8*x*931AA/8*x*931HA Universal Serial Bus Peripheral Controller

Advanced Information Datasheet

Product Features

- 8*x*931AA Hubless USB Peripheral Controller
- On-chip USB Transceivers
- On-chip Phase-locked loop
- FIFO Data Buffers
  - —Two Pairs of 8-byte Transmit and Receive FIFOs
  - —One Pair of 16-byte Transmit and Receive FIFOs
  - —Supports Isochronous and Non-isochronous Data
- Automatic FIFO Management
- Three USB Interrupt Vectors
  - —Endpoint Transmit/Receive Done
  - —Start of Frame
  - —Global Suspend/Resume/USB Reset
- Regulated 3V Output for Root Port Pullup Resistor
- On-chip ROM Options
  - —0 or 8 Kbytes
- 256 bytes On-chip Data RAM
- Four Input/Output Ports
- MCS® 51 UART
- Three 16-bit Timer/Counters
- Keyboard Control Interface
- Four Dedicated LED Driver Outputs
- 6- or 12-MHz Crystal Operation
  - —Low Clock Mode (3MHz)
- 8*x*931HA Includes all 8*x*931AA Features
- 8*x*931HA USB Hub has One Internal Downstream, and Four External Downstream Ports
  - —Universal Serial Bus Specification 1.0 Compliant
  - —Serves as both USB Hub and USB Embedded Function (Internal Port)
- USB Hub
  - —Connectivity Management
  - —Downstream Device Connect/ Disconnect Detection
  - —Power Management, Including Suspend and Resume
  - —Bus Fault Detection and Recovery
  - —Full and Low Speed Downstream Device Support
- Hub Endpoint Done Interrupt
- Output Pin for Port Power Switching
- Input Pin for Overcurrent Detection
- Hub FIFO Data Buffers
  - —One Pair of 8-byte Transmit and Receive FIFOs
  - —One 1-byte Transmit Register
- Embedded Function FIFO Data Buffers
  - —Same as the 8*x*931AA
- 12-MHz Crystal Operation
  - —Low Clock Mode (3MHz)

The 8*x*931AA and 8*x*931HA USB peripheral controllers are based on the MCS®51 microcontroller. They consist of standard 8XC51Fx peripherals plus a USB module. The 8*x*931HA USB module provides both USB hub and USB embedded function capabilities. The 8*x*931HA supports USB hub functionality, embedded function, suspend/resume modes, isochronous/non-isochronous transfers, and is USB rev 1.0 specification compliant. The USB

Notice: This document contains information on products in the sampling and initial production phases of development. The specifications are subject to change without notice. Verify with your local Intel sales office that you have the latest datasheet before finalizing a design.

Order Number: 273108-003
March 1998

module contains one internal and 4 external downstream ports and integrates the USB transceivers, serial bus interface engine (SIE), hub interface unit (HIU), function interface unit (FIU), and transmit/receive FIFOs. The 8*x*931AA is a hubless USB peripheral controller which contains the same feature set as the 8*x*931HA hub controller except for the hub module. The 8*x*931AA/8*x*931HA Universal Serial Bus Peripheral Controller uses the standard instruction set of the MCS®51 architecture.

Contents

Figures

Tables

1.0 About This Document

This data sheet contains advance information about Intel's 8*x*931AA and 8*x*931HA Universal Serial Bus peripheral controllers, based on the MCS®51 architecture, which includes a functional overview, mechanical data, targeted electrical specifications (simulated), and bus functional waveforms. A detailed functional description, other than parametric performance, is published in the 8x931AA, 8x931HA Universal Serial Bus Peripheral Controller User's Manual (273102-001).

1.1 Additional Information Sources

Intel documentation is available from your local Intel Sales Representative or Intel Literature Sales.

Intel Corporation
Literature Sales
PO Box 5937
Denver, CO 80217-9808

or call 1-800-548-4725

1.2 Electronic Information

We offer a variety of technical and product information through the World Wide Web (see Table for URL) and through FaxBack service which is an on-demand publishing system that sends documents to your fax machine. You can get product announcements, change notifications, product literature, device characteristics, design recommendations, and quality and reliability information 24 hours a day, 7 days a week. Just dial the telephone number and respond to the system prompts.

Table 1. Related Documentation

Document Title	Order/Contact
8x931AA, 8x931HA Universal Serial Bus Peripheral Controller User's Manual	Intel Order #273102-001
Universal Serial Bus Specification, Rev. 1.0	Intel Order #272904

Table 2. Electronic Information

Document Title	Order/Contact
Intel's World-Wide Web (WWW) Location:	http://www.intel.com/design/usb/
Customer Support (US and Canada):	800-628-8686
FaxBack Service:	
US and Canada	800-628-2283
Europe	+44(0)793-496646
worldwide	916-356-3105
Application Bulletin Board Service:	
up to 14.4-Kbaud line, worldwide	916-356-3600
dedicated 2400-baud line, worldwide	916-356-7209
Europe	+44(0)793-496340

1.3 Product Summary

Figure 1. 8*x*931 Functional Block Diagram

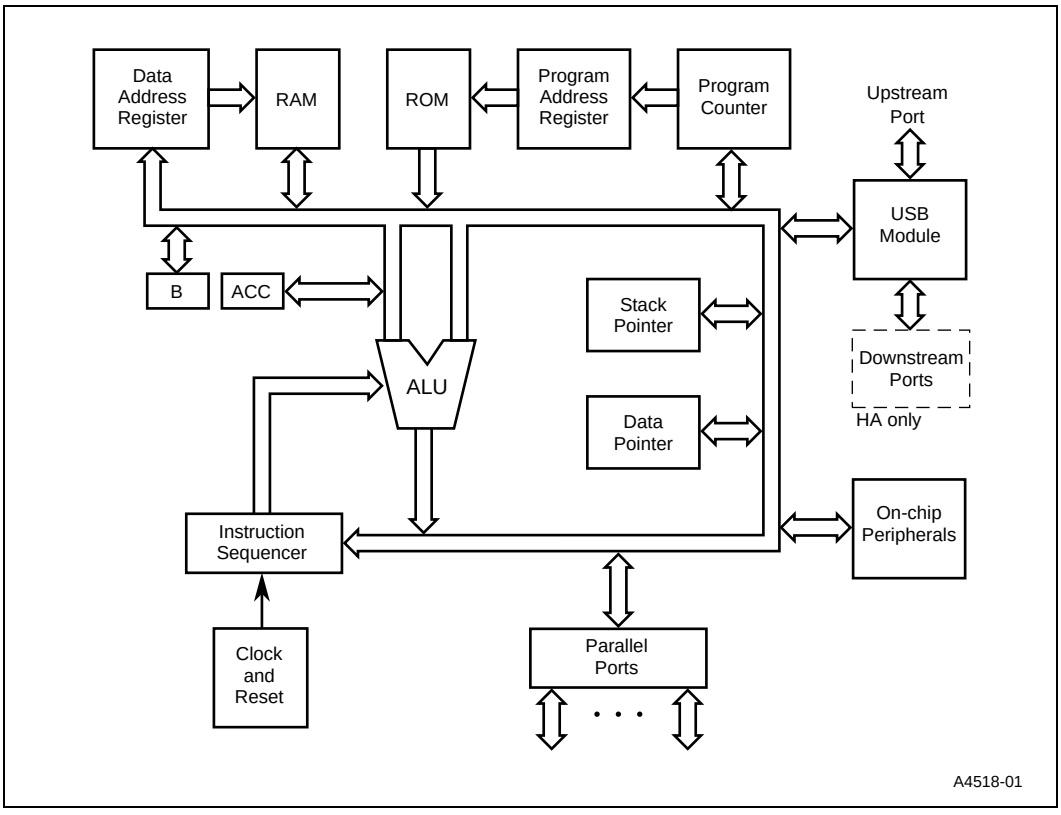
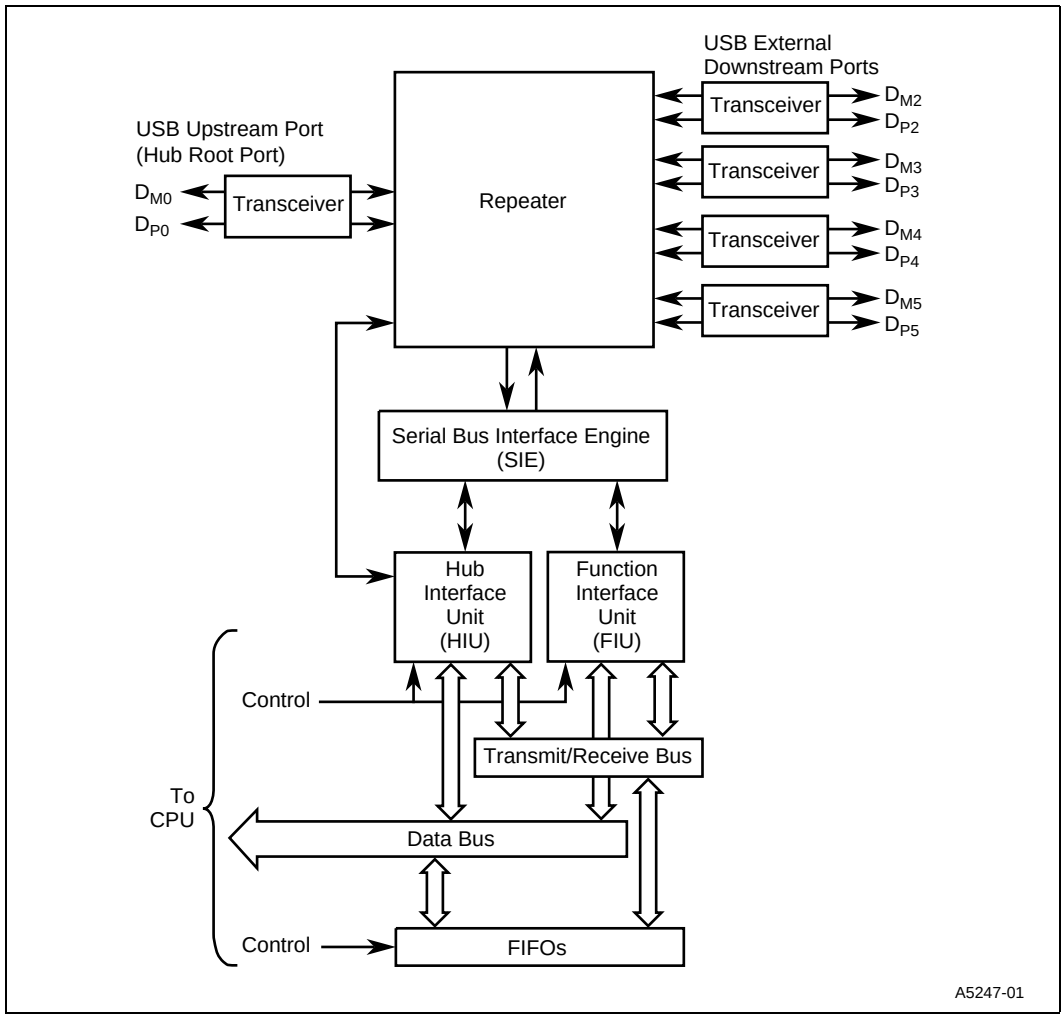


Figure 2. 8x931HA USB Module Block Diagram



2.0 Nomenclature Overview

Figure 3. Product Nomenclature

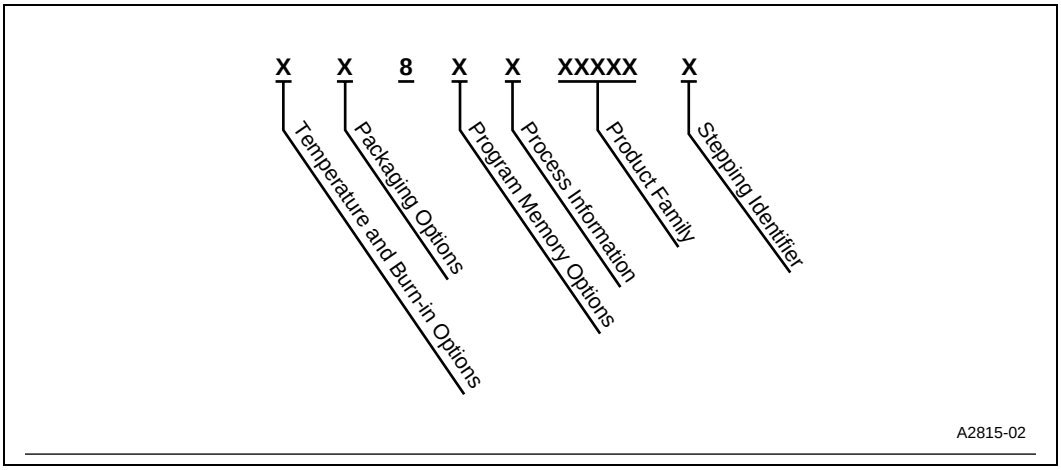


Table 3. Description of Product Nomenclature

Parameter	Options	Description
Temperature and Burn-in	no mark	Commercial operating temperature range (0^{o}C to 70^{o}C) with Intel standard burn-in
Packaging Options	N	Plastic Leaded Chip Carrier (PLCC)
Program Memory Options	0	Without ROM
	3	With ROM
Process and Voltage Information	no mark	CHMOS
Product Family	931Hx	Advanced 8-bit microcontroller architecture with on-chip Universal Serial Bus Hub and Function capability. Indicates ROM size, RAM size, and quantity of external downstream ports (see Table).
	931Ax	Advanced 8-bit microcontroller architecture with on-chip Universal Serial Bus Function capability. Indicates ROM size, RAM size, and quantity of external downstream ports (see Table).
Stepping Information	see spec update	Identification for product stepping revisions.

Table 4. 8*x*931HA Proliferation Options

Part Name	ROM Size	RAM Size	Package
N80931HA	0	256 bytes	68-pin PLCC
N83931HA	8 Kbytes	256 bytes	68-pin PLCC

Table 5. 8*x*931AA Proliferation Options

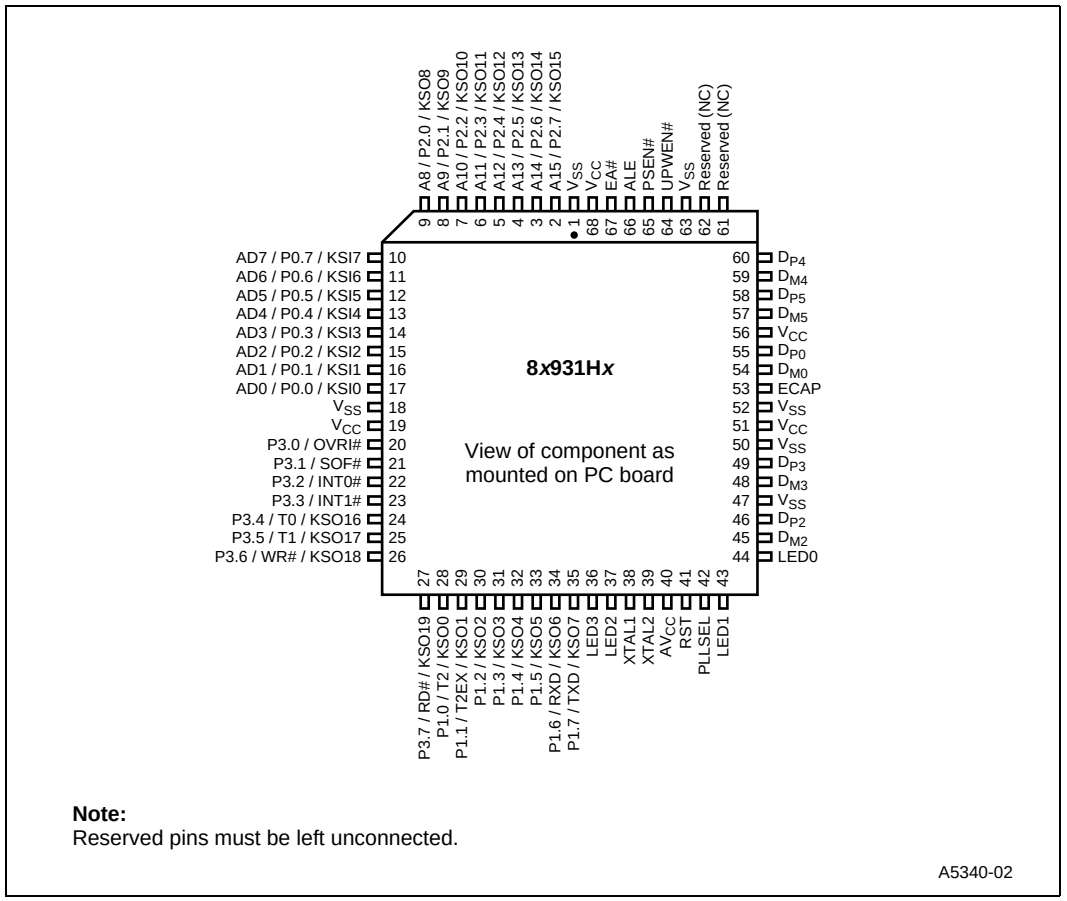
Part Name	ROM Size	RAM Size	Package
N80931AA	0	256 bytes	68-pin PLCC
N83931AA	8 Kbytes	256 bytes	68-pin PLCC

3.0 Pinout

3.1 8*x*931HA 68-pin PLCC Package

Figure 4 illustrates a diagram of the 8*x*931HA PLCC package. Table 6 and Table contain indexes of the pin arrangement. Table 8 contains the signal descriptions for all pins.

Figure 4. 8*x*931HA 68-pin PLCC Package



Note:
Reserved pins must be left unconnected.

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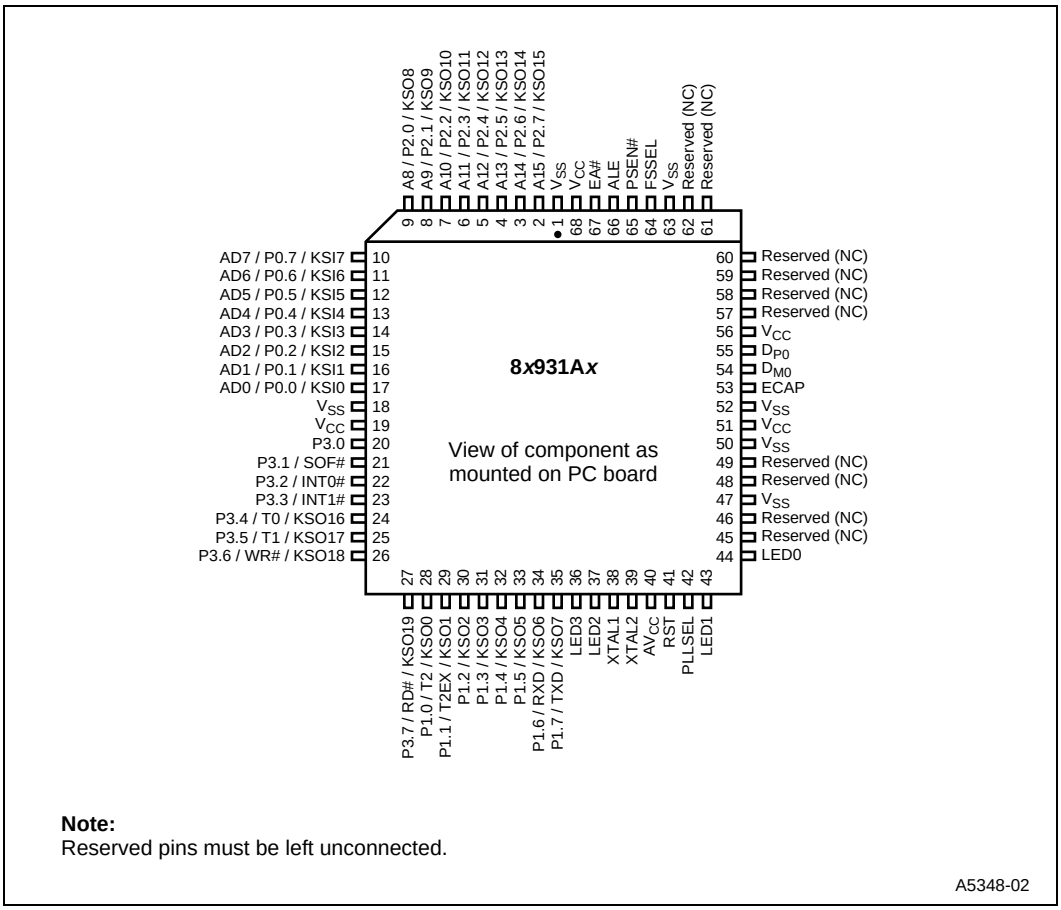
3.2 8*x*931AA 68-pin PLCC Package

Figure 5 illustrates a diagram of the 8*x*931AA PLCC package. Table 6 and Table 7 contain indexes of the pin arrangement. Table 8 contains the signal descriptions for all pins.

Figure 5. 8*x*931AA 68-pin PLCC Package



Note:
Reserved pins must be left unconnected.

Table 6. 68-pin PLCC Pin Assignment

Pin	Name	Pin	Name	Pin	Name
1	V_{SS}	24	P3.4/T0/KSO16	47	V_{SS}
2	A15/P2.7/KSO15	25	P3.5/T1/KSO17	48	Reserved†/ D_{M3}††
3	A14/P2.6/KSO14	26	P3.6/WR#/KSO18	49	Reserved†/ D_{P3}††
4	A13/P2.5/KSO13	27	P3.7/RD#/KSO19	50	V_{SS}
5	A12/P2.4/KSO12	28	P1.0/T2/KSO0	51	V_{CC}
6	A11/P2.3/KSO11	29	P1.1/T2EX/KSO1	52	V_{SS}
7	A10/P2.2/KSO10	30	P1.2/KSO2	53	ECAP
8	A9/P2.1/KSO9	31	P1.3/KSO3	54	D_{M0}
9	A8/P2.0/KSO8	32	P1.4/KSO4	55	D_{P0}
10	AD7/P0.7/KSI7	33	P1.5/KSO5	56	V_{CC}
11	AD6/P0.6/KSI6	34	P1.6/KSO6/RXD	57	Reserved†/ D_{M5}††
12	AD5/P0.5/KSI5	35	P1.7/KSO7/TXD	58	Reserved†/ D_{P5}††
13	AD4/P0.4/KSI4	36	LED3	59	Reserved†/ D_{M4}††
14	AD3/P0.3/KSI3	37	LED2	60	Reserved†/ D_{P4}††
15	AD2/P0.2/KSI2	38	XTAL1	61	Reserved (NC)
16	AD1/P0.1/KSI1	39	XTAL2	62	Reserved (NC)
17	AD0/P0.0/KSI0	40	AV_{CC}	63	V_{SS}
18	V_{SS}	41	RST	64	FSSEL†/ UPWEN#††
19	V_{CC}	42	PLLSEL	65	PSEN#
20	P3.0/ OVRI#††	43	LED1	66	ALE
21	P3.1/SOF#	44	LED0	67	EA#
22	P3.2/INT0#	45	Reserved†/ D_{M2}††	68	V_{CC}
23	P3.3/INT1#	46	Reserved†/ D_{P2}††		

† Specific to the 8*x*931AA

†† Specific to the 8*x*931HA

Table 7. 68-pin PLCC Signal Assignments Arranged by Functional Category

Address & Data	
Name	**Pin**
A15/P2.7/KSO15	2
A14/P2.6/KSO14	3
A13/P2.5/KSO13	4
A12/P2.4/KSO12	5
A11/P2.3/KSO11	6
A10/P2.2/KSO10	7
A9/P2.1/KSO9	8
A8/P2.0/KSO8	9
AD7/P0.7/KSI7	10
AD6/P0.6/KSI6	11
AD5/P0.5/KSI5	12
AD4/P0.4/KSI4	13
AD3/P0.3/KSI3	14
AD2/P0.2/KSI2	15
AD1/P0.1/KSI1	16
AD0/P0.0/KSI0	17

Input/Output	
Name	**Pin**
P1.0/T2/KSO0	28
P1.1/T2EX/KSO1	29
P1.2/KSO2	30
P1.3/KSO3	31
P1.4/KSO4	32
P1.5/KSO5	33
P1.6/KSO6	34
P1.7/KSO7	35
P3.0/ OVRI#††	20
P3.1/SOF#	21
P3.2/INT0#	22
P3.3/INT1#	23
P3.4/T0/KSO16	24
P3.5/T1/KSO17	25
P3.6/WR#/KSO18	26
P3.7/RD#/KSO19	27

USB	
Name	**Pin**
PLLSEL	42
D_{M0}	54
D_{P0}	55
Reserved†/ D_{M5}††	57
Reserved†/ D_{P5}††	58
Reserved†/ D_{M2}††	45
Reserved†/ D_{P2}††	46
Reserved†/ D_{M3}††	48
Reserved†/ D_{P3}††	49
ECAP	53
Reserved†/ D_{M4}††	59
Reserved†/ D_{P4}††	60
FSSEL†/UPWEN#††	64
OVRI#††	20

Processor Control	
Name	**Pin**
P3.2/INT0#	22
P3.3/INT1#	23
RST	41
XTAL1	38
XTAL2	39

Power & Ground	
Name	**Pin**
V_{CC}	19,51,56,68
AV_{CC}	40
V_{SS}	1,18, 47,50, 52,63

Bus Control & Status	
Name	**Pin**
P3.6/WR#/KSO18	26
P3.7/RD#/KSO19	27
PSEN#	65
ALE	66
EA#	67

† Specific to the 8*x*931AA

†† Specific to the 8*x*931HA

4.0 Signals

Table 8. Signal Descriptions (Sheet 1 of 3)

Signal Name	Type	Description	Alternate Function
A15:8	O	**Address Lines**. Upper byte of external memory address.	P2.7:0/KS08:15
AD7:0	I/O	**Address/Data Lines**. Lower byte of external memory address multiplexed with data	P0.7:0/KSI0:7
ALE	O	**Address Latch Enable**. ALE signals the start of an external bus cycle and indicates that valid address information is available on lines A15:8 and AD7:0. An external latch can use ALE to demultiplex the address from the address/data bus.	—
AV_{CC}	PWR	**Analog V_{CC}**. A separate V_{CC} input for the phase-locked loop circuitry.	—
D_{M0}, D_{P0}	I/O	**USB Port 0**. Root port. Upstream port to the host PC. D_{P0} and D_{M0} are the differential data plus and data minus signals of USB port 0. These lines do not have internal pullup resistors. Provide an external 1.5 KΩ pullup resistor at D_{P0} so the device indicates to the host that it is a full-speed device; or provide an external 1.5 KΩ pullup resistor at D_{M0} so the device indicates to the host that it is a low-speed device. ***NOTE:*** *D_{P0} low AND D_{M0} low signals an SE0 (USB reset), causing the 8x931 to stay in reset.*	—
D_{M2}, D_{P2} D_{M3}, D_{P3} D_{M4}, D_{P4} D_{M5}, D_{P5}	I/O	**USB External Downstream Ports 2, 3, 4,5.** These pins are the differential data plus and data minus lines for the four USB external downstream ports. These lines do not have internal pulldown resistors. Provide an external 15 KΩ pulldown resistor at each of these pins. See Design Considerations on page 24.	—
EA#	I	**External Access**. Directs program memory accesses to on-chip or off-chip code memory. For EA# strapped to ground, all program memory accesses are off-chip. For EA# strapped to V_{CC}, program accesses on-chip ROM if the address is within the range of the on-chip ROM; otherwise the access is off-chip. The value of EA# is latched at reset. For devices without on-chip ROM, EA# must be strapped to ground.	—
ECAP	I	**External Capacitor**. Connect a 1 µF or larger capacitor between this pin and V_{SS} to ensure proper operation of the differential line drivers. May be used to supply 3.0v to 3.1v for 1.5K pullup resistor connected to USB Port 0. See “Design Considerations” on page 24.	—
FSSEL		**Full Speed Select.** Applies to the **8*x*931AA** only. If this pin is high, full speed USB data rate is selected (12Mbps). If pin is low, low speed USB data rate is selected (1.5 Mbps). Refer to Table 11.	—
INT1:0#	I	**External Interrupts 0 and 1**. These inputs set the IE1:0 interrupt flags in the TCON register. Bits IT1:0 in TCON select the triggering method: edge-triggered (high-to-low) or level triggered (active low). INT1:0 also serves as external run control for timer1:0 when selected by GATE1:0# in TCON.	P3.3:2
KSI7:0	I	**Keyboard Scan Input.** Schmitt-trigger inputs with firmware-enabled internal pullup resistors used for the input side of the keyboard scan matrix.	AD7:0/P0.7:0

Table 8. Signal Descriptions (Sheet 2 of 3)

Signal Name	Type	Description	Alternate Function
KSO19 KSO18 KSO17:16 KSO15:8 KSO7:0	O	**Keyboard Scan Output.** Quasi-bidirectional ports with weak internal pullup resistors used for the output side of the keyboard scan matrix.	P3.7/RD# P3.6/WR# P3.5:4/T1:0 A15:8/P2.7:0 P1.7:0
LED3:0	O	**LED Drivers.** Designed to drive LEDs connected directly to V_{CC}. The current each driver is capable of sinking is given as V_{OL2} in the datasheet.	—
OVRI#	I	**Overcurrent Sense**. Sense input to indicate an overcurrent condition on an external down-stream port. Active low with an internal pullup.	P3.0
P0.7:0	I/O	**Port 0**. Eight-bit, open-drain, bidirectional I/O port. Port 0 pins have Schmitt trigger inputs.	AD7:0/KSI7:0
P1.7:0	I/O	**Port 1**. Eight-bit quasi-bidirectional I/O port with internal pullups.	KSO7:0
P2.7:0	I/O	**Port 2**. Eight-bit quasi-bidirectional I/O port with internal pullups.	A15:8/KSO15:8
P3.0 P3.1 P3.2 P3.3 P3.4 P3.5 P3.6 P3.7	I/O	**Port 3**. Eight-bit quasi-bidirectional I/O port with internal pullups.	OVRI# SOF# INT0# INT1# T0/KSO16 T1/KSO17 WR#/KSO18 RD#/KSO19
PLLSEL	I	**Phase-locked Loop Select**. For normal operation using the 8*x*931HA, connect PLLSEL to logic high. PLLSEL = 0 is used for factory test only. (See Table 10). For 8*x*931AA operation, see Table 11.	—
PSEN#	O	**Program Store Enable**. Read signal output. Asserted for read accesses to external program memory.	—
RD#	O	**Read.** Read signal output. Asserted for read accesses to external data memory.	P3.7/KSO19
RXD	I/O	**Receive Serial Data**. RXD sends and receives data in serial I/O mode 0 and receives data in serial I/O modes 1, 2, and 3.	P1.6
RST	I	**Reset**. Reset input to the chip. Holding this pin high for two machine cycles while the oscillator is running resets the device. The port pins are driven to their reset conditions when a voltage greater than V_{IH1} is applied, whether or not the oscillator is running. This pin has an internal pulldown resistor which allows the device to be reset by connecting a capacitor between this pin and V_{CC}. Asserting RST when the chip is in idle mode or powerdown mode returns the chip to normal operation.	—
SOF#	O	**Start of Frame**. Start of frame pulse. Active low. Asserted for 8 states when frame timer is locked to USB frame timing and SOF token or artificial SOF is detected.	P3.1
T1:0	I	**Timer 1:0 External Clock Input**. When timer 1:0 operates as a counter, a falling edge on the T1:0 pin increments the count.	P3.5:4/KSO17:16
T2	I/O	**Timer 2 Clock Input/Output**. For the timer 2 capture mode, this signal is the external clock input. For the clock-out mode, it is the timer 2 clock output.	P1.0

Table 8. Signal Descriptions (Sheet 3 of 3)

Signal Name	Type	Description	Alternate Function
T2EX	I	**Timer 2 External Input**. In timer 2 capture mode, a falling edge initiates a capture of the timer 2 registers. In auto-reload mode, a falling edge causes the timer 2 registers to be reloaded. In the up-down counter mode, this signal determines the count direction: 1 = up, 0 = down.	P1.1
TXD	O	**Transmit Serial Data**. TXD outputs the shift clock in serial I/O mode 0 and transmits serial data in serial I/O modes 1, 2, and 3.	P1.7
UPWEN#	O	**USB Power Enable**. A low signal on this pin applies power to the external downstream ports.	—
V_{CC}	PWR	**Supply Voltage**. Connect this pin to the +5v supply voltage. Use a 0.1µf decoupling capacitor for each Vcc pin.	—
V_{SS}	GND	**Circuit Ground**. Connect this pin to ground.	—
WR#	O	**Write.** Write signal output to external memory.	P3.6/KSO19
XTAL1	I	**Oscillator Amplifier Input**. When implementing the on-chip oscillator, connect the external crystal or ceramic resonator across XTAL1 and XTAL2. If an external clock source is used, connect it to this pin.	—
XTAL2	O	**Oscillator Amplifier Output**. When implementing the on-chip oscillator, connect the external crystal or ceramic resonator across XTAL1 and XTAL2. If an external oscillator is used, leave XTAL2 unconnected.	—

5.0 Electrical Characteristics

Note: This document contains information on products in the sampling and initial production phases of development. The specifications are subject to change without notice.Verify with your local Intel sales office that you have the latest datasheet before finalizing a design.

Table 9. Absolute Maximum Ratings†

Parameter	Maximum Rating
Ambient Temperature Under Bias	–40°C to +85°C
Storage Temperature	–65°C to +150°C
Voltage on Any Pins to V_{SS}	–0.5 V to +6.5 V
I_{OL} per I/O Pin	15 mA
Power Dissipation[a]	1.5 W

a. Maximum power dissipation is based on package heat-transfer limitations, not device power consumption.

† Warning: *Stressing the device beyond the "Absolute Maximum Ratings" may cause permanent damage. These are stress ratings only. Operation beyond the "Operating Conditions" is not recommended and extended exposure beyond the "Operating Conditions" may affect device reliability.*

Table 10. Operating Conditions†

Symbol	Parameter	Min	Max
T_A	Ambient Temperature Under Bias	–0°C	+70°C
V_{CC}	Digital Supply Voltage	4.40 V	5.25 V
V_{SS}	Digital Supply Voltage	0V	
AV_{CC}	Analog Supply Voltage	4.40 V	5.25 V
F_{OSC}	XTAL1 Frequency	12 MHz ± 0.25%	

Table 11. 8*x*931AA/8*x*931HA Supply Voltages

Parameter	Condition	Symbol	Min	Max
Supply Voltage		8*x*931HA Vcc/Vbus	4.40V	5.25V
		8*x*931AA Vcc/Vbus	4.15V†	5.25V

†For bus-powered device, voltage droop during hot plug may cause the supply voltage to drop to 4V worst case. The functionality of the device is supported at this voltage.

5.1 Operating Frequencies

Table 12. 8*x*931HA Operating Frequency

PLLSEL	XTAL1 Frequency (F_{osc})	USB Rate (1)	Internal Frequency (F_{CLK}) (2)	XTAL1 Clocks per State (T_{osc}/state) (3)	Comments
0 (4)	–	–	–	–	–
1	12 MHz	12 Mbps (Full Speed)	6 MHz (3)	2	PLL On

NOTES:
1. The sampling rate is 4 times the USB rate.
2. The internal frequency, $F_{CLK} = 1/T_{CLK}$, is the clock signal distributed to the CPU and the on-chip peripherals,
3. Following device reset, the CPU and on-chip peripherals operate in low-clock mode (F_{CLK} = 3 MHz) until the LC bit in the PCON register is cleared. In low clock mode, there are four T_{OSC} periods per state. Low-clock mode does not affect the USB rate.
4. PLLSEL = 0 is used during factory test only.

Table 13. 8*x*931AA Operating Frequency

PLLSEL Pin	FSSEL Pin	LC Bit (1)	XTAL1 Frequency (MHz)	USB Rate (FS/LS) (2)	Core Frequency F_{CLK} (Mhz)	Comment
0	0	0	6	LS	3	PLL Off
0	0	1	6	LS	3	PLL Off
1	0	0	12	LS	6	PLL Off
1	0	1	12	LS	3	PLL Off
1	1	0	12	FS	6	PLL On
1	1	1	12	FS	3	PLL On

NOTES:
1. Reset and power up routines set the LC bit in PCON to put the 8*x*931AA in low-clock mode (core frequency = 3 MHz) for lower I_{CC} prior to device enumeration. Following completion of device enumeration, firmware should clear the LC bit to exit the low-clock mode. The user may switch the core frequency back and forth at any time, as needed.
2. USB rates: Low speed = 1.5 Mbps; Full speed = 12 Mbps. The USB sample rate is 4X the USB rate.

5.2 DC Characteristics

Table 14. DC Characteristics at Operating Conditions (Sheet 1 of 2)

Symbol	Parameter	Min	Typical (1)	Max	Units	Test Conditions
V_{IL}	Input Low Voltage (except EA#)	–0.5		0.2 V_{CC} – 0.1	V	
V_{IL1}	Input Low Voltage (EA#)	0		0.2 V_{CC} – 0.3	V	
V_{IH}	Input High Voltage (except XTAL1, RST)	0.2 V_{CC} + 0.9		V_{CC} + 0.5	V	
V_{IH1}	Input High Voltage (XTAL1, RST)	0.7 V_{CC}		V_{CC} + 0.5	V	
V_{OL}	Output Low Voltage (port 1, 2, 3) (2)			0.3 0.45 1.0	V	I_{OL} = 100 µA I_{OL} = 1.6 mA I_{OL} = 3.5 mA
V_{OL1}	Output Low Voltage (port 0, ALE, PSEN#, SOF#) (2)			0.3 0.45 1.0	V	I_{OL} = 200 µA I_{OL} = 3.2 mA I_{OL} = 7.0 mA
V_{OL2}	Output Low Voltage (LED 0, 1, 2, 3)			2.0 3.0	V	I_{OL} = 6 mA I_{OL} = 22 mA
V_{OH}	Output High Voltage (port 1, 2, 3, ALE, PSEN#, SOF#) (3)	V_{CC} – 0.3 V_{CC} – 0.7 V_{CC} – 1.5			V	I_{OH} = –10 µA I_{OH} = –30 µA I_{OH} = –60 µA
V_{OH1}	Output High Voltage (port 0 in external address space) (3)	V_{CC} – 0.3 V_{CC} – 0.7 V_{CC} – 1.5			V	I_{OH} = –200 µA I_{OH} = –3.2 mA I_{OH} = –7.0 mA
I_{IL}	Logical 0 Input Current (port 1,2,3)			–50	µA	V_{IN} = 0.45 V
I_{LI}	Input Leakage Current (port 0)			±10	µA	V_{IN} = V_{IL} or V_{IH}
I_{TL}	Logical 1-to-0 Transition Current (Port 1, 2,3)			–650	µA	V_{IN} = 2.0 V
R_{RST}	RST Pulldown Resistor	40		100	KΩ	
C_{IO}	Pin Capacitance		10		pF	F_{OSC} = 12 MHz T_A = 25°C

NOTES:
1. Typical values are obtained using V_{CC} = 5.0V, T_A = 25°C and are not guaranteed.
2. Capacitive loading on ports 0 and 2 may cause spurious noise pulses above 0.4 V on the low-level outputs of ALE and ports 1, 2 and 3. The noise is due to external bus capacitance discharging into the port 0 and port 2 pins when these pins change from 1 to 0. In applications where capacitive loading exceeds 100 pF, the noise pulses on these signals may exceed 0.8 V. It may be desirable to qualify ALE or other signals with a Schmitt trigger or CMOS-level input logic.
3. Capacitive loading on ports 0 and 2 causes the V_{OH} on ALE and PSEN to drop below the V_{CC} specification when the address lines are stabilizing.

Table 14. DC Characteristics at Operating Conditions (Sheet 2 of 2)

Symbol	Parameter	Min	Typical (1)	Max	Units	Test Conditions
I_{PD}	Powerdown Current USB suspend		145	175	µA	
I_{DL}	Idle Mode I_{CC}			40	mA	F_{CLK} =6 MHz
				30		F_{CLK} =3 MHz
I_{CC}	Active I_{CC}			70	mA	F_{CLK} = 6 MHz
				50		F_{CLK} = 3MHz
U_{ZDRV}	USB Drivers Output	10		25	KΩ	

NOTES:
1. Typical values are obtained using V_{CC} = 5.0V, T_A = 25°C and are not guaranteed.
2. Capacitive loading on ports 0 and 2 may cause spurious noise pulses above 0.4 V on the low-level outputs of ALE and ports 1, 2 and 3. The noise is due to external bus capacitance discharging into the port 0 and port 2 pins when these pins change from 1 to 0. In applications where capacitive loading exceeds 100 pF, the noise pulses on these signals may exceed 0.8 V. It may be desirable to qualify ALE or other signals with a Schmitt trigger or CMOS-level input logic.
3. Capacitive loading on ports 0 and 2 causes the V_{OH} on ALE and PSEN to drop below the V_{CC} specification when the address lines are stabilizing.

5.3 Explanation of Timing Symbols

Table defines the timing symbols used in Tables 14 through and the associated timing diagrams. They have the form Txxyy, where the character pairs represent a signal and its condition. Timing symbols represent the time between two signal / condition points.

Table 15. AC Timing Symbol Definitions

Symbol	Definition
A	Address: A15:8, A7:0
C	External Clock (XTAL1)
D	Data In: D7:0
L	ALE: Address Latch Enable
P	Program Store Enable (PSEN#)
Q	Data Out: D7:0
R	Read: RD#
W	Write: WR#

Character	Condition
H	High
L	Low
V	Valid, Setup
X	No Longer Valid, Hold
Z	Floating (low impedance)

5.4 System Bus AC Characteristics

Test Conditions: Fosc = 12 MHz. Rise and fall times = 10 ns. Capacitive loading on ALE, PSEN#, and port P0 = 100 pF. Capacitive loading on all other outputs = 80 pF.

Table 16. External Bus Characteristics (Sheet 1 of 2)

Symbol	Parameter	F_{OSC} = 12 MHz, F_{CLK} = 6 MHz		Variable F_{CLK}		Units
		Min	Max	Min	Max	
F_{OSC}	XTAL1 Frequency	12 ± 0.25%				MHz
T_{CLK}	$1/F_{CLK}$ = 1/CPU Frequency	166.67 (Typical)				ns
T_{LHLL}	ALE Pulse Width	127		$T_{CLK} - 40$		ns
T_{AVLL}	Address Valid to ALE Low	43		$0.5T_{CLK} - 40$		ns
T_{LLAX}	Address Hold after ALE Low	53		$0.5T_{CLK} - 30$		ns
T_{PLAZ}	PSEN# Low to Address Float		10		10	ns
T_{LLIV}	ALE Low to Instruction In Valid		259		$2T_{CLK} - 75$	ns
T_{LLPL}	ALE Low to PSEN# Low	53		$0.5T_{CLK} - 30$		ns
T_{PLPH}	PSEN# Pulse Width	205		$1.5T_{CLK} - 45$		ns
T_{PLIV}	PSEN# Low to Instruction In Valid		77		$T_{CLK} - 90$	ns
T_{PHIX}	Instruction Hold after PSEN# High	0		0		ns
T_{PHIZ}	Instruction Float after PSEN# High		63		$0.5T_{CLK} - 20$	ns
T_{AVIV}	Address Valid to Instruction Valid		312		$2.5T_{CLK} - 105$	ns
T_{LLRL}, T_{LLWL}	ALE Low to RD# or WR# Low	200	300	$1.5T_{CLK} - 50$	$1.5T_{CLK} + 50$	ns
T_{RLRH}, T_{WLWH}	RD# and WR# Pulse Width	400		$3T_{CLK} - 100$		ns
T_{LLDV}	ALE Low to Data In Valid		578		$4T_{CLK} - 90$	ns
T_{RLDV}	RD# Low to Data In Valid		322		$2.5T_{CLK} - 95$	ns
T_{RLAZ}	RD# Low to Address Float		0		0	ns
T_{RHDX}	Data Hold After RD# High	0		0		ns
T_{RHDZ}	Data Float After RD# High		23		$0.5T_{CLK} - 60$	ns
T_{AVRL}, T_{AVWL}	Address Valid to RD# or WR# Low	244		$2T_{CLK} - 90$		ns
T_{AVDV}	Address Valid to Data In Valid		661		$4.5T_{CLK} - 90$	ns
T_{RHLH}, T_{WHLH}	RD# or WR# High to ALE High	43	123	$0.5T_{CLK} - 40$	$0.5T_{CLK} + 40$	ns

Table 16. External Bus Characteristics (Sheet 2 of 2)

Symbol	Parameter	F_{OSC} = 12 MHz, F_{CLK} = 6 MHz		Variable F_{CLK}		Units
		Min	Max	Min	Max	
T_{QVWX}	Data Valid to WR# Transition	48		$0.5T_{CLK} - 35$		ns
T_{QVWH}	Data Valid to WR# High	514		$3.5T_{CLK} - 70$		ns
T_{WHQX}	Data Hold After WR# High	43		$0.5T_{CLK} - 40$		ns

5.4.1 System Bus Timing Diagrams

Figure 6. 8*x*931 External Program Memory Read

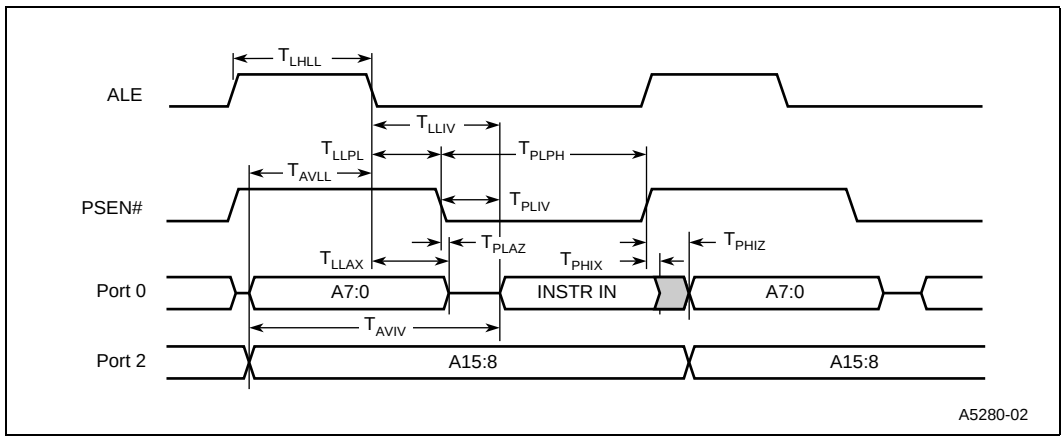


Figure 7. 8x931 External Data Memory Read

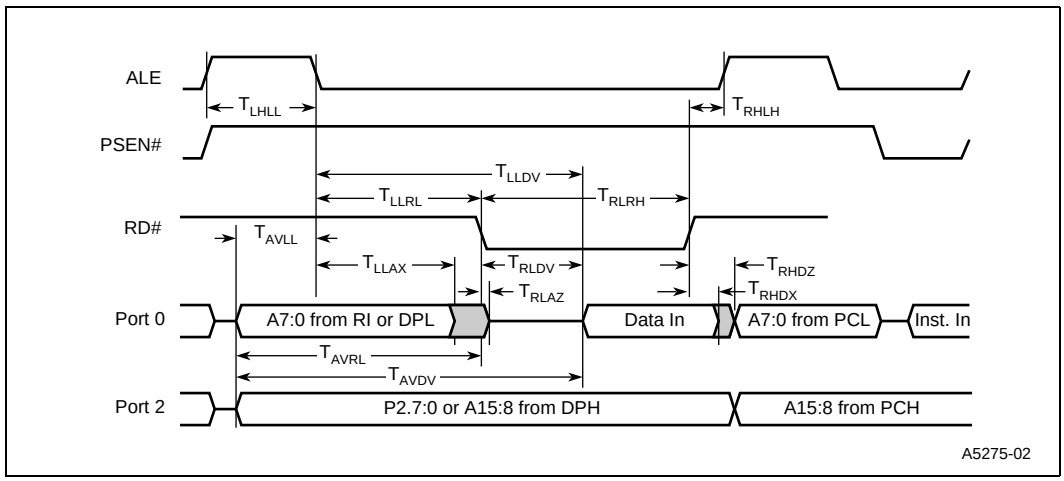
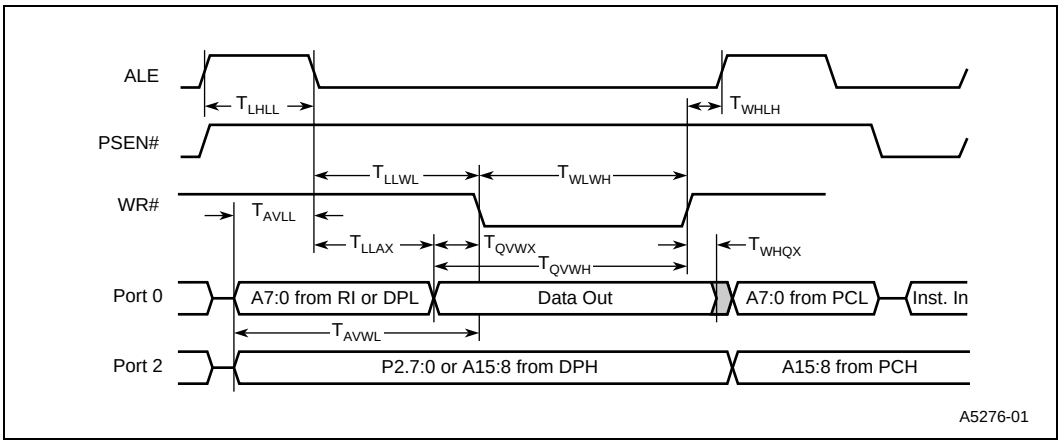


Figure 8. 8x931 External Data Memory Write



5.5 AC Characteristics — Synchronous Mode 0

Figure 9. Serial Port Waveform — Synchronous Mode 0

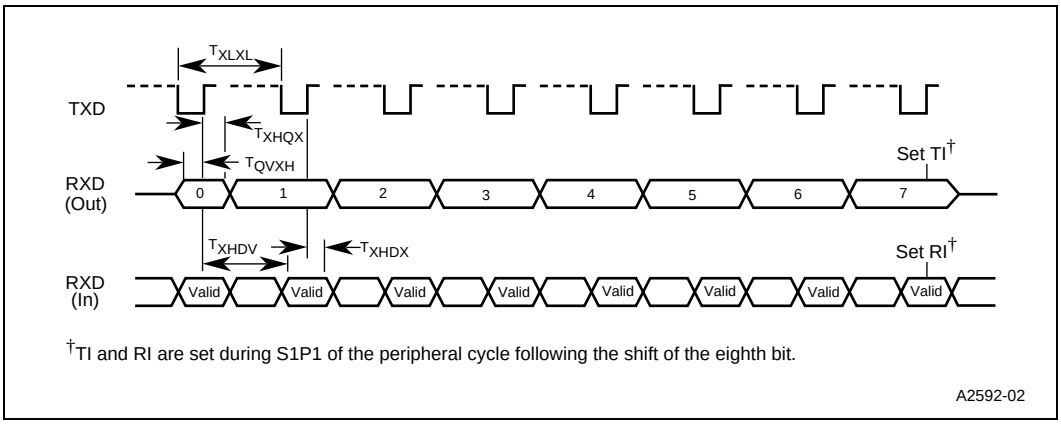


Table 17. Serial Port Timing — Synchronous Mode 0

Symbol	Parameter	Min	Max	Units
T_{xlxl}	Serial Port Clock Cycle Time	12 T_{osc}		ns
T_{qvxh}	Output Data Setup to Clock Rising Edge	10 T_{OSC} – 133		ns
T_{xhqx}	Output Data Hold after Clock Rising Edge	2 T_{osc} – 50		ns
T_{xhdx}	Input Data Hold after Clock Rising Edge	0		ns
T_{xhdv}	Clock Rising Edge to Input Data Valid		10 T_{OSC} – 133	ns

5.6 External Clock Drive

Figure 10. External Clock Drive Waveforms

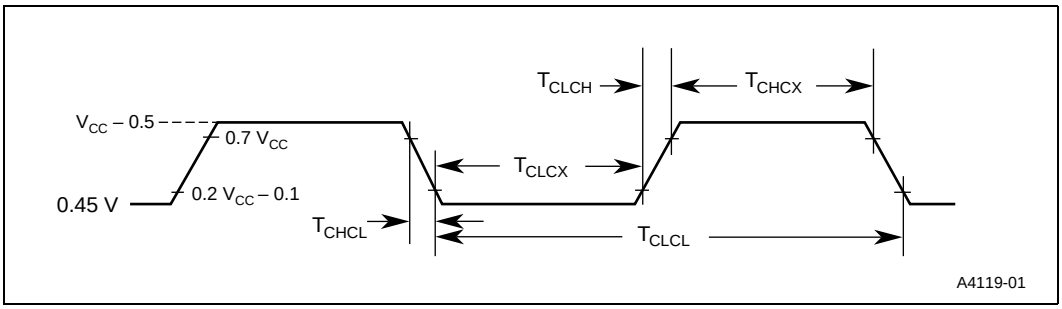
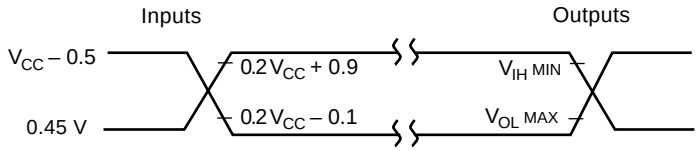


Table 18. External Clock Drive

Symbol	Parameter	Min	Max	Units
$1/T_{OSC}$	Oscillator Frequency (F_{OSC})	6	12	MHz
T_{CHCX}	High Time	20		ns
T_{CLCX}	Low Time	20		ns
T_{CLCH}	Rise Time		20	ns
T_{CHCL}	Fall Time		20	ns

5.7 Testing Waveforms

Figure 11. AC Testing Input, Output Waveforms



AC inputs during testing are driven at V_{CC} – 0.5V for a logic 1 and 0.45 V for a logic 0. Timing measurements are made at a min of V_{IH} for a logic 1 and V_{OL} for a logic 0.

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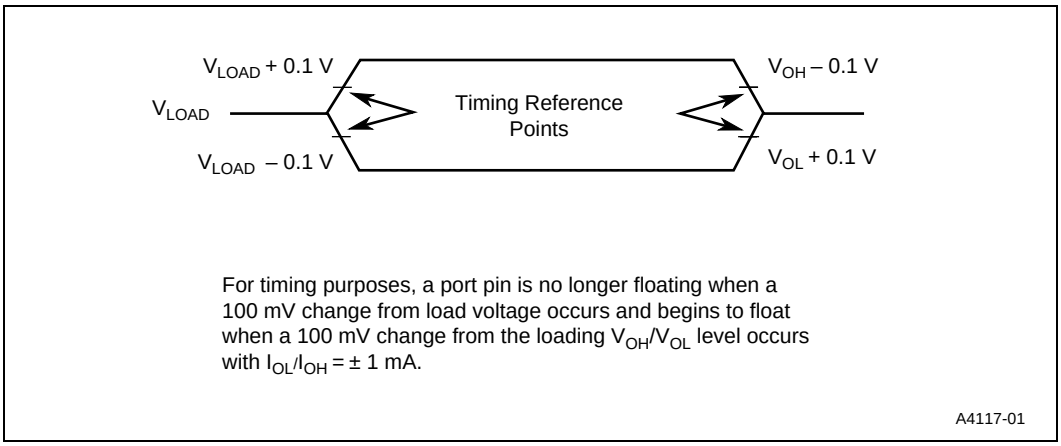
Figure 12. Float Waveforms



6.0 Thermal Characteristics

The microcontroller operates over the commercial temperature range from 0oC to 70oC. All thermal impedance data (see Table 17) is approximate for static air conditions at 1 watt of power dissipation. Values change depending on operating conditions and application requirements. The Intel Packaging Handbook (order number 240800) describes Intel's thermal impedance test methodology. The Components Quality and Reliability Handbook (order number 210997) provides quality and reliability information.

Table 19. Thermal Characteristics

Package Type	θ_{JA}†	θ_{JC}†
68-pin PLCC	N/A	N/A

† Data unavailable at time of publication.

7.0 Design Considerations

7.1 Low Clock Mode Frequency

During low clock mode, the internal clock F_{CLK} distributed to the CPU and peripherals is 3 MHz. Peripheral timing and external bus accesses (including instruction fetch and data read/write) are affected. Refer to Table 10 and Table 11 for clock rates.

7.2 Setting RXFFRC Bit Clears Only the Oldest Packet in the FIFO

If the receive FIFO is set as a dual packet mode, then it can receive two packets. Setting RXFFRC (in RXCON registers) to indicate FIFO Read Complete will **not** flush the entire FIFO; it will flush only the oldest packet. The read marker will be advanced to the location of the read pointer.

7.3 Series Resistor Requirement for Impedance Matching

Per USB rev. 1.0 specification (page 111, section 7.1.1.1), the impedance of the differential driver must be between 29Ω and 44Ω. To match the cable impedance, a series resistor of 27Ω to 33Ω should be connected to each USB line; i.e., on D_{P0} and on D_{M0}. If the USB line is improperly terminated or not matched, then signal fidelity will suffer. This condition can be seen on the oscilloscopes as excessive overshoot and undershoot. This condition can potentially introduce bit errors.

7.4 Pullup Resistor Requirement for 8*x*931 devices

The USB specification requires a pullup resistor to allow the host to identify which devices are low speed and which are full speed in order to communicate at the appropriate data rate. For 8*x*931HA hub devices (12 Mbps), use a 1.5KΩ pullup resistor (to 3.0 V – 3.6 V; may use the ECAP pin.) on the D_{P0} line. 8*x*931AA devices can be either full speed or low speed; add a 1.5KΩ pullup to the appropriate USB line.

7.5 Powerdown Mode Cannot Be Invoked Before USB Suspend

If the 8*x*931 is put into powerdown mode before receiving a USB suspend signal from the host, then a USB resume will not properly wake up the 8*x*931 from powerdown mode.

7.6 Unused Downstream Ports

If the USB downstream ports are not used, it is still required that the two data lines be pulled low externally (similar to a disconnect) so that the inputs are not floating. This will eliminate the possibility of induced system noise. All USB data lines require 15KΩ external pulldown resistors. Do **not** leave unused port(s) disconnected.

7.7 ECAP Usage to Supply 3.0 to 3.1 Volts for 1.5K Ohm Pullup

For a self-powered or bus-powered device, the voltage at ECAP pin is maintained at 3.0v – 3.1v. The capability for this pin to supply the 3.0v to 3.1v voltage to the 1.5KΩ USB pullup terminator is not dependent upon the V_{CC} voltage level.

8.0 8*x*931 Errata

The 8*x*931 may contain design defects or errors known as errata. Characterized errata that may cause the 8*x*931's operational behavior to deviate from published specifications are documented in a specification update. Specification updates can be obtained from your local Intel sales office or from the World Wide Web (***www.intel.com***).

9.0 Datasheet Revision History

Datasheets are changed as new device information becomes available. Verify with your local Intel sales office that you have the latest version before finalizing a design or ordering devices.

This (-002) revision of the 8*x*931 datasheet replaces earlier product information. The following changes were made in this version:

1. Changed product nomenclature parameter information in Figure 3 and Table on page 8. Changed the Device Speed parameter to Stepping Identifier and changed the description.
2. Changed ECAP voltage range to 3.0 – 3.1 on page 25.
3. Changed Figure 12 "Float Waveforms" on page 24 to reflect a reduction to theI_{OL}/I_{OH} load value from +/- 20mA to +/- 1mA.