers meet PCI specifications.
2. See “5V-Tolerant Input Current” on page 45.

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Notes
Logic Supply Voltage	V_{DD}	2.3	2.5	2.7	V	
I/O Supply Voltage	OV_{DD}	3.0	3.3	3.6	V	
PLL Supply Voltage	AV_{DD}	2.3	2.5	2.7	V	
Input Logic High (2.5V CMOS receivers)	V_{IH}	1.7		V_{DD}	V	
Input Logic High (3.3V LVTTTL receivers)	V_{IH}	2.0		OV_{DD}	V	
Input Logic High (5.0V LVTTTL receivers)	V_{IH}	2.0		5.0	V	
Input Logic Low (2.5V CMOS receivers)	V_{IL}	0		0.7	V	
Input Logic Low (3.3/5.0V LVTTTL receivers)	V_{IL}	0		0.8	V	
Output Logic High	V_{OH}	2.4		OV_{DD}	V	
Output Logic Low	V_{OL}	0		0.4	V	
3.3V I/O Input Current (no pull-up or pull-down)	I_{IL1}			± 10	μA	
Input Current (with internal pull-down)	I_{IL2}	± 10 (@ 0V)		400 (@ V_{DD})	μA	
5V Tolerant I/O Input Current	I_{IL4}	± 10		-650	μA	2
Input Max Allowable Overshoot (2.5V CMOS receivers)	V_{IMAO25}			$V_{DD} + 0.6$	V	
Input Max Allowable Overshoot (3.3V LVTTTL receivers)	V_{IMAO3}			$OV_{DD} + 0.6$	V	
Input Max Allowable Overshoot (5.0V LVTTTL receivers)	V_{IMAO5}			5.5	V	
Input Max Allowable Undershoot	V_{IMAU}	-0.6			V	
Output Max Allowable Overshoot	V_{OMAO}			$OV_{DD} + 0.3$	V	
Output Max Allowable Undershoot	V_{OMAU3}	-0.6			V	
Case Temperature	T_C	-40		+85	$^{\circ}C$	

5V-Tolerant Input Current



Input Capacitance

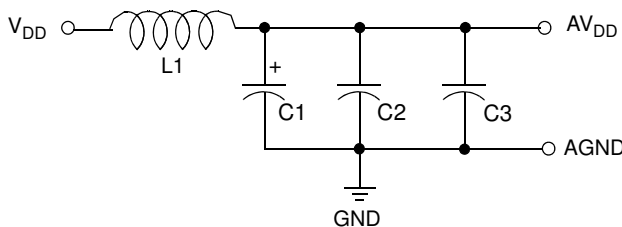
Parameter	Symbol	Maximum	Unit	Notes
3.3V LVTTTL I/O	C _{IN1}	5.5	pF	
5V tolerant LVTTTL I/O	C _{IN2}	5	pF	
PCI I/O	C _{IN3}	7	pF	
Rx only pins	C _{IN4}	4	pF	

DC Electrical Characteristics

Parameter	Symbol	Typical	Maximum	Unit
Active Operating Current (V _{DD})–133MHz	I _{DD}	TBD	TBD	mA
Active Operating Current (V _{DD})–200MHz	I _{DD}	550	670	mA
Active Operating Current (V _{DD})–266 MHz	I _{DD}	730	880	mA
Active Operating Current (OV _{DD})–133MHz	I _{ODD}	TBD	TBD	mA
Active Operating Current (OV _{DD})–200MHz	I _{ODD}	35	37	mA
Active Operating Current (OV _{DD})–266 MHz	I _{ODD}	37	40	mA
PLL V _{DD} Input current	I _{PLL}	16	23	mA
Active Operating Power–133MHz	P _{DD}	TBD	TBD	W
Active Operating Power–200MHz	P _{DD}	1.5	2.0 ¹	W
Active Operating Power–266MHz	P _{DD}	2.0	2.6 ¹	W

Note:

- Maximum power is characterized at V_{DD} = +2.7V, OV_{DD} = +3.6V, T_C = +85°C, across the silicon process (worse case to best case), while running an application designed to maximize power consumption. The specifications at 200MHz correspond to CPU = 200 MHz, PLB = 100MHz, OPB = EBC = 50MHz, PCI = 33.3MHz. The specifications at 266MHz correspond to CPU = 266.6MHz, PLB = 133.3MHz, OPB = EBC = 66.6MHz, and PCI = 33.3MHz.
- AV_{DD} should be derived from V_{DD} using the following circuit:

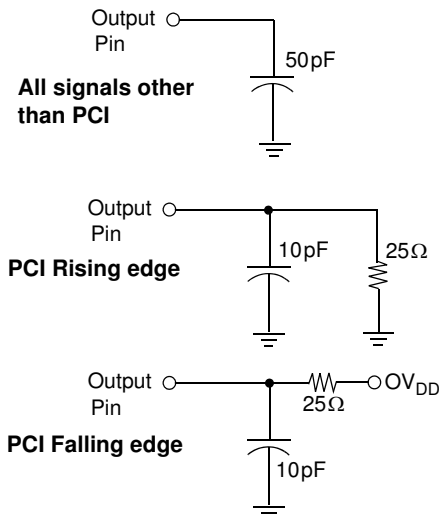


- L1 – 2.2µH SMT inductor (equivalent to MuRata LQH3C2R2M34) or SMT chip ferrite bead (equivalent to MuRata BLM31A700S)
- C1 – 3.3 µF SMT tantalum
- C2 – 0.1 µF SMT monolithic ceramic capacitor with X7R dielectric or equivalent
- C3 – 0.01 µF SMT monolithic ceramic capacitor with X7R dielectric or equivalent

Test Conditions

Clock timing and switching characteristics are specified in accordance with operating conditions shown in the table “Recommended DC Operating Conditions.” For all signals other than PCI signals, AC specifications are characterized at OV_{DD} = +3V and T_C = +85°C with the 50pF test load shown in the figure at right.

For PCI signals there are two different test load circuits, one for the rising edge and one the falling edge as shown in the figures at right.

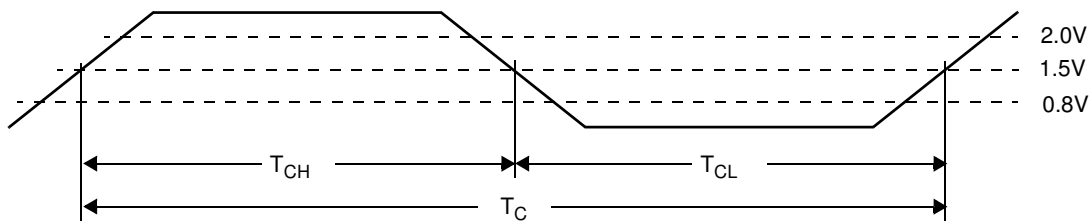


Data Sheet

Clocking Specifications

Symbol	Parameter	Min	Max	Units
CPU				
PF_C	Processor clock frequency		133.33/200/266.66	MHz
PT_C	Processor clock period	7.5/5/3.75		ns
SysClk Input				
SCF_C	Clock input frequency	25	66.66	MHz
SCT_C	Clock period	15	40	ns
SCT_{CS}	Clock edge stability (phase jitter, cycle to cycle)		± 0.15	ns
SCT_{CH}	Clock input high time	40% of nominal period	60% of nominal period	ns
SCT_{CL}	Clock input low time	40% of nominal period	60% of nominal period	ns
Note: Input slew rate > 2V/ns				
MemClkOut Output				
$MCOF_C$	Clock output frequency @ $PF_C = 133\text{MHz}$		66.66	MHz
$MCOT_C$	Clock period @ $PF_C = 133\text{MHz}$	15		ns
$MCOF_C$	Clock output frequency @ $PF_C = 200\text{MHz}$		100	MHz
$MCOT_C$	Clock period @ $PF_C = 200\text{MHz}$	10		ns
$MCOF_C$	Clock output frequency @ $PF_C = 266\text{MHz}$		133.33	MHz
$MCOT_C$	Clock period @ $PF_C = 266\text{MHz}$	7.5		ns
$MCOT_{CS}$	Clock edge stability (phase jitter, cycle to cycle)		± 0.2	ns
$MCOT_{CH}$	Clock output high time	45% of nominal period	55% of nominal period	ns
$MCOT_{CL}$	Clock output low time	45% of nominal period	55% of nominal period	ns
Other Clocks				
$VCOF_C$	VCO frequency	400	800	MHz
$PLBF_C$	PLB frequency @ $PF_C = 133\text{MHz}$		66.66	MHz
$PLBF_C$	PLB frequency @ $PF_C = 200\text{MHz}$		100	MHz
$PLBF_C$	PLB frequency @ $PF_C = 266\text{MHz}$		133.33	MHz
$OPBF_C$	OPB frequency @ $PF_C = 133\text{MHz}$		33.33	MHz
$OPBF_C$	OPB frequency @ $PF_C = 200\text{MHz}$		50	MHz
$OPBF_C$	OPB frequency @ $PF_C = 266\text{MHz}$		66.66	MHz

Clocking Waveform



Spread Spectrum Clocking

Care must be taken when using a spread spectrum clock generator (SSCG) with the PPC405GP. This controller uses a PLL for clock generation inside the chip. The accuracy with which the PLL follows the SSCG is referred to as tracking skew. The PLL bandwidth and phase angle determine how much tracking skew there is between the SSCG and the PLL for a given frequency deviation and modulation frequency. When using an SSCG with the PPC405GP the following conditions must be met:

- The frequency deviation must not violate the minimum clock cycle time. Therefore, when operating the PPC405GP with one or more internal clocks at their maximum supported frequency, the SSCG can only lower the frequency.
- The maximum frequency deviation cannot exceed –3%, and the modulation frequency cannot exceed 40kHz. In some cases, on-board PPC405GP peripherals impose more stringent requirements (see Note 1).
- Use the peripheral bus clock (PerClk) for logic that is synchronous to the peripheral bus since this clock tracks the modulation.
- Use the SDRAM MemClkOut since it also tracks the modulation.

Please refer to the application note *Using a Spread Spectrum Clock Generator with the PowerPC 405GP* for additional details. This application note is available on the AMCC web site at <http://www.amcc.com>.

Notes:

1. The serial port baud rates are synchronous to the modulated clock. The serial port has a tolerance of approximately 1.5% on baud rate before framing errors begin to occur. The 1.5% tolerance assumes that the connected device is running at precise baud rates. If an external serial clock is used the baud rate is unaffected by the modulation.

2. Operation of the PPC405GP PCI Bridge is unaffected by the use of a SSCG.

For PCI frequencies of 33.33 MHz and below the PCI controller supports synchronous mode operation. This is accomplished by strapping the PPC405GP for synchronous mode PCI and connecting the PCI bus clock to the PPC405GP SysClk input. For 33.33 MHz signalling, the PCI specification has no limitation on the amount of frequency deviation or modulation that may be applied to the PCI clock. Therefore, the PPC405GP SSCG requirements stated above take precedence.

At PCI frequencies above 33.33 MHz, the PCI controller must be operated in asynchronous mode. When in asynchronous mode, the PCI bus clock must be driven into the PPC405GP PCIClk input. In this configuration the PCI controller supports the 66.66 MHz PCI clock specification which specifies a maximum frequency deviation of -1% at a modulation of between 30 kHz and 33 kHz.

3. Ethernet operation is unaffected.

4. IIC operation is unaffected.

Caution: It is up to the system designer to ensure that any SSCG used with the PPC405GP meets the above requirements and does not adversely affect other aspects of the system.

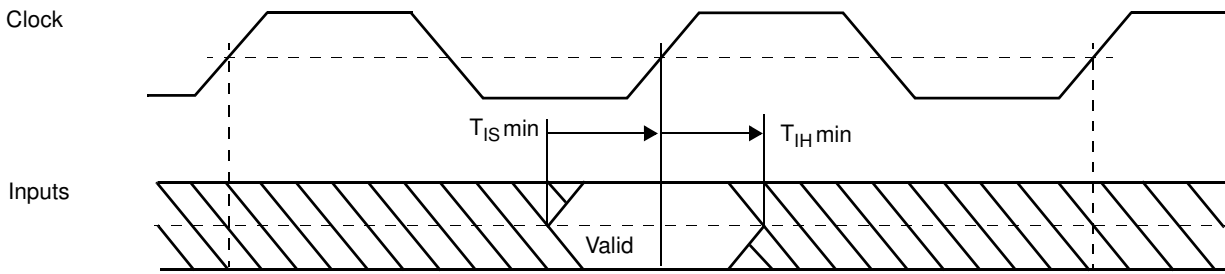
Data Sheet**Peripheral Interface Clock Timings**

Parameter	Min	Max	Units
PCIClk input frequency (asynchronous mode)	Note 1	66.66	MHz
PCIClk period (asynchronous mode)	15	Note 1	ns
PCI Clock frequency (synchronous mode)	25	33.33	MHz
PCI Clock period (synchronous mode - Note 2)	30	40	ns
PCIClk input high time	40% of nominal period	60% of nominal period	ns
PCIClk input low time	40% of nominal period	60% of nominal period	ns
EMCMDClk output frequency	–	2.5	MHz
EMCMDClk period	400	–	ns
EMCMDClk output high time	160	–	ns
EMCMDClk output low time	160	–	ns
PHYTxClk input frequency	2.5	25	MHz
PHYTxClk period	40	400	ns
PHYTxClk input high time	35% of nominal period	–	ns
PHYTxClk input low time	35% of nominal period	–	ns
PHYRxCIk input frequency	2.5	25	MHz
PHYRxCIk period	40	400	ns
PHYRxCIk input high time	35% of nominal period	–	ns
PHYRxCIk input low time	35% of nominal period	–	ns
PerClk output frequency–133MHz	–	33.33	MHz
PerClk period–133MHz	30	–	ns
PerClk output frequency–200MHz	–	50	MHz
PerClk period–200MHz	20	–	ns
PerClk output frequency–266MHz	–	66.66	MHz
PerClk period–266MHz	15	–	ns
PerClk output high time	45% of nominal period	55% of nominal period	ns
PerClk output low time	45% of nominal period	55% of nominal period	ns
PerClk clock edge stability (phase jitter, cycle to cycle)		± 0.3	ns
UARTSerClk input frequency (Note 3)	–	$1000/(2T_{OPB}+2ns)$	MHz
UARTSerClk period	$2T_{OPB}+2$	–	ns
UARTSerClk input high time	$T_{OPB}+1$	–	ns
UARTSerClk input low time	$T_{OPB}+1$	–	ns
TmrClk input frequency–133MHz	–	33.33	MHz
TmrClk period–133MHz	30	–	ns
TmrClk input frequency–200MHz	–	50	MHz
TmrClk period–200MHz	20	–	ns
TmrClk input frequency–266MHz	–	66.66	MHz
TmrClk period–266MHz	15	–	ns
TmrClk input high time	40% of nominal period	60% of nominal period	ns
TmrClk input low time	40% of nominal period	60% of nominal period	ns

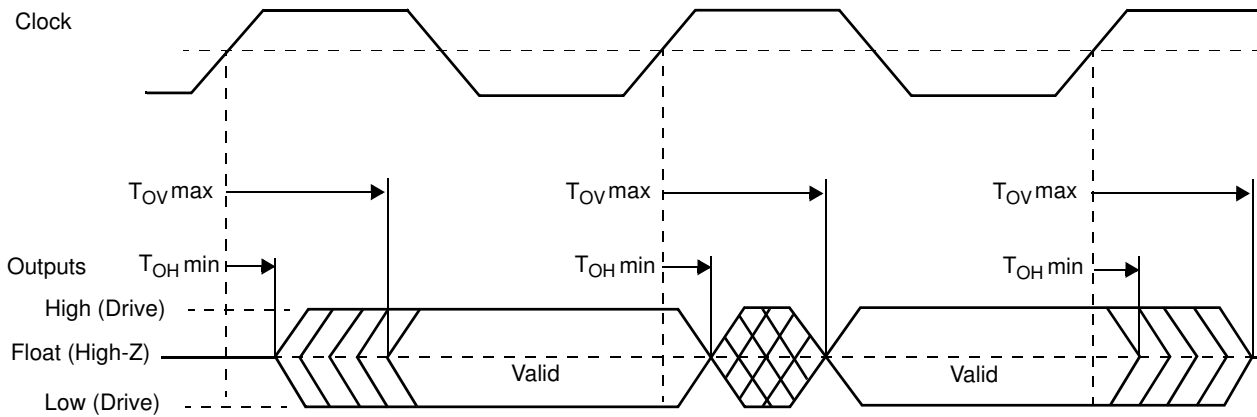
Note:

1. In asynchronous PCI mode the minimum PCIClk frequency is 1/8 the PLB Clock. Refer to the *PowerPC 405GP Embedded Processor User's Manual* for more information.
2. In synchronous PCI mode the PCI clock is derived from SysClk and the PCIClk input pin is unused.
3. T_{OPB} is the period in ns of the OPB clock. The maximum OPB clock frequency is 50 MHz for 200MHz parts and 66.66MHz for 266MHz parts.

Input Setup and Hold Waveform



Output Delay and Float Timing Waveform



Data Sheet

- Notes:** 1. In all of the following I/O Specifications tables a timing values of “na” means “not applicable” and “dc” means “don’t care.”
2. See “Test Conditions” on page 46 for output capacitive loading.

I/O Specifications—All speeds (Part 1 of 2)**Notes:**

1. PCI timings are for operation up to 66.66MHz. PCI output hold time requirement is 1 ns for 66.66MHz and 2ns for 33.33MHz. In synchronous mode, timing is relative to SysClk. In asynchronous mode, timing is relative to PCIClk.
2. Ethernet interface meets timing requirements as defined by IEEE 802.3 standard.
3. For PCI, I/O H is specified at 0.90V_{DD} and I/O L is specified at 0.10V_{DD}. For all other interfaces, I/O H is specified at 2.4 V and I/O L is specified at 0.4 V.

Signal	Input (ns)		Output (ns)		Output Current (mA)		Clock	Notes
	Setup Time (T _{IS} min)	Hold Time (T _{IH} min)	Valid Delay (T _{Ov} max)	Hold Time (T _{OH} min)	I/O H (min)	I/O L (min)		
PCI Interface								
PCIA _{D31:0}	3	0	6	1	0.5	1.5	PCI Clock	1
PCIC _{3:0} [BE _{3:0}]	3	0	6	1	0.5	1.5	PCI Clock	1
PCIClk	dc	dc	na	na	na	na		async
PCIDevSel	3	0	6	1	0.5	1.5	PCI Clock	1
PCIFrame	3	0	6	1	0.5	1.5	PCI Clock	1
PCIGnt ₀ [Req] PCIGnt _{1:5}	na	na	6	1	0.5	1.5	PCI Clock	1
PCIIDSel	3	0	6	1	na	na	PCI Clock	1
PCIIINT[PerWE]	na	na	dc	dc	0.5	1.5	PCI Clock	async
PCIIIRDY	3	0	6	1	0.5	1.5	PCI Clock	1
PCIParity	3	0	6	1	0.5	1.5	PCI Clock	1
PCIPErr	3	0	6	1	0.5	1.5	PCI Clock	1
PCIReq ₀ [Gnt] PCIReq _{1:5}	5	0	na	na	na	na	PCI Clock	1
PCIReset	na	na	na	na	0.5	1.5	PCI Clock	
PCISErr	na	na	na	na	0.5	1.5	PCI Clock	
PCIS _{top}	3	0	6	1	0.5	1.5	PCI Clock	1
PCITRDY	3	0	6	1	0.5	1.5	PCI Clock	1
Ethernet Interface								
EMCMDClk	na	na	settable	2	9	6		2, async
EMCMDIO[PHYMDIO]	100	0	1 OPB clock period + 10ns	1 OPB clock period	9	6	EMCMDClk	2
EMCTxD _{3:0}	na	na	20	2	9	6	PHYTX	2
EMCTxEn	na	na	20	2	9	6	PHYTX	2
EMCTxErr	na	na	20	2	9	6	PHYTX	2
PHYCol					9	6		2, async
PHYCrS					9	6		2, async
PHYRxClk					na	na		2, async
PHYRx _{D3:0}	4	1	na	na	9	6	PHYRX	2
PHYRx _{DV}	4	1	na	na	9	6	PHYRX	2
PHYRxErr	4	1	na	na	9	6	PHYRX	2
PHYTxClk					na	na		2, async

I/O Specifications—All speeds (Part 2 of 2)

Notes:

1. PCI timings are for operation up to 66.66MHz. PCI output hold time requirement is 1 ns for 66.66MHz and 2ns for 33.33MHz. In synchronous mode, timing is relative to SysClk. In asynchronous mode, timing is relative to PCIClk.
2. Ethernet interface meets timing requirements as defined by IEEE 802.3 standard.
3. For PCI, I/O H is specified at 0.90V_{DD} and I/O L is specified at 0.10V_{DD}. For all other interfaces, I/O H is specified at 2.4 V and I/O L is specified at 0.4 V.

Signal	Input (ns)		Output (ns)		Output Current (mA)		Clock	Notes
	Setup Time (T _{IS} min)	Hold Time (T _{IH} min)	Valid Delay (T _{Ov} max)	Hold Time (T _{OH} min)	I/O H (min)	I/O L (min)		
Internal Peripheral Interface								
IIC_SCL	na	na	na	na	19	12		
IIC_SDA	na	na	na	na	19	12		
UART0_CTS	na	na			12	8		
UART0_DCD	na	na			12	8		
UART0_DSR	na	na			12	8		
UART0_DTR					12	8		
UART0_RI	na	na			12	8		
UART0_RTS			na	na	12	8		
UART0_Rx	na	na			12	8		
UART0_Tx			na	na	12	8		
UART1_RTS/ UART1_DTR			na	na	12	8		
UART1_DSR/ UART1_CTS	na	na			na	na		
UART1_Rx	na	na			na	na		
UART1_Tx			na	na	12	8		
UARTSerClk	na	na			na	na		
Interrupts Interface								
IRQ0:6[GPIO17:23]					12	8		
JTAG Interface								
TCK					na	na		async
TDI					na	na		async
TDO					12	8		async
TMS					na	na		async
TRST					na	na		async
System Interface								
Drvrlnh1:2	dc	dc	na	na	na	na		
GPIO1[TS1E] GPIO2[TS2E] GPIO3[TS1O] GPIO4[TS2O] GPIO5[TS3] GPIO6[TS4] GPIO7[TS5] GPIO8[TS6] GPIO9[TrcClk]					12	8		
Halt	dc	dc	na	na	na	na		async
Rcvrlnh	dc	dc	na	na	na	na		
SysClk			na	na	na	na		
SysErr			na	na	12	8		async
SysReset			10	1	12	8		async
TestEn	dc	dc	na	na	na	na		async
TmrClk	dc	dc	na	na	na	na		async

Data Sheet**I/O Specifications—133 and 200MHz****Notes:**

1. The SDRAM command interface is configurable through SDRAM0_TR[LDF] to provide a 2 to 4 cycle delay before the command is used by SDRAM.
2. SDRAM I/O timings are specified relative to a MemClkOut terminated into a lumped 10pF load.
3. SDRAM interface hold times are guaranteed at the PPC405GP package pin. System designers must use the PPC405GP IBIS model (available from www.amcc.com) to ensure their clock distribution topology minimizes loading and reflections, and that the relative delays on clock wiring do not exceed the delays on other SDRAM signal wiring.
4. PerClk rising edge at package pin with a 10pF load trails the internal PLB clock by approximately 0.8ns.
5. I/O H is specified at 2.4 V and I/O L is specified at 0.4 V.

Signal	Input (ns)		Output (ns)		Output Current (mA)		Clock	Notes
	Setup Time (T _{IS} min)	Hold Time (T _{IH} min)	Valid Delay (T _{OV} max)	Hold Time (T _{OH} min)	I/O H (minimum)	I/O L (minimum)		
SDRAM Interface								
BA1:0	na	na	7.5	1	19	12	MemClkOut	1, 2
BankSel3:0	na	na	6.2	1	19	12	MemClkOut	2
CAS	na	na	7.5	1	19	12	MemClkOut	1, 2
ClkEn0:1	na	na	5.2	1	40	25	MemClkOut	2
DQM0:3	na	na	6.1	1	19	12	MemClkOut	2
DQMCB	na	na	6.2	1	19	12	MemClkOut	2
ECC0:7	2	1	6.2	1	19	12	MemClkOut	2
MemAddr12:0	na	na	7.6	1	19	12	MemClkOut	1, 2
MemData0:31	2	1	6.3	1	19	12	MemClkOut	2
RAS	na	na	7.5	1	19	12	MemClkOut	1, 2
WE	na	na	7.5	1	19	12	MemClkOut	1, 2
External Slave Peripheral Interface								
DMAAck0:3	na	na	8	0	12	8	PerClk	
DMAReq0:3	5	1	na	na	na	na	PerClk	
EOT0:3/TC0:3	dc	dc	8	0	12	8	PerClk	
PerAddr0:31	4	1	10	0	19	12	PerClk	
PerBLast	4	1	8	0	12	8	PerClk	
PerCS0	na	na	8	0	12	8	PerClk	
PerCS1:7[GPIO10:16]	na	na	8	0	12	8	PerClk	
PerData0:31	6	1	10	0	19	12	PerClk	
PerOE	na	na	8	0	12	8	PerClk	
PerPar0:3	4	1	10	0	19	12	PerClk	
PerR/W	4	1	8	0	12	8	PerClk	
PerReady	9	1	na	na	na	na	PerClk	
PerWBE0:3	3	1	8	0	12	8	PerClk	
External Master Peripheral Interface								
BusReq	na	na	8	0	12	8	PerClk	
ExtAck	na	na	7	0	12	8	PerClk	
ExtReq	5	1	na	na	na	na	PerClk	
ExtReset	na	na	8	0	19	12	PerClk	
HoldAck	na	na	8	0	12	8	PerClk	
HoldPri	4	1	na	na	na	na	PerClk	
HoldReq	5	1	na	na	na	na	PerClk	
PerClk	na	na	0.9	0.7	19	12	PLB Clk	4
PerErr	3	1	na	na	na	na	PerClk	

I/O Specifications—266 MHz

Notes:

1. The SDRAM command interface is configurable through SDRAM0_TR[LDF] to provide a 2 to 4 cycle delay before the command is used by SDRAM.
2. SDRAM I/O timings are specified relative to a MemClkOut terminated into a lumped 10pF load.
3. SDRAM interface hold times are guaranteed at the PPC405GP package pin. System designers must use the PPC405GP IBIS model (available from www.amcc.com) to ensure their clock distribution topology minimizes loading and reflections, and that the relative delays on clock wiring do not exceed the delays on other SDRAM signal wiring.
4. PerClk rising edge at package pin with a 10pF load trails the internal PLB clock by approximately 0.8ns.
5. I/O H is specified at 2.4 V and I/O L is specified at 0.4 V.

Signal	Input (ns)		Output (ns)		Output Current (mA)		Clock	Notes
	Setup Time (T _{IS} min)	Hold Time (T _{IH} min)	Valid Delay (T _{OV} max)	Hold Time (T _{OH} min)	I/O H (maximum)	I/O L (minimum)		
SDRAM Interface								
BA1:0	na	na	5.7	1	19	12	MemClkOut	1, 2
BankSel3:0	na	na	4.8	1	19	12	MemClkOut	2
CAS	na	na	5.7	1	19	12	MemClkOut	1, 2
ClkEn0:1	na	na	4.2	1	40	25	MemClkOut	2
DQM0:3	na	na	4.8	1	19	12	MemClkOut	2
DQMCB	na	na	4.8	1	19	12	MemClkOut	2
ECC0:7	1.5	1	4.8	1	19	12	MemClkOut	2
MemAddr12:0	na	na	5.7	1	19	12	MemClkOut	1, 2
MemData0:31	1.5	1	4.9	1	19	12	MemClkOut	2
RAS	na	na	5.7	1	19	12	MemClkOut	1, 2
WE	na	na	5.7	1	19	12	MemClkOut	1, 2
External Slave Peripheral Interface								
DMAAck0:3	na	na	6	0	12	8	PerClk	
DMAReq0:3	4	1	na	na	na	na	PerClk	
EOT0:3/TC0:3	dc	dc	6	0	12	8	PerClk	
PerAddr0:31	3	1	7.2	0	19	12	PerClk	
PerBLast	3	1	6	0	12	8	PerClk	
PerCS0 PerCS1:7[GPIO10:16]	na	na	6	0	12	8	PerClk	
PerData0:31	5	1	7.2	0	19	12	PerClk	
PerOE	na	na	6	0	12	8	PerClk	
PerPar0:3	3	1	7.2	0	19	12	PerClk	
PerR/W	4	1	6	0	12	8	PerClk	
PerReady	6.5	1	na	na	na	na	PerClk	
PerWBE0:3	3	1	6	0	12	8	PerClk	
External Master Peripheral Interface								
BusReq	na	na	6	0	12	8	PerClk	
ExtAck	na	na	6	0	12	8	PerClk	
ExtReq	4	1	na	na	na	na	PerClk	
ExtReset	na	na	6	0	19	12	PerClk	
HoldAck	na	na	6	0	12	8	PerClk	
HoldPri	3	1	na	na	na	na	PerClk	
HoldReq	4	1	na	na	na	na	PerClk	
PerClk	na	na	0.9	0.7	19	12	PLB Clk	4
PerErr	3	1	na	na	na	na	PerClk	

Strapping

When the $\overline{\text{SysReset}}$ input is driven low by an external device (system reset), the state of certain I/O pins is read to enable default initial conditions prior to PPC405GP start-up. The actual capture instant is the nearest SysClk edge before the deassertion of reset. These pins must be strapped using external pull-up (logical 1) or pull-down (logical 0) resistors to select the desired default conditions. The recommended pull-up is $3\text{k}\Omega$ to +3.3V or $10\text{k}\Omega$ to +5V. The recommended pull-down is $1\text{k}\Omega$ to GND. These pins are use for strap functions only during reset. They are used for other signals during normal operation. The following table lists the strapping pins along with their functions and strapping options. The pin for the 456-ball package is listed first (for example, AF3), followed by the corresponding pin for the 413-ball package (for example, U8), which appears as AF3/U8. The signal names assigned to the pins for normal operation follow the pin numbers.

PPC405GP Strapping Pin Assignments (Part 1 of 2)

Function	Option	Ball Strapping		
		AF3/U8 UART0_Tx	AF2/T8 UART0_DTR	AD16/AB15 UART0_RTS
PLL Tuning ¹ for $6 \leq M \leq 7$ use choice 3 for $7 < M \leq 12$ use choice 5 for $12 < M \leq 32$ use choice 6	Choice 1; TUNE[5:0] = 010001	0	0	0
	Choice 2; TUNE[5:0] = 111011	0	0	1
	Choice 3; TUNE[5:0] = 010011	0	1	0
	Choice 4; TUNE[5:0] = 111101	0	1	1
	Choice 5; TUNE[5:0] = 010101	1	0	0
	Choice 6; TUNE[5:0] = 010110	1	0	1
	Choice 7; TUNE[5:0] = 111110	1	1	0
	Choice 8; TUNE[5:0] = 100100	1	1	1
PLL Forward Divider ²		D16/A17 DMAAck0	B15/B14 DMAAck1	
	Bypass mode	0	0	
	Divide by 3	0	1	
	Divide by 4	1	0	
PLL Feedback Divider ²		B14/A15 DMAAck2	C12/A8 DMAAck3	
	Divide by 1	0	0	
	Divide by 2	0	1	
	Divide by 3	1	0	
PLB Divider from CPU ²		P25/R23 EMCTxD3	L24/J22 EMCTxD2	
	Divide by 1	0	0	
	Divide by 2	0	1	
	Divide by 3	1	0	
OPB Divider from PLB ²		L25/K21 EMCTxD1	J26/F22 EMCTxD0	
	Divide by 1	0	0	
	Divide by 2	0	1	
	Divide by 3	1	0	
	Divide by 4	1	1	

PPC405GP Strapping Pin Assignments (Part 2 of 2)

Function	Option	Ball Strapping	
PCI Divider from PLB ^{2,3}		D18/A20 GPIO1[TS1E]	C20/C19 GPIO2[TS2E]
	Divide by 1	0	0
	Divide by 2	0	1
	Divide by 3	1	0
	Divide by 4	1	1
External Bus Divider from PLB ²		K25/K20 EMCTxErr	K23/J21 EMCTxEn
	Divide by 2	0	0
	Divide by 3	0	1
	Divide by 4	1	0
	Divide by 5	1	1
ROM Width		AC2/N3 UART1_Tx	AD2/N7 UART1_RTS/ UART1_DTR
	8-bit ROM	0	0
	16-bit ROM	0	1
	32-bit ROM	1	0
	Reserved	1	1
ROM Location		U2/P4 HoldAck	
	PPC405GP Peripheral Attach	0	
	PPC405GP PCI Attach	1	
PCI Asynchronous Mode Enable		Y3/U4 ExtAck	
	Synchronous PCI Mode	0	
	Asynchronous Mode	1	
PCI Arbiter Enable ³		AF18/AB18 GPIO4[TS2O]	
	Internal Arbiter Disabled	0	
	Internal Arbiter Enabled	1	

Note:

1. The tune bits adjust parameters that control PLL jitter. The recommended values minimize jitter for the PLL implemented in the PPC405GP. These bits are shown for information only; and do not require modification except in special clocking circumstances such as spread spectrum clocking. For details on the use of Spread Spectrum Clock Generators (SSCGs) with the PPC405GP, visit the technical documents area of the AMCC PowerPC web site.
2. Not all combinations of dividers produce valid operating configurations. Frequencies must be within the limits specified in "Clocking Specifications" on page 47. Further requirements are detailed in the Clocking chapter of the *PowerPC 405GP Embedded Processor User's Manual*.
3. Additional consideration must be given to pins that normally function as Trace signals. Improved design margin can be gained by using three-state buffers instead of strapping resistors, and minimizing trace lengths and stubs.

Data Sheet**Revision Log**

Date	Contents of Modification
02/12/2003	Timing diagram update
04/14/2003	Update legal statements regarding document status.
06/19/2003	Add 133 MHz part numbers.
12/02/2004	Update to AMCC format.
01/06/2005	Add lead-free PNs. Correct typographical error in 27 mm package drawing.
03/13/2007	Revise package drawings to add logo view. Update AMCC address and copyright date on last page.
09/07/2007	Change TestEn signal from active low to active high. Correct AMCC telephone numbers.

Printed in the United States of America, September 2007

The following are trademarks of AMCC in the United States, or other countries, or both:

AMCC

Other company, product, and service names may be trademarks or service marks of others.

The information contained in this document is subject to change or withdrawal at any time without notice and is being provided on an "AS IS" basis without warranty or indemnity of any kind, whether express or implied, including without limitation, the implied warranties of non-infringement, merchantability, or fitness for a particular purpose. Any products, services, or programs discussed in this document are sold or licensed under AMCC's standard terms and conditions, copies of which may be obtained from your local AMCC representative. Nothing in this document shall operate as an express or implied license or indemnity under the intellectual property rights of AMCC or third parties.

Without limiting the generality of the foregoing, any performance data contained in this document was determined in a specific or controlled environment and not submitted to any formal AMCC test. Therefore, the results obtained in other operating environments may vary significantly. Under no circumstances will AMCC be liable for any damages whatsoever arising out of or resulting from any use of the document or the information contained herein.



Applied Micro Circuits Corporation
215 Moffett Park Drive, Sunnyvale, CA 94089
Phone: (408) 542-8600 — (800) 840-6055 — Fax: (408) 542-8601
<http://www.amcc.com>

AMCC reserves the right to make changes to its products, its datasheets, or related documentation, without notice and warrants its products solely pursuant to its terms and conditions of sale, only to substantially comply with the latest available datasheet. Please consult AMCC's Term and Conditions of Sale for its warranties and other terms, conditions and limitations. AMCC may discontinue any semiconductor product or service without notice, and advises its customers to obtain the latest version of relevant information to verify, before placing orders, that the information is current. AMCC does not assume any liability arising out of the application or use of any product or circuit described herein, neither does it convey any license under its patent rights nor the rights of others. AMCC reserves the right to ship devices of higher grade in place of those of lower grade.

AMCC SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, INTENDED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT APPLICATIONS, DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS.

AMCC is a registered Trademark of Applied Micro Circuits Corporation. Copyright © 2007 Applied Micro Circuits Corporation.