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Understanding Embedded - Microprocessors

Embedded microprocessors are specialized computing chips designed to perform specific tasks within an embedded system. Unlike general-purpose microprocessors found in personal computers, embedded microprocessors are tailored for dedicated functions within larger systems, offering optimized performance, efficiency, and reliability. These microprocessors are integral to the operation of countless electronic devices, providing the computational power necessary for controlling processes, handling data, and managing communications.

Applications of Embedded - Microprocessors

Embedded microprocessors are utilized across a broad spectrum of applications, making them indispensable in

Details	
Product Status	Obsolete
Core Processor	PowerPC 603e
Number of Cores/Bus Width	1 Core, 32-Bit
Speed	266MHz
Co-Processors/DSP	-
RAM Controllers	SDRAM
Graphics Acceleration	No
Display & Interface Controllers	-
Ethernet	-
SATA	-
USB	-
Voltage - I/O	3.3V
Operating Temperature	0°C ~ 105°C (TA)
Security Features	-
Package / Case	357-BBGA
Supplier Device Package	357-PBGA (25x25)
Purchase URL	https://www.e-xfl.com/product-detail/nxp-semiconductors/mpc8241lvr266d

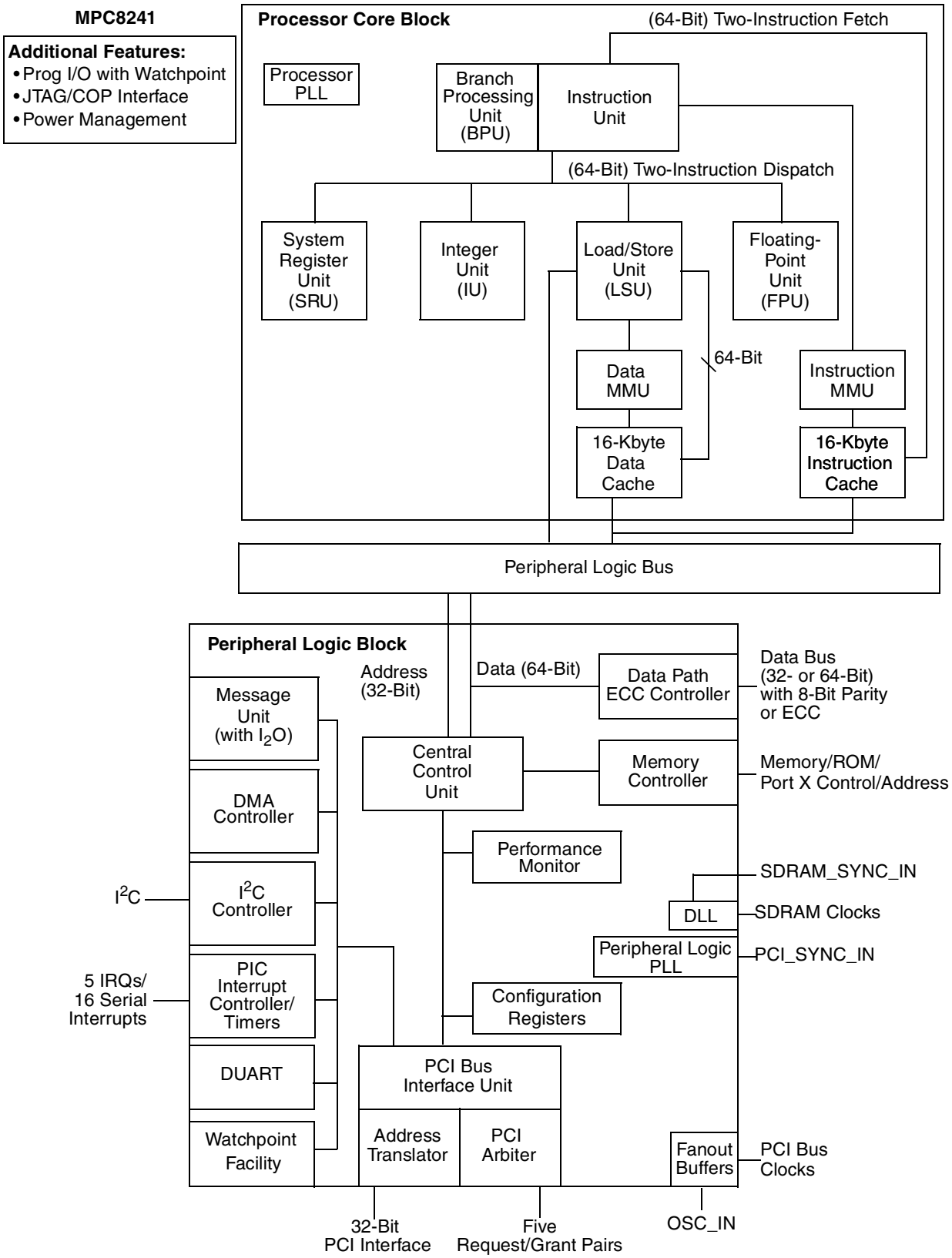


Figure 1. MPC8241 Block Diagram

  - I^2C controller with full master/slave support that accepts broadcast messages
  - Programmable interrupt controller (PIC)
    - Five hardware interrupts (IRQs) or 16 serial interrupts
    - Four programmable timers with cascade
  - Two (dual) universal asynchronous receiver/transmitters (UARTs)
  - Integrated PCI bus and SDRAM clock generation
  - Programmable PCI bus and memory interface output drivers
- System level performance monitor facility
- Debug features
  - Memory attribute and PCI attribute signals
  - Debug address signals
  - $\overline{\text{MIV}}$ signal—marks valid address and data bus cycles on the memory bus
  - Programmable input and output signals with watchpoint capability
  - Error injection/capture on data path
  - IEEE Std. 1149.1 (JTAG)/test interface

3 General Parameters

The following list summarizes the general parameters of the MPC8241:

Technology	0.25 µm CMOS, five-layer metal
Die size	49.2 mm^2
Transistor count	4.5 million
Logic design	Fully static
Packages	Surface-mount 357 (thick substrate and thick mold cap) plastic ball grid array (PBGA)
Core power supply	1.8 V ± 100 mV DC (nominal; see Table 2 for details and recommended operating conditions)
I/O power supply	3.0 to 3.6 V DC

4 Electrical and Thermal Characteristics

This section provides the AC and DC electrical specifications and thermal characteristics for the MPC8241.

4.1 DC Electrical Characteristics

This section covers ratings, conditions, and other characteristics.

4.1.1 Absolute Maximum Ratings

This section describes the MPC8241 DC electrical characteristics. Table 1 provides the absolute maximum ratings.

Table 1. Absolute Maximum Ratings

Characteristic [1]	Symbol	Range	Unit
Supply voltage—CPU core and peripheral logic	V_{DD}	–0.3 to 2.1	V
Supply voltage—memory bus drivers, PCI and standard I/O buffers	$GV_{DD\_}OV_{DD}$	–0.3 to 3.6	V
Supply voltage—PLLs	$AV_{DD}/AV_{DD}2$	–0.3 to 2.1	V
Supply voltage—PCI reference	LV_{DD}	–0.3 to 5.4	V
Input voltage [2]	V_{in}	–0.3 to 3.6	V
Operational die-junction temperature range	T_j	0 to 105	•C
Storage temperature range	T_{stg}	–55 to 150	•C

Notes:
1. Table 2 provides functional and tested operating conditions. Absolute maximum ratings are stress ratings only, and functional operation at the maximums is not guaranteed. Stresses beyond those listed may affect device reliability or cause permanent damage to the device.
2. PCI inputs with LV_{DD} = 5 V ± 5% V DC may be correspondingly stressed at voltages exceeding LV_{DD} + 0.5 V DC.

4.1.2 Recommended Operating Conditions

Table 2 provides the recommended operating conditions for the MPC8241.

Table 2. Recommended Operating Conditions [1]

Characteristic		Symbol	Recommended Value	Unit	Notes
Supply voltage		V_{DD}	1.8 ± 100 mV	V	2
I/O buffer supply for PCI and standard; supply voltages for memory bus drivers		$GV_{DD}\_OV_{DD}$	3.3 ± 0.3	V	2
CPU PLL supply voltage		AV_{DD}	1.8 ± 100 mV		2
PLL supply voltage—peripheral logic		$AV_{DD}2$	1.8 ± 100 mV	V	2
PCI reference		LV_{DD}	5.0 ± 5%	V	4, 5, 6
			3.3 ± 0.3	V	5, 6, 7
Input voltage	PCI inputs	V_{in}	0 to 3.6 or 5.75	V	4, 7
	All other inputs		0 to 3.6	V	8
Die-junction temperature		T_j	0 to 105	•C	

Notes:

1. Freescale has tested these operating conditions and recommends them. Proper device operation outside of these conditions is not guaranteed.
2. **Caution:** $GV_{DD}\_OV_{DD}$ must not exceed $V_{DD}/AV_{DD}/AV_{DD}2$ by more than 1.8 V at any time including during power-on reset. Note that $GV_{DD}\_OV_{DD}$ pins are all shorted together: This limit may be exceeded for a maximum of 20 ms during power-on reset and power-down sequences. Connections should not be made to individual PWRRING pins.
3. **Caution:** $V_{DD}/AV_{DD}/AV_{DD}2$ must not exceed $GV_{DD}\_OV_{DD}$ by more than 0.6 V at any time, including during power-on reset. This limit may be exceeded for a maximum of 20 ms during power-on reset and power-down sequences.
4. PCI pins are designed to withstand LV_{DD} + 0.5 V DC when LV_{DD} is connected to a 5.0 V DC power supply.
5. **Caution:** LV_{DD} must not exceed $V_{DD}/AV_{DD}/AV_{DD}2$ by more than 5.4 V at any time, including during power-on reset. This limit may be exceeded for a maximum of 20 ms during power-on reset and power-down sequences.
6. **Caution:** LV_{DD} must not exceed $GV_{DD}\_OV_{DD}$ by more than 3.0 V at any time, including during power-on reset. This limit may be exceeded for a maximum of 20 ms during power-on reset and power-down sequences.
7. PCI pins are designed to withstand LV_{DD} + 0.5 V DC when LV_{DD} is connected to a 3.3 V DC power supply.
8. **Caution:** Input voltage (V_{in}) must not be greater than the supply voltage ($V_{DD}/AV_{DD}/AV_{DD}2$) by more than 2.5 V at all times including during power-on reset. Input voltage (V_{in}) must not be greater than $GV_{DD}\_OV_{DD}$ by more than 0.6 V at all times including during power-on reset.

Table 3. DC Electrical Specifications (continued)

Characteristics	Conditions	Symbol	Min	Max	Unit	Notes
Capacitance	V_{in} = 0 V, f = 1 MHz	C_{in}	—	16.0	pF	

Notes:
1. See Table 16 for pins with internal pull-up resistors.
2. All grounded pins are connected together.
3. Leakage current is measured on input and output pins in the high-impedance state. The leakage current is measured for nominal GV_{DD}_OV_{DD}/LV_{DD} and V_{DD} or both GV_{DD}_OV_{DD}/LV_{DD} and V_{DD} must vary in the same direction.
4. See Table 4 for the typical drive capability of a specific signal pin based on the type of output driver associated with that pin as listed in Table 16.

4.2.1 Output Driver Characteristics

Table 4 provides information on the characteristics of the output drivers referenced in Table 16. The values are preliminary estimates from an IBIS model and are not tested.

Table 4. Drive Capability of MPC8241 Output Pins [5, 6]

Driver Type	Programmable Output Impedance (Ω)	Supply Voltage	I_{OH}	I_{OL}	Unit	Notes
DRV_STD_MEM	20 (default)	GV_{DD}_OV_{DD} = 3.3 V	36.6	18.0	mA	2, 4
	40		18.6	9.2	mA	2, 4
DRV_PCI	20		12.0	12.4	mA	1, 3
	40 (default)		6.1	6.3	mA	1, 3
DRV_MEM_CTRL DRV_PCI_CLK DRV_MEM_CLK	6 (default)		89.0	42.3	mA	2, 4
	20		36.6	18.0	mA	2, 4
	40		18.6	9.2	mA	2, 4

Notes:
1. For DRV_PCI, I_{OH} read from the IBIS listing in the pull-up mode, I(Min) column, at the 0.33-V label by interpolating between the 0.3- and 0.4-V table entries current values which corresponds to the PCI V_{OH} = 2.97 = 0.9 × GV_{DD}_OV_{DD} (GV_{DD}_OV_{DD} = 3.3 V) where table entry voltage = GV_{DD}_OV_{DD} – PCI V_{OH}.
2. For all others with GV_{DD}_ OV_{DD} = 3.3 V, I_{OH} read from the IBIS listing in the pull-up mode, I(Min) column, at the 0.9-V table entry which corresponds to the V_{OH} = 2.4 V where table entry voltage = GV_{DD}_OV_{DD} – V_{OH}.
3. For DRV_PCI, I_{OL} read from the IBIS listing in the pull-down mode, I(Min) column, at 0.33 V = PCI V_{OL} = 0.1 × GV_{DD}_OV_{DD} (GV_{DD}_OV_{DD} = 3.3 V) by interpolating between the 0.3- and 0.4-V table entries.
4. For all others with GV_{DD}_OV_{DD} = 3.3 V, I_{OL} read from the IBIS listing in the pull-down mode, I(Min) column, at the 0.4-V table entry.
5. See driver bit details for output driver control register (0x73) in the *MPC8245 Integrated Processor Reference Manual*.
6. See Chip Errata No. 19 in the *MPC8245/MPC8241 Integrated Processor Chip Errata*.

Table 8. Clock AC Timing Specifications (continued)

At recommended operating conditions (see Table 2) with LV_{DD} = 3.3 V ± 0.3 V

Num	Characteristics and Conditions	Min	Max	Unit	Notes
21	OSC_IN frequency stability	—	100	ppm	

Notes:

1. Rise and fall times for the PCI_SYNC_IN input are measured from 0.4 through 2.4 V.
2. Specification value at maximum frequency of operation.
3. Pin-to-pin skew includes quantifying the additional amount of clock skew (or jitter) from the DLL besides any intentional skew added to the clocking signals from the variable length DLL synchronization feedback loop, that is, the amount of variance between the internal *sys_logic_clk* and the SDRAM_SYNC_IN signal after the DLL is locked. While pin-to-pin skew between SDRAM_CLKs can be measured, the relationship between the internal *sys_logic_clk* and the external SDRAM_SYNC_IN cannot be measured and is guaranteed by design.
4. Relock time is guaranteed by design and characterization. Relock time is not tested.
5. Relock timing is guaranteed by design. PLL-relock time is the maximum amount of time required for PLL lock after a stable V_{DD} and PCI_SYNC_IN are reached during the reset sequence. This specification also applies when the PLL has been disabled and subsequently re-enabled during sleep mode. Also note that $\overline{\text{HRST\_CPU}}$/$\overline{\text{HRST\_CTRL}}$ must be held asserted for a minimum of 255 bus clocks after the PLL-relock time during the reset sequence.
6. DLL_EXTEND is bit 7 of the PMC2 register <72>. *N* is a non-zero integer (see Figure 7 through Figure 10). T_{clk} is the period of one SDRAM_SYNC_OUT clock cycle in ns. T_{loop} is the propagation delay of the DLL synchronization feedback loop (PC board runner) from SDRAM_SYNC_OUT to SDRAM_SYNC_IN in ns; 6.25 inches of loop length (unloaded PC board runner) corresponds to approximately 1 ns of delay. For details about how Figure 7 through Figure 10 may be used, refer to the Freescale application note AN2164, *MPC8245/MPC8241 Memory Clock Design Guidelines,* for details on MPC8241 memory clock design.
7. Rise and fall times for the OSC_IN input are guaranteed by design and characterization. OSC_IN input rise and fall times are not tested.

Figure 6 shows the PCI_SYNC_IN input clock timing diagram, and Figure 7 through Figure 10 show the DLL locking range loop delay versus frequency of operation.

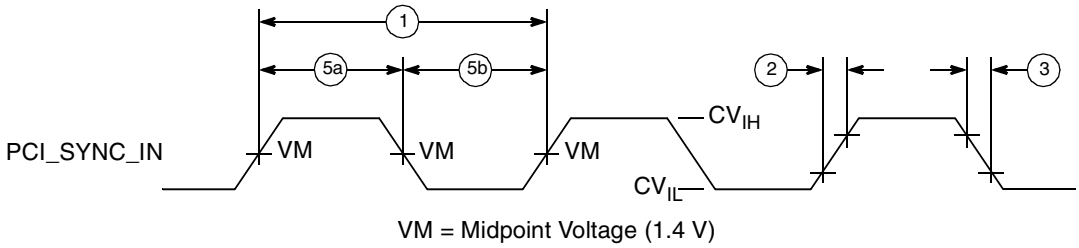


Figure 6. PCI_SYNC_IN Input Clock Timing Diagram

Table 11. Output AC Timing Specifications (continued)

Num	Characteristic	Min	Max	Unit	Notes
14b	*sys_logic_clk* to output high impedance (for all others)	—	4.0	ns	2

Notes:

1. All PCI signals are measured from $GV_{DD}\_OV_{DD}/2$ of the rising edge of PCI_SYNC_IN to $0.285 \times GV_{DD}\_OV_{DD}$ or $0.615 \times GV_{DD}\_OV_{DD}$ of the signal in question for 3.3 V PCI signaling levels. See Figure 12.
2. All memory and related interface output signal specifications are specified from the VM = 1.4 V of the rising edge of the memory bus clock, *sys_logic_clk* to the TTL level (0.8 or 2.0 V) of the signal in question. *sys_logic_clk* is the same as PCI_SYNC_IN in 1:1 mode, but is twice the frequency in 2:1 mode (processor/memory bus clock rising edges occur on every rising and falling edge of PCI_SYNC_IN). See Figure 11.
3. PCI bused signals are composed of the following signals: $\overline{\text{LOCK}}$, $\overline{\text{IRDY}}$, $\overline{\text{C/BE}}$[3:0], PAR, $\overline{\text{TRDY}}$, $\overline{\text{FRAME}}$, $\overline{\text{STOP}}$, $\overline{\text{DEVSEL}}$, $\overline{\text{PERR}}$, $\overline{\text{SERR}}$, AD[31:0], $\overline{\text{REQ}}$[4:0], $\overline{\text{GNT}}$[4:0], $\overline{\text{IDSEL}}$, and $\overline{\text{INTA}}$.
4. To meet minimum output hold specifications relative to PCI_SYNC_IN for both 33- and 66-MHz PCI systems, the MPC8241 has a programmable output hold delay for PCI signals (the PCI_SYNC_IN to output valid timing is also affected). The initial value of the output hold delay is determined by the values on the $\overline{\text{MCP}}$ and CKE reset configuration signals; the values on these two signals are inverted and subsequently stored as the initial settings of PCI_HOLD_DEL = PMCR2[5, 4] (power management configuration register 2 <0x72>), respectively. Because $\overline{\text{MCP}}$ and CKE have internal pull-up resistors, the default value of PCI_HOLD_DEL after reset is 0b00. Additional output hold delay values are available by programming the PCI_HOLD_DEL value of the PMCR2 configuration register. See Figure 15 for PCI_HOLD_DEL effect on output valid and hold time.

Figure 14 provides the AC test load for the MPC8241.

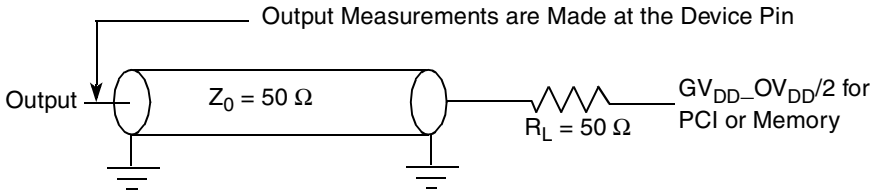


Figure 14. AC Test Load for the MPC8241

Table 12. I^2C DC Electrical Characteristics

At recommended operating conditions with OV_{DD} of 3.3 V ± 5%.

Pulse width of spikes which must be suppressed by the input filter	t_{I2KHKL}	0	50	ns	2
Input current each I/O pin (input voltage is between $0.1 \times OV_{DD}$ and $0.9 \times OV_{DD}$(max)	I_I	–10	10	µA	3
Capacitance for each I/O pin	C_I	—	10	pF	

Notes:

1. Output voltage (open drain or open collector) condition = 3 mA sink current.
2. Refer to the *MPC8245 Integrated Processor Reference Manual* for information on the digital filter used.
3. I/O pins obstruct the SDA and SCL lines if the OV_{DD} is switched off.

4.6.2 I^2C AC Electrical Specifications

Table 13 provides the AC timing parameters for the I^2C interfaces.

Table 13. I^2C AC Electrical Specifications

All values refer to V_{IH} (min) and V_{IL} (max) levels (see Table 12).

Parameter	Symbol [1]	Min	Max	Unit
SCL clock frequency	f_{I2C}	0	400	kHz
Low period of the SCL clock	t_{I2CL} [4]	1.3	—	µs
High period of the SCL clock	t_{I2CH} [4]	0.6	—	µs
Setup time for a repeated START condition	t_{I2SVKH} [4]	0.6	—	µs
Hold time (repeated) START condition (after this period, the first clock pulse is generated)	t_{I2SXKL} [4]	0.6	—	µs
Data setup time	t_{I2DVKH} [4]	100	—	ns
Data input hold time: CBUS compatible masters I^2C bus devices	t_{I2DXKL}	 — 0 [2]	 — —	µs
Data output delay time:	t_{I2OVKL}	—	0.9[3]	
Set-up time for STOP condition	t_{I2PVKH}	0.6	—	µs
Bus free time between a STOP and START condition	t_{I2KHDX}	1.3	—	µs
Noise margin at the LOW level for each connected device (including hysteresis)	V_{NL}	$0.1 \times OV_{DD}$	—	V

Table 13. I^2C AC Electrical Specifications (continued)

All values refer to V_{IH} (min) and V_{IL} (max) levels (see Table 12).

Parameter	Symbol [1]	Min	Max	Unit
Noise margin at the HIGH level for each connected device (including hysteresis)	V_{NH}	$0.2 \times OV_{DD}$	—	V

Note:

1. The symbols used for timing specifications herein follow the pattern of $t_{\text{(first two letters of functional block)(signal)(state) (reference)(state)}}$ for inputs and $t_{\text{(first two letters of functional block)(reference)(state)(signal)(state)}}$ for outputs. For example, t_{I2DVKH} symbolizes I^2C timing (I2) with respect to the time data input signals (D) reach the valid state (V) relative to the t_{I2C} clock reference (K) going to the high (H) state or setup time. Also, t_{I2SXKL} symbolizes I^2C timing (I2) for the time that the data with respect to the start condition (S) went invalid (X) relative to the t_{I2C} clock reference (K) going to the low (L) state or hold time. Also, t_{I2PVKH} symbolizes I^2C timing (I2) for the time that the data with respect to the stop condition (P) reaching the valid state (V) relative to the t_{I2C} clock reference (K) going to the high (H) state or setup time. For rise and fall times, the latter convention is used with the appropriate letter: R (rise) or F (fall).
2. As a transmitter, the MPC8245 provides a delay time of at least 300 ns for the SDA signal (referred to the Vihmin of the SCL signal) to bridge the undefined region of the falling edge of SCL to avoid the unintended generation of a Start or Stop condition. When the MPC8245 acts as the I^2C bus master while transmitting, it drives both SCL and SDA. As long as the load on SCL and SDA is balanced, the MPC8245 does not cause an unintended generation of a Start or Stop condition. Therefore, the 300 ns SDA output delay time is not a concern. If, under some rare condition, the 300 ns SDA output delay time is required for the MPC8245 as transmitter, the following setting is recommended for the FDR bit field of the I2CFDR register to ensure both the desired I^2C SCL clock frequency and SDA output delay time are achieved. It is assumed that the desired I^2C SCL clock frequency is 400 KHz and the digital filter sampling rate register (DFFSR bits in I2CFDR) is programmed with its default setting of 0x10 (decimal 16):

SDRAM Clock Frequency	100 MHz	133 MHz
FDR Bit Setting	0x00	0x2A
Actual FDR Divider Selected	384	896
Actual I^2C SCL Frequency Generated	260.4 KHz	148.4 KHz

   For details on I^2C frequency calculation, refer to the application note AN2919 “Determining the I^2C Frequency Divider Ratio for SCL”.
3. The maximum t_{I2DXKL} has only to be met if the device does not stretch the LOW period (t_{I2CL}) of the SCL signal.
4. Guaranteed by design

Figure 16 provides the AC test load for the I^2C.

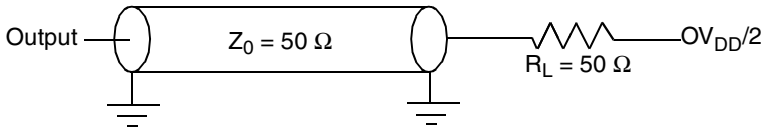


Figure 16. I^2C AC Test Load

Figure 17 shows the AC timing diagram for the I^2C bus.

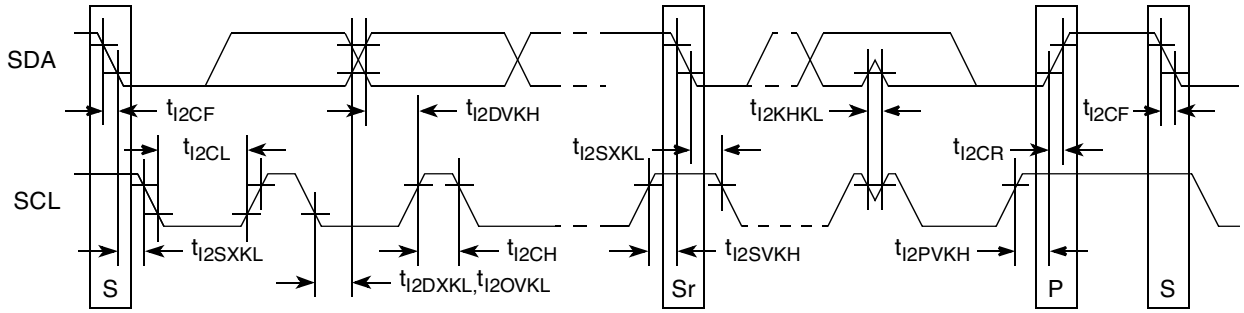


Figure 17. I^2C Bus AC Timing Diagram

4.7 PIC Serial Interrupt Mode AC Timing Specifications

Table 14 provides the PIC serial interrupt mode AC timing specifications for the MPC8241 at recommended operating conditions (see Table 2) with GV_{DD}–OV_{DD} = 3.3 V ± 5% and LV_{DD} = 3.3 V ± 0.3 V.

Table 14. PIC Serial Interrupt Mode AC Timing Specifications

Num	Characteristic	Min	Max	Unit	Notes
1	S_CLK frequency	1/14 SDRAM_SYNC_IN	1/2 SDRAM_SYNC_IN	MHz	1
2	S_CLK duty cycle	40	60	%	—
3	S_CLK output valid time	—	6	ns	—
4	Output hold time	0	—	ns	—
5	$\overline{\text{S\_FRAME}}$, S_RST output valid time	—	1 *sys_logic_clk* period + 6	ns	2
6	S_INT input setup time to S_CLK	1 *sys_logic_clk* period + 2	—	ns	2
7	S_INT inputs invalid (hold time) to S_CLK	—	0	ns	2

Notes:

1. See the *MPC8245 Integrated Processor Reference Manual* for a description of the PIC interrupt control register (ICR) and S_CLK frequency programming.
2. S_RST, $\overline{\text{S\_FRAME}}$, and S_INT shown in Figure 18 and Figure 19, depict timing relationships to *sys_logic_clk* and S_CLK and do not describe functional relationships between S_RST, $\overline{\text{S\_FRAME}}$, and S_INT. The *MPC8245 Integrated Processor Reference Manual* describes the functional relationships between these signals.
3. The *sys_logic_clk* waveform is the clocking signal of the internal peripheral logic from the output of the peripheral logic PLL; *sys_logic_clk* is the same as SDRAM_SYNC_IN when the SDRAM_SYNC_OUT to SDRAM_SYNC_IN feedback loop is implemented and the DLL is locked. See the *MPC8245 Integrated Processor Reference Manual* for a complete clocking description.

Figure 25 shows the top surface, side profile, and pinout of the MPC8241, 357 PBGA ZQ and VR packages.

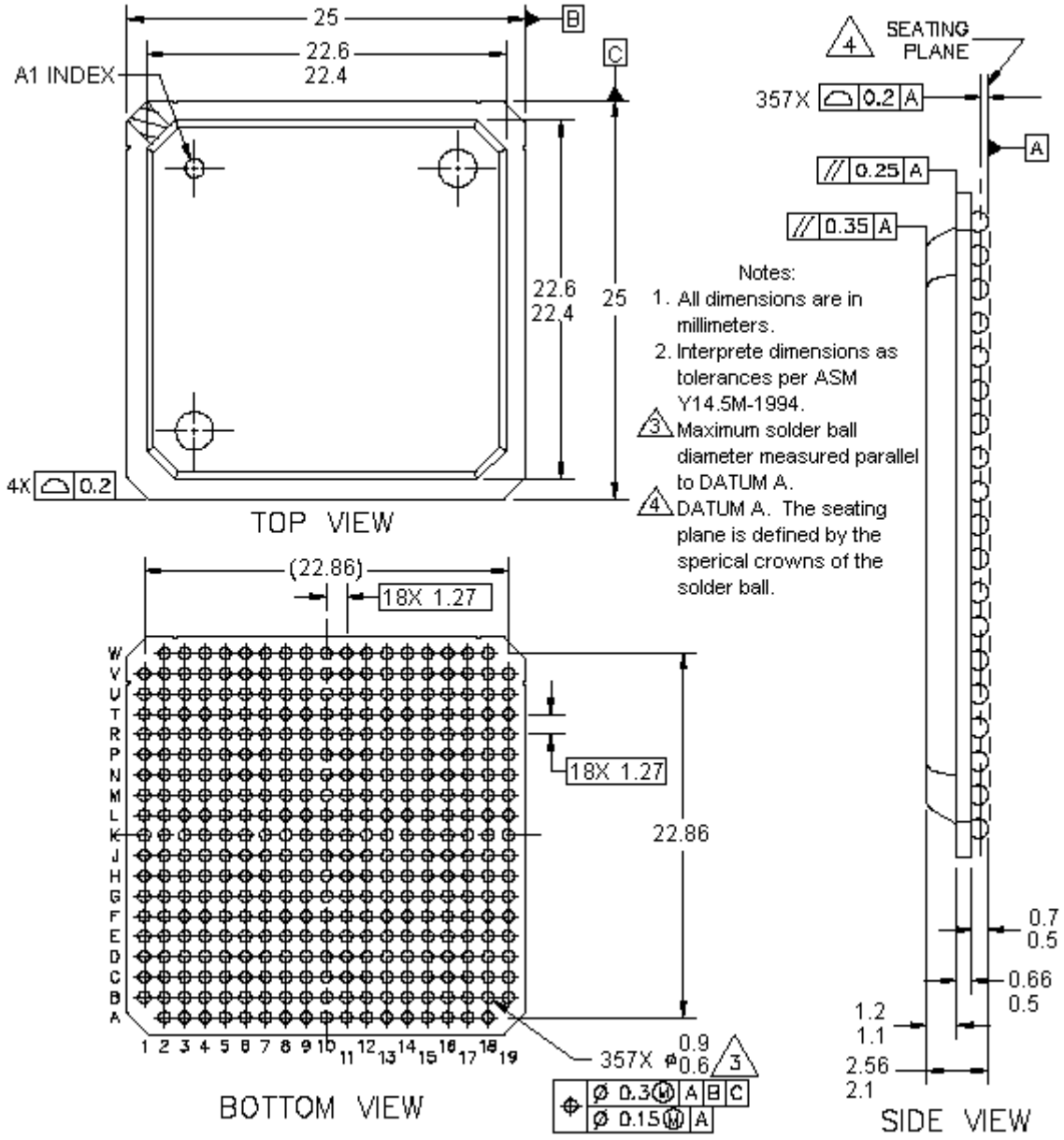


Figure 25. MPC8241 Package Dimensions and Pinout Assignments (ZQ and VR Packages)

Table 16. MPC8241 Pinout Listing (continued)

Signal Name	Package Pin Number	Pin Type	Power Supply	Output Driver Type	Notes
TMS	T18	Input	GV_{DD}_OV_{DD}	—	6, 13
$\overline{TRST}$	R16	Input	GV_{DD}_OV_{DD}	—	6, 13
Power and Ground Signals					
GNDRING/GND	F07 F08 F09 F10 F11 F12 F13 G07 G08 G09 G10 G11 G12 G13 H07 H08 H09 H10 H11 H12 H13 J07 J08 J09 J10 J11 J12 J13 K07 K08 K09 K10 K11 K12 K13 L07 L08 L09 L10 L11 L12 L13 M07 M08 M09 M10 M11 M12 M13 N07 N08 N09 N10 N11 N12 N13 P08 P09 P10 P11 P12 P13 R15	Ground	—	—	17
LV_{DD}	R18 U18 T1 U4 T6 W11 T14	Reference voltage 3.3 V, 5.0 V	LV_{DD}	—	—
GV_{DD}_OV_{DD}/PWRRING	D09 D10 D11 E06 E07 E08 E09 E10 E11 E12 E13 E14 F06 F14 G06 G14 H06 H14 J06 J14 K06 K14 L06 L14 M06 M14 N06 N14 P06 P07 P14 R08 R09 R10 R11 R12	Power for memory drivers and PCI/Stnd 3.3 V	GV_{DD}_OV_{DD}	—	18
V_{DD}	F03 H3 L5 N4 P5 V5 U8 W12 W16 R13 P19 L19 H19 F19 F15 C15 A13 A8 B5 A2	Power for core 1.8 V	V_{DD}	—	—
No Connect	N5 W2 B1	—	—	—	—
AV_{DD}	M5	Power for PLL (CPU core logic) 1.8 V	AV_{DD}	—	—
$AV_{DD}2$	R14	Power for PLL (peripheral logic) 1.8 V	$AV_{DD}2$	—	—
Debug/Manufacturing Pins					
DA0/$\overline{QACK}$	A3	Output	GV_{DD}_OV_{DD}	DRV_STD_MEM	5, 11, 12
DA1/CKO	L1	Output	GV_{DD}_OV_{DD}	DRV_STD_MEM	5
DA2	R5	Output	GV_{DD}_OV_{DD}	DRV_PCI	19
DA3/PCI_CLK4	V17	Output	GV_{DD}_OV_{DD}	DRV_PCI_CLK	5
DA4/$\overline{REQ4}$	W13	I/O	GV_{DD}_OV_{DD}	—	5, 6
DA5/$\overline{GNT4}$	T11	Output	GV_{DD}_OV_{DD}	DRV_PCI	2, 4, 5

Table 16. MPC8241 Pinout Listing (continued)

Signal Name	Package Pin Number	Pin Type	Power Supply	Output Driver Type	Notes
DA[10:6]/ PLL_CFG[0:4]	N3 N2 N1 M4 M3	I/O	GV_{DD}_OV_{DD}	—	1, 5, 20
DA[11]	T13	Output	GV_{DD}_OV_{DD}	DRV_PCI	1, 19
DA[12:13]	M16 N16	Output	GV_{DD}_OV_{DD}	DRV_STD_MEM	19
DA[14:15]	B6 D8	Output	GV_{DD}_OV_{DD}	DRV_MEM_CTRL	1, 19

Notes:

1. Multi-pin signals such as AD[31:0] or MDL[0:31] physical package pin numbers are listed in order corresponding to the signal names. Ex: AD0 is on pin U1, AD1 is on pin U2,..., AD31 is on pin U13.
2. This pin is affected by a programmable PCI_HOLD_DEL parameter.
3. A weak pull-up resistor (2–10 kΩ) should be placed on this PCI control pin to LV_{DD}.
4. $\overline{\text{GNT4}}$ is a reset configuration pin with an internal pull-up resistor that is enabled only when in the reset state.
5. This pin is a multiplexed signal and appears more than once in this table.
6. This pin has an internal pull-up resistor that is enabled at all times. The value of the internal pull-up resistor is not guaranteed, but is sufficient to prevent unused inputs from floating.
7. This pin is a sustained three-state pin as defined by the *PCI Local Bus Specification* (Rev. 2.2).
8. This pin is an open-drain signal.
9. DL[0] is a reset configuration pin with an internal pull-up resistor that is enabled only when in the reset state. The value of the internal pull-up resistor is not guaranteed, but is sufficient to ensure that a logic 1 is read into configuration bits during reset.
10. This pin has an internal pull-up resistor that is enabled only when in the reset state. The value of the internal pull-up resistor is not guaranteed, but is sufficient to ensure that a logic 1 is read into configuration bits during reset.
11. This pin is a reset configuration pin.
12. A weak pull-up resistor (2–10 kΩ) should be placed on this pin to GV_{DD}_OV_{DD}.
13. V_{IH} and V_{IL} for these signals are the same as the PCI V_{IH} and V_{IL} entries in Table 3.
14. External PCI clocking source or fanout buffer may be required for system if using the MPC8241 DUART functionality because PCI_CLK[0:3] are not available in DUART mode. Only PCI_CLK4 is available in DUART mode.
15. OSC_IN uses the 3.3-V PCI interface driver, which is 5-V tolerant. See Table 2 for details.
16. This pin can be programmed as driven (default) or as open-drain (in MIOCR 1).
17. All grounded pins are connected together. Connections should not be made to individual pins. The list represents the balls that are connected to ground.
18. GV_{DD}_OV_{DD} must not exceed V_{DD}/AV_{DD}/AV_{DD}2 by more than 1.8 V at any time including during power-on reset. Note that GV_{DD}_OV_{DD} pins are all shorted together, PWRRING. The list represents the balls that are connected to PWRRING. Connections should not be made to individual PWRRING pins.
19. Treat these pins as no connects unless debug address functionality is used.
20. PLL_CFG signals must be driven on reset and must be held for at least 25 clock cycles after the negation of $\overline{\text{HRST\_CTRL}}$ and $\overline{\text{HRST\_CPU}}$ in order to be latched.
21. Place a pull-up resistor of 120 Ω or less on the $\overline{\text{TEST0}}$ pin.
22. SDRAM_CLK[0:3] and SDRAM_SYNC_OUT signals use DRV_MEM_CTRL for chip Rev. 1.1 (A). These signals use DRV_MEM_CLK for chip Rev. 1.2B.
23. The driver capability of this pin is hardwired to 40 Ω and cannot be changed.
24. Freescale typically expects that customers using the serial port will have sufficient drivers available in the RS232 transceiver to drive the $\overline{\text{CTS}}$ pin actively as an input if they are using that mode. No pullups would be needed in these circumstances.
25. $\overline{\text{HRST\_CPU}}$/$\overline{\text{HRST\_CTRL}}$ must transition from a logic 0 to a logic 1 in less than one SDRAM_SYNC_IN clock cycle for the device to be in the nonreset state

Table 17. PLL Configurations (166- and 200-MHz) (continued)

Ref [2]	PLL_CFG [0:4] [1]	166 MHz-Part [2]			200-MHz Part [2]			Multipliers	
		PCI Clock Input (PCI_SYNC_IN) Range [3] (MHz)	Peripheral Logic/ Mem Bus Clock Range (MHz)	CPU Clock Range (MHz)	PCI Clock Input (PCI_SYNC_IN) Range [3] (MHz)	Peripheral Logic/ Mem Bus Clock Range (MHz)	CPU Clock Range (MHz)	PCI-to-Mem (Mem VCO)	Mem-to-CPU (CPU VCO)
1E	11110[14]	Not usable			Not usable			Off	Off
1F	11111[14]	Not usable			Not usable			Off	Off

Notes:

1. PLL_CFG[0:4] settings not listed are reserved. Bits 7–4 of register offset <0xE2> contain the PLL_CFG[0:4] setting value. Note the impact of the relevant revisions for mode 7.
2. Range values are shown rounded down to the nearest whole number (decimal place accuracy removed) for clarity.
3. Limited by maximum PCI input frequency (66 MHz).
4. Limited by minimum CPU VCO frequency (300 MHz).
5. Limited by maximum CPU operating frequency.
6. In PLL bypass mode, the PCI_SYNC_IN input signal clocks the internal processor directly, the peripheral logic PLL is disabled, and the bus mode is set for 1:1 (PCI:Mem) mode operation. This mode is intended for hardware modeling. The AC timing specifications in this document do not apply in PLL bypass mode.
7. Limited by minimum CPU operating frequency (100 MHz).
8. Limited due to maximum memory VCO frequency (352 MHz).
9. In dual PLL bypass mode, the PCI_SYNC_IN input signal clocks the internal peripheral logic directly, the peripheral logic PLL is disabled, and the bus mode is set for 1:1 (PCI_SYNC_IN:Mem) mode operation. In this mode, the OSC_IN input signal clocks the internal processor directly in 1:1 (OSC_IN:CPU) mode operation, and the processor PLL is disabled. The PCI_SYNC_IN and OSC_IN input clocks must be externally synchronized. This mode is intended for hardware modeling. The AC timing specifications in this document do not apply in dual PLL bypass mode.
10. Limited by maximum CPU VCO frequency (704 MHz).
11. Limited by maximum system memory interface operating frequency (83 MHz @ 166 MHz CPU bus speed).
12. Limited by maximum system memory interface operating frequency (100 MHz @ 200 MHz CPU bus speed).
13. Limited by minimum memory VCO frequency (132 MHz).
14. In clock off mode, no clocking occurs inside the MPC8241, regardless of the PCI_SYNC_IN input.

Table 18. PLL Configurations (266-MHz Parts)

Ref [2]	PLL_CFG[0:4] [10,11]	266-MHz Part [9]			Multipliers	
		PCI Clock Input (PCI_SYNC_IN) Range [1] (MHz)	Periph Logic/ Mem Bus Clock Range (MHz)	CPU Clock Range (MHz)	PCI-to-Mem (Mem VCO)	Mem-to-CPU (CPU VCO)
0	00000	25–35[5]	75–105	188–263	3 (2)	2.5 (2)
1	00001	25–29[5]	75–88	225–264	3 (2)	3 (2)
2	00010	50[15]–59[5]	50–59	225–266	1 (4)	4.5 (2)
3	00011[12]	50[14]–66[1]	50–66	100–133	1 (Bypass)	2 (4)
4	00100	25–44[4]	50–88	100–176	2 (4)	2 (4)

7.4 Pull-Up/Pull-Down Resistor Requirements

The data bus input receivers are normally turned off when no read operation is in progress; therefore, they do not require pull-up resistors on the bus. The data bus signals are: MDH[0:31], MDL[0:31], and PAR[0:7].

If the 32-bit data bus mode is selected, the input receivers of the unused data and parity bits (MDL[0:31] and PAR[4:7]) are disabled, and their outputs drive logic zeros when they would otherwise be driven. For this mode, these pins do not require pull-up resistors and should be left unconnected to minimize possible output switching.

The $\overline{\text{TEST0}}$ pin requires a pull-up resistor of 120 Ω or less connected to GV_{DD}_OV_{DD}.

RTC should have weak pull-up resistors (2–10 kΩ) connected to GV_{DD}_OV_{DD} and that the following signals should be pulled up to GV_{DD}_OV_{DD} with weak pull-up resistors (2–10 kΩ): SDA, SCL, $\overline{\text{SMI}}$, $\overline{\text{SRESET}}$/SDMA12, TBEN/SDMA13, $\overline{\text{CHKSTOP\_IN}}$/SDMA14, TRIG_IN/$\overline{\text{RCS2}}$, $\overline{\text{QACK}}$/DA0, and $\overline{\text{DRDY}}$.

The following PCI control signals should be pulled up to LV_{DD} (the clamping voltage) with weak pull-up resistors (2–10 kΩ): $\overline{\text{DEVSEL}}$, $\overline{\text{FRAME}}$, $\overline{\text{IRDY}}$, $\overline{\text{LOCK}}$, $\overline{\text{PERR}}$, $\overline{\text{SERR}}$, $\overline{\text{STOP}}$, and $\overline{\text{TRDY}}$. The resistor values may need to have stronger adjustment to reduce induced noise on specific board designs.

The following pins have internal pull-up resistors enabled at all times: $\overline{\text{REQ}}$[3:0], $\overline{\text{REQ4}}$/DA4, TCK, TDI, TMS, and $\overline{\text{TRST}}$. See Table 16.

The following pins have internal pull-up resistors that are enabled only while the device is in the reset state: $\overline{\text{GNT4}}$/DA5, MDL0, $\overline{\text{FOE}}$, $\overline{\text{RCS0}}$, $\overline{\text{SDRAS}}$, $\overline{\text{SDCAS}}$, CKE, $\overline{\text{AS}}$, $\overline{\text{MCP}}$, MAA[0:2], and PMAA[0:2]. See Table 16.

The following pins are reset configuration pins: $\overline{\text{GNT4}}$/DA5, MDL[0], $\overline{\text{FOE}}$, $\overline{\text{RCS0}}$, CKE, $\overline{\text{AS}}$, $\overline{\text{MCP}}$, $\overline{\text{QACK}}$/DA0, MAA[0:2], PMAA[0:2], SDMA[1:0], MDH[16:31], and PLL_CFG[0:4]/DA[10:15]. These pins are sampled during reset to configure the device. The PLL_CFG[0:4] signals are sampled a few clocks after the negation of $\overline{\text{HRST\_CPU}}$ and $\overline{\text{HRST\_CTRL}}$.

Reset configuration pins should be tied to GND by means of 1-kΩ pull-down resistors to ensure that a logic zero level is read into the configuration bits during reset if the default logic-one level is not desired.

Any other unused active low input pins should be tied to a logic-one level by means of weak pull-up resistors (2–10 kΩ) to the appropriate power supply listed in Table 16. Unused active high input pins should be tied to GND by means of weak pull-down resistors (2–10 kΩ).

7.5 PCI Reference Voltage—LV_{DD}

The MPC8241 PCI reference voltage (LV_{DD}) pins should be connected to 3.3 ± 0.3 V power supply if interfacing the MPC8241 into a 3.3-V PCI bus system. Similarly, the LV_{DD} pins should be connected to 5.0 V ± 5% power supply if interfacing the MPC8241 into a 5-V PCI bus system. For either reference voltage, the MPC8241 always performs 3.3-V signaling as described in the *PCI Local Bus Specification* (Rev. 2.2). The MPC8241 tolerates 5-V signals when interfaced into a 5-V PCI bus system. (See Errata No. 18 in the *MPC8245/MPC8241 Integrated Processor Chip Errata*).

7.6 JTAG Configuration Signals

Boundary scan testing is enabled through the JTAG interface signals. The $\overline{\text{TRST}}$ signal is optional in the IEEE 1149.1 specification, but is provided on all processors that implement the PowerPC architecture. While the TAP controller can be forced to the reset state using only the TCK and TMS signals, more reliable power-on reset performance will be obtained if the $\overline{\text{TRST}}$ signal is asserted during power-on reset. Because the JTAG interface is also used for accessing the common on-chip processor (COP) function, simply tying $\overline{\text{TRST}}$ to $\overline{\text{HRESET}}$ is not practical.

The COP function of these processors allows a remote computer system (typically, a PC with dedicated hardware and debugging software) to access and control the internal operations of the processor. The COP interface connects primarily through the JTAG port, with additional status monitoring signals. The COP port must independently assert $\overline{\text{HRESET}}$ or $\overline{\text{TRST}}$ to control the processor. If the target system has independent reset sources, such as voltage monitors, watchdog timers, power supply failures, or push-button switches, the COP reset signals must be merged into these signals with logic.

The arrangement shown in Figure 27 allows the COP port to independently assert $\overline{\text{HRESET}}$ or $\overline{\text{TRST}}$, while ensuring that the target can drive $\overline{\text{HRESET}}$ as well. If the JTAG interface and COP header will not be used, $\overline{\text{TRST}}$ should be tied to $\overline{\text{HRESET}}$ through a 0-Ω isolation resistor so that it is asserted when the system reset signal ($\overline{\text{HRESET}}$) is asserted, ensuring that the JTAG scan chain is initialized during power-on. Although Freescale recommends that the COP header be designed into the system as shown in Figure 27, if this is not possible, the isolation resistor will allow future access to $\overline{\text{TRST}}$ in the case where a JTAG interface may need to be wired onto the system in debug situations.

The COP interface has a standard header for connection to the target system, based on the 0.025" square-post, 0.100" centered header assembly (often called a Berg header). Typically, pin 14 is removed as a connector key.

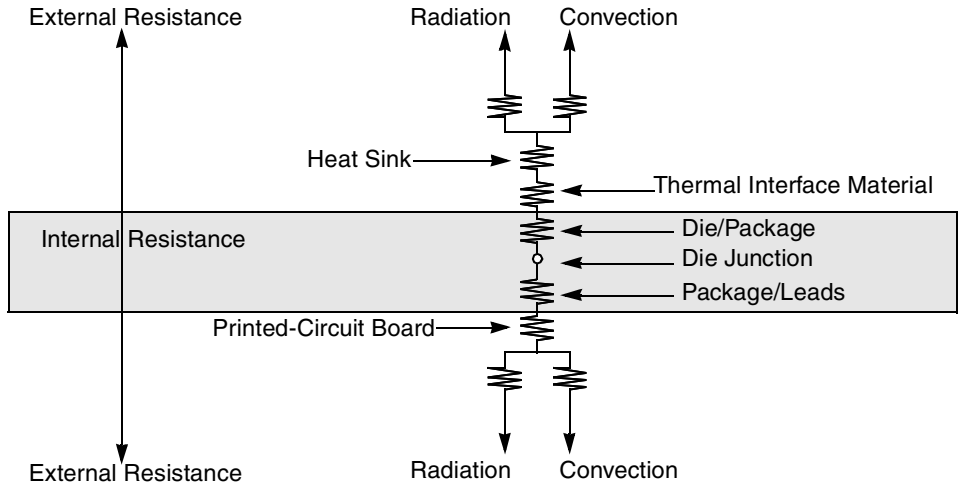
There is no standardized way to number the COP header shown in Figure 27. Consequently, different emulator vendors number the pins differently. Some pins are numbered top-to-bottom and left-to-right while others use left-to-right then top-to-bottom and still others number the pins counter clockwise from pin 1 (as with an IC). Regardless of the numbering, the signal placement recommended in Figure 27 is common to all known emulators.

7.7.1 Internal Package Conduction Resistance

For the PBGA, die-up, packaging technology, shown in Figure 28, the intrinsic conduction thermal resistance paths are as follows:

- The die junction-to-case thermal resistance
- The die junction-to-ball thermal resistance

Figure 30 depicts the primary heat transfer path for a package with an attached heat sink mounted to a printed-circuit board.



(Note the internal versus external package resistance)

Figure 30. PBGA Package with Heat Sink Mounted to a Printed-Circuit Board

For this die-up, wire-bond PBGA package, heat generated on the active side of the chip is conducted mainly through the mold cap, the heat sink attach material (or thermal interface material), and finally through the heat sink where forced-air convection removes it.

7.7.2 Adhesives and Thermal Interface Materials

A thermal interface material should be used between the top of the mold cap and the bottom of the heat sink minimizes thermal contact resistance. For applications that attach the heat sink by a spring clip mechanism, Figure 31 shows the thermal performance of three thin-sheet thermal-interface materials (silicone, graphite/oil, floroether oil), a bare joint, and a joint with thermal grease as a function of contact pressure. As shown, the performance of these thermal interface materials improves with increasing contact pressure. Thermal grease significantly reduces the interface thermal resistance. That is, the bare joint offers a thermal resistance approximately seven times greater than the thermal grease joint.

A spring clip attaches heat sinks to holes in the printed-circuit board (see Figure 28). Therefore, the synthetic grease offers the best thermal performance, considering the low interface pressure. The selection of any thermal interface material depends on factors such as thermal performance requirements, manufacturability, service temperature, dielectric properties, and cost.

where:

T_T = thermocouple temperature atop the package (°C)
ψ_{JT} = thermal characterization parameter (°C/W)
P_D = power dissipation in package (W)

The thermal characterization parameter is measured per JESD51-2 specification using a 40-gauge type T thermocouple epoxied to the top center of the package case. The thermocouple should be positioned so that the thermocouple junction rests on the package. A small amount of epoxy is placed over the thermocouple junction and over about 1 mm of wire extending from the junction. The thermocouple wire is placed flat against the package case to avoid measurement errors caused by cooling effects of the thermocouple wire.

When a heat sink is used, the junction temperature is determined from a thermocouple inserted at the interface between the case of the package and the interface material. A clearance slot or hole is normally required in the heat sink. Minimizing the size of the clearance minimizes the change in thermal performance that is caused by removing part of the thermal interface to the heat sink. Considering the experimental difficulties with this technique, many engineers measure the heat sink temperature and then back calculate the case temperature using a separate measurement of the thermal resistance of the interface. From this case temperature, the junction temperature is determined from the junction-to-case thermal resistance.

In many cases, it is appropriate to simulate the system environment using a computational fluid dynamics thermal simulation tool. In such a tool, the simplest thermal model of a package that has demonstrated reasonable accuracy (about 20%) is a two-resistor model consisting of a junction-to-board and a junction-to-case thermal resistance. The junction-to-case covers the situation where a heat sink is used or a substantial amount of heat is dissipated from the top of the package. The junction-to-board thermal resistance describes the thermal performance when most of the heat is conducted to the printed-circuit board.

7.8 References

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MIL-SPEC and EIA/JESD (JEDEC) specifications are available from Global Engineering Documents at 800-854-7179 or 303-397-7956.

JEDEC specifications are available on the web at http://www.jedec.org.

8 Ordering Information

Ordering information for the parts that this document fully covers is provided in Section 8.1, “Part Numbers Fully Addressed by This Document.” Section 8.2, “Part Numbers Not Fully Addressed by This Document,” lists the part numbers which do not fully conform to the specifications of this document. These special part numbers require an additional document called a hardware specifications addendum.

8.1 Part Numbers Fully Addressed by This Document

Table 19 provides the Freescale part numbering nomenclature for the MPC8241. Note that the individual part numbers correspond to a maximum processor core frequency. For available frequencies, contact your local Freescale sales office. In addition to the processor frequency, the part numbering scheme also includes an application modifier that may specify special application conditions. Each part number also contains a revision code that refers to the die mask revision number. Read the Revision ID register at address offset 0x08 to determine the revision level.

Table 19. Part Numbering Nomenclature

MPC	*nnnn*	L	*xx*	*nnn*	*x*
Product Code	**Part Identifier**	**Process Descriptor**	**Package [1]**	**Processor Frequency [2] (MHz)**	**Revision Level**
MPC	8241	L = Standard spec. 0° to 105°C	ZQ = thick substrate and thick mold cap PBGA (two layers)	166, 200 1.8 V ± 100 mV	D:1.4 = Rev. ID:0x14
			ZQ = thick substrate and thick mold cap PBGA (four layers, thermally enhanced)	266 1.8 V ± 100 mV	
			VR = Lead-free version of package	166, 200, 266 1.8 V ± 100 mV	

Notes:
1. See Section 5, “Package Description,” for more information on available package types.
2. Processor core frequencies supported by parts addressed by this specification only. Not all parts described in this specification support all core frequencies. Additionally, parts addressed by hardware specifications addendums may support other maximum core frequencies.

8.2 Part Numbers Not Fully Addressed by This Document

Parts with application modifiers or revision levels not fully addressed in this specification document are described in separate hardware specifications addendums that supplement and supersede this document (see Table 20).

Table 20. Part Numbers Addressed by MPC8241TXXPNS Series (Document No. MPC8241ECSO1AD))

MPC	*nnnn*	T	*xx*	*nnn*	*x*	
Product Code	**Part Identifier**	**Process Descriptor**	**Package [1]**	**Processor Frequency [2] (MHz)**	**Revision Level**	**Processor Version Register Value**

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