

# 83C196EA

## CHMOS 16-BIT MICROCONTROLLER

*Automotive*

- 32 MHz operation
- Optional clock doubler
- 2 Mbytes of linear address space
- 1 Kbyte of register RAM
- 3 Kbytes of code RAM
- 8 Kbytes of ROM
- Register-to-register architecture
- Stack overflow/underflow monitor with user-defined upper and lower stack pointer boundary limits
- 2 peripheral interrupt handlers (PIH) provide direct hardware handling of up to 43 interrupts
- Peripheral transaction server (PTS) with high-speed, microcoded interrupt service routines
- Up to 83 I/O port pins
- 2 full-duplex serial ports with dedicated baud-rate generators
- Enhanced synchronous serial unit
- 8 pulse-width modulator (PWM) outputs with 8-bit resolution
- 16-bit watchdog timer
- Sixteen 10-bit A/D channels with auto-scan mode and dedicated results registers
- Serial debug unit provides read and write access to code RAM with no CPU overhead
- Chip-select unit (CSU)
- 3 chip-select pins
- Dynamic demultiplexed/multiplexed address/data bus for each chip-select
- Programmable wait states (0, 1, 2, or 3) for each chip-select
- Programmable bus width (8- or 16-bit) for each chip-select
- Programmable address range for each chip-select
- Event processor array (EPA)
- 4 flexible 16-bit timer/counters
- 17 high-speed capture/compare channels
- 8 output-only channels capture value of any other timer upon compare, providing easy conversion between angle and time domains
- Programmable clock output signal
- 160-pin QFP package
- Complete system development support
- High-speed CHMOS technology

---

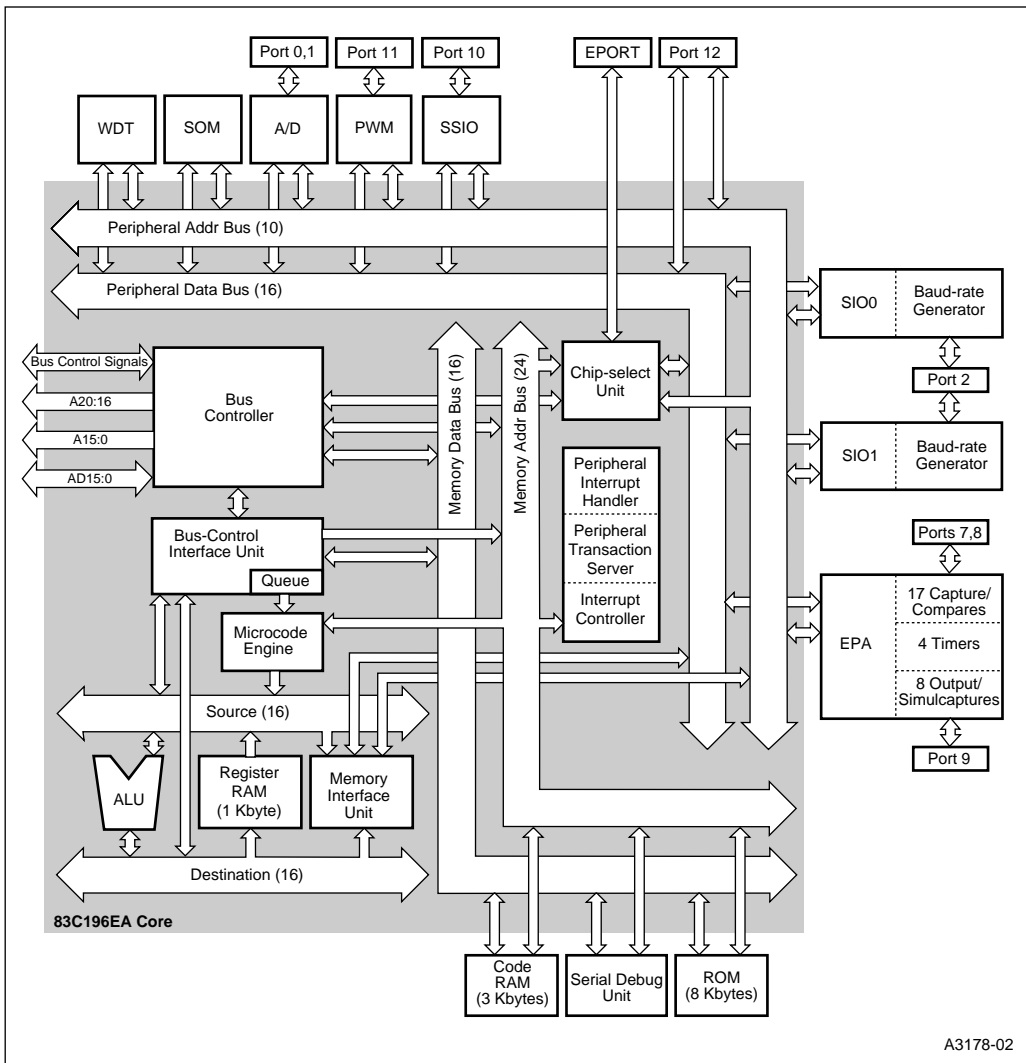
### NOTE

This document contains information on products in the design phase 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.

The 83C196EA is the first member of a new family of microcontrollers with features that are useful in automotive applications, such as powertrain control. Two Mbytes of linear address space provide more space for high-level language compilation. A demultiplexed address/data bus and three chip-select signals make it easier to design low-cost memory solutions. The external bus can dynamically switch between multiplexed and demultiplexed operation.

The 83C196EA is highly integrated with an enhanced peripheral set. The serial debug unit (SDU) provides system debug and development capabilities. The SDU can set a single hardware breakpoint and provides

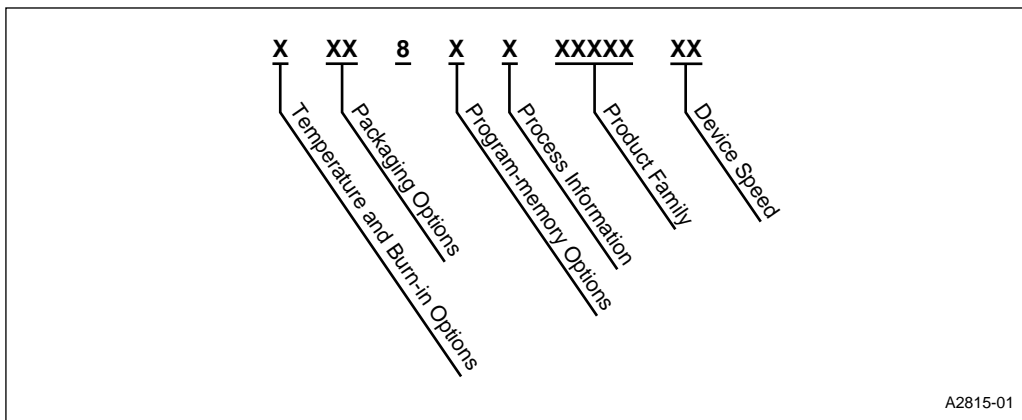
read and write access to code RAM through a high-speed, dedicated serial link. A stack overflow/underflow monitor assists in code development by causing an unmaskable interrupt if the stack pointer crosses a user-defined boundary. The 16-channel A/D converter supports an auto-scan mode that operates with no CPU overhead. Each A/D channel has a dedicated result register. The EPA supports high-speed event captures and output compares with 17 programmable, high-speed capture/compare channels. Eight output-only channels provide support for time-base conversions by capturing the value of one of four timers when a compare occurs.



A3178-02

Figure 1. 83C196EA Block Diagram

## 1.0 NOMENCLATURE OVERVIEW



A2815-01

Figure 2. Product Nomenclature

Table 1. Description of Product Nomenclature

Parameter	Options	Description
Temperature and Burn-in Options	A	Automotive operating temperature range (–40° C to 125° C case) with Intel standard burn-in.
Packaging Options	S	QFP
Program Memory Options	3	Internal ROM
Process Information	C	CHMOS
Product Family	196EA	
Device Speed	no mark	32 MHz

2.0 PINOUT

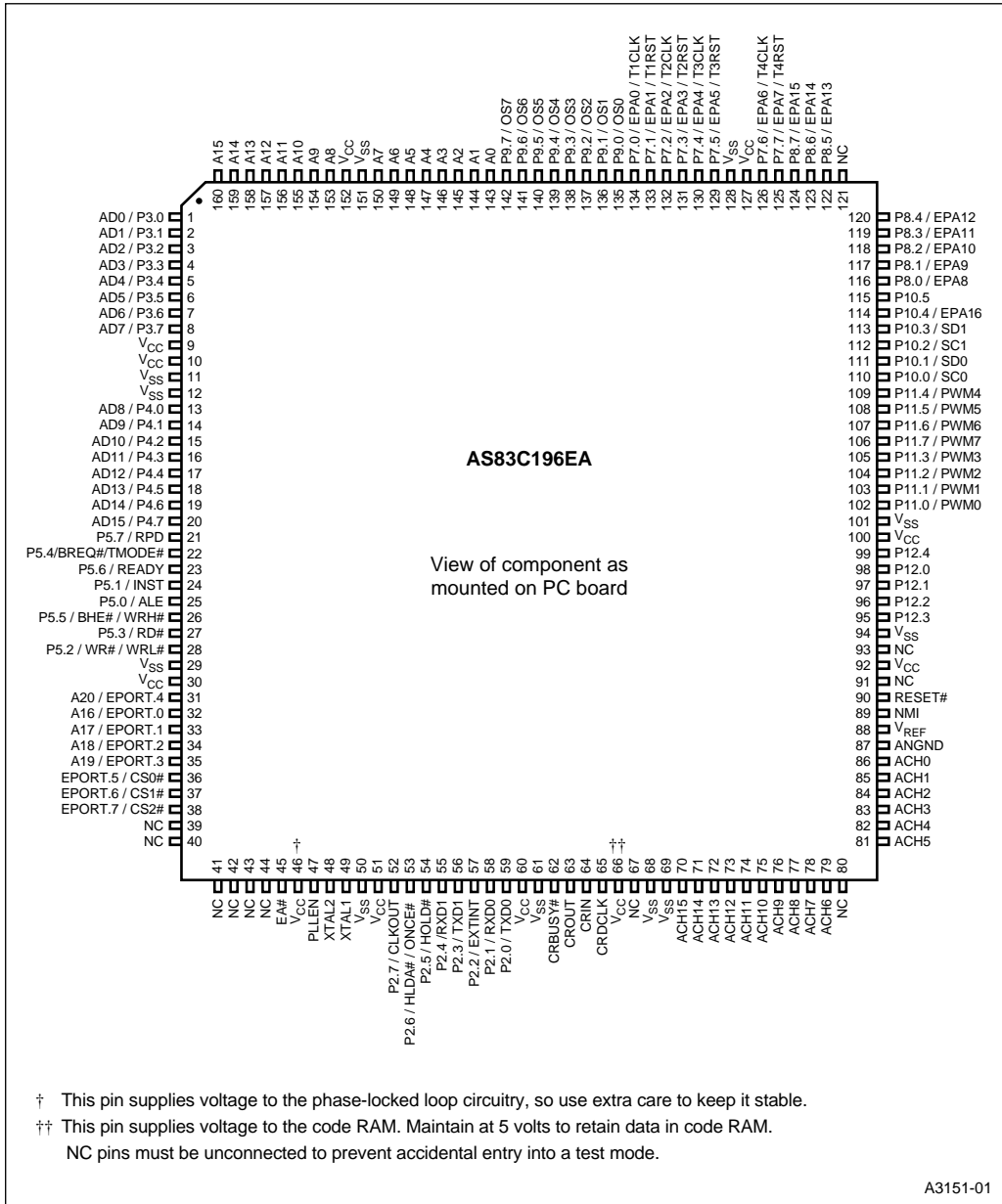


Figure 3. 83C196EA 160-pin QFP Package

**Table 2. 83C196EA 160-pin QFP Package Pin Assignments**

Pin	Name	Pin	Name	Pin	Name	Pin	Name
1	AD0 / P3.0	41	NC	81	ACH5	121	NC
2	AD1 / P3.1	42	NC	82	ACH4	122	P8.5 / EPA13
3	AD2 / P3.2	43	NC	83	ACH3	123	P8.6 / EPA14
4	AD3 / P3.3	44	NC	84	ACH2	124	P8.7 / EPA15
5	AD4 / P3.4	45	EA#	85	ACH1	125	P7.7 / EPA7 / T4RST
6	AD5 / P3.5	46	V <sub>CC</sub>	86	ACH0	126	P7.6 / EPA6 / T4CLK
7	AD6 / P3.6	47	PLEN	87	ANGND	127	V <sub>CC</sub>
8	AD7 / P3.7	48	XTAL2	88	V <sub>REF</sub>	128	V <sub>SS</sub>
9	V <sub>CC</sub>	49	XTAL1	89	NMI	129	P7.5 / EPA5 / T3RST
10	V <sub>CC</sub>	50	V <sub>SS</sub>	90	RESET#	130	P7.4 / EPA4 / T3CLK
11	V <sub>SS</sub>	51	V <sub>CC</sub>	91	NC	131	P7.3 / EPA3 / T2RST
12	V <sub>SS</sub>	52	P2.7 / CLKOUT	92	V <sub>CC</sub>	132	P7.2 / EPA2 / T2CLK
13	AD8 / P4.0	53	P2.6 / HLDA# / ONCE#	93	NC	133	P7.1 / EPA1 / T1RST
14	AD9 / P4.1	54	P2.5 / HOLD#	94	V <sub>SS</sub>	134	P7.0 / EPA0 / T1CLK
15	AD10 / P4.2	55	P2.4 / RXD1	95	P12.3	135	P9.0 / OS0
16	AD11 / P4.3	56	P2.3 / TXD1	96	P12.2	136	P9.1 / OS1
17	AD12 / P4.4	57	P2.2 / EXTINT	97	P12.1	137	P9.2 / OS2
18	AD13 / P4.5	58	P2.1 / RXD0	98	P12.0	138	P9.3 / OS3
19	AD14 / P4.6	59	P2.0 / TXD0	99	P12.4	139	P9.4 / OS4
20	AD15 / P4.7	60	V <sub>CC</sub>	100	V <sub>CC</sub>	140	P9.5 / OS5
21	P5.7 / RPD	61	V <sub>SS</sub>	101	V <sub>SS</sub>	141	P9.6 / OS6
22	P5.4/BREQ#/TMODE#	62	CRBUSY#	102	P11.0 / PWM0	142	P9.7 / OS7
23	P5.6 / READY	63	CROUT	103	P11.1 / PWM1	143	A0
24	P5.1 / INST	64	CRIN	104	P11.2 / PWM2	144	A1
25	P5.0 / ALE	65	CRDCLK	105	P11.3 / PWM3	145	A2
26	P5.5 / BHE# / WRH#	66	V <sub>CC</sub>	106	P11.7 / PWM7	146	A3
27	P5.3 / RD#	67	NC	107	P11.6 / PWM6	147	A4
28	P5.2 / WR# / WRL#	68	V <sub>SS</sub>	108	P11.5 / PWM5	148	A5
29	V <sub>SS</sub>	69	V <sub>SS</sub>	109	P11.4 / PWM4	149	A6
30	V <sub>CC</sub>	70	ACH15	110	P10.0 / SC0	150	A7
31	A20 / EPORT.4	71	ACH14	111	P10.1 / SD0	151	V <sub>SS</sub>
32	A16 / EPORT.0	72	ACH13	112	P10.2 / SC1	152	V <sub>CC</sub>
33	A17 / EPORT.1	73	ACH12	113	P10.3 / SD1	153	A8
34	A18 / EPORT.2	74	ACH11	114	P10.4 / EPA16	154	A9
35	A19 / EPORT.3	75	ACH10	115	P10.5	155	A10
36	EPORT.5 / CS0#	76	ACH9	116	P8.0 / EPA8	156	A11
37	EPORT.6 / CS1#	77	ACH8	117	P8.1 / EPA9	157	A12
38	EPORT.7 / CS2#	78	ACH7	118	P8.2 / EPA10	158	A13
39	NC	79	ACH6	119	P8.3 / EPA11	159	A14
40	NC	80	NC	120	P8.4 / EPA12	160	A15

Table 3. Pin Assignment Arranged by Functional Categories

Addr & Data		Input/Output		Input/Output (Cont'd)		Input/Output (Cont'd)																																					
Name	Pin	Name	Pin	Name	Pin	Name	Pin																																				
A0	143	P2.0 / TXD0	59	EPORT.7	38	P12.0	98																																				
A1	144	P2.1 / RXD0	58	P7.0 / EPA0 / T1CLK	134	P12.1	97																																				
A2	145	P2.2	57	P7.1 / EPA1 / T1RST	133	P12.2	96																																				
A3	146	P2.3 / TXD1	56	P7.2 / EPA2 / T2CLK	132	P12.3	95																																				
A4	147	P2.4 / RXD1	55	P7.3 / EPA3 / T2RST	131	P12.4	99																																				
A5	148	P2.5	54	P7.4 / EPA4 / T3CLK	130	<table border="1"> <thead> <tr><th colspan="2">Analog Inputs</th></tr> <tr><th>Name</th><th>Pin</th></tr> </thead> <tbody> <tr><td>ACH0</td><td>86</td></tr> <tr><td>ACH1</td><td>85</td></tr> <tr><td>ACH2</td><td>84</td></tr> <tr><td>ACH3</td><td>83</td></tr> <tr><td>ACH4</td><td>82</td></tr> <tr><td>ACH5</td><td>81</td></tr> <tr><td>ACH6</td><td>79</td></tr> <tr><td>ACH7</td><td>78</td></tr> <tr><td>ACH8</td><td>77</td></tr> <tr><td>ACH9</td><td>76</td></tr> <tr><td>ACH10</td><td>75</td></tr> <tr><td>ACH11</td><td>74</td></tr> <tr><td>ACH12</td><td>73</td></tr> <tr><td>ACH13</td><td>72</td></tr> <tr><td>ACH14</td><td>71</td></tr> <tr><td>ACH15</td><td>70</td></tr> </tbody> </table>		Analog Inputs		Name	Pin	ACH0	86	ACH1	85	ACH2	84	ACH3	83	ACH4	82	ACH5	81	ACH6	79	ACH7	78	ACH8	77	ACH9	76	ACH10	75	ACH11	74	ACH12	73	ACH13	72	ACH14	71	ACH15	70
Analog Inputs																																											
Name	Pin																																										
ACH0	86																																										
ACH1	85																																										
ACH2	84																																										
ACH3	83																																										
ACH4	82																																										
ACH5	81																																										
ACH6	79																																										
ACH7	78																																										
ACH8	77																																										
ACH9	76																																										
ACH10	75																																										
ACH11	74																																										
ACH12	73																																										
ACH13	72																																										
ACH14	71																																										
ACH15	70																																										
A6	149	P2.6	53	P7.5 / EPA5 / T3RST	129																																						
A7	150	P2.7	52	P7.6 / EPA6 / T4CLK	126																																						
A8	153	P3.0	1	P7.7 / EPA7 / T4RST	125																																						
A9	154	P3.1	2	P8.0 / EPA8	116																																						
A10	155	R3.2	3	P8.1 / EPA9	117																																						
A11	156	P3.3	4	P8.2 / EPA10	118																																						
A12	157	P3.4	5	P8.3 / EPA11	119																																						
A13	158	P3.5	6	P8.4 / EPA12	120																																						
A14	159	P3.6	7	P8.5 / EPA13	122																																						
A15	160	P3.7	8	P8.6 / EPA14	123																																						
A16	32	P4.0	13	P8.7 / EPA15	124																																						
A17	33	P4.1	14	P9.0 / OS0	135																																						
A18	34	P4.2	15	P9.1 / OS1	136																																						
A19	35	P4.3	16	P9.2 / OS2	137																																						
A20	31	P4.4	17	P9.3 / OS3	138																																						
AD0	1	P4.5	18	P9.4 / OS4	139																																						
AD1	2	P4.6	19	P9.5 / OS5	140																																						
AD2	3	P4.7	20	P9.6 / OS6	141																																						
AD3	4	P5.0	25	P9.7 / OS7	142																																						
AD4	5	P5.1	24	P10.0 / SC0	110																																						
AD5	6	P5.2	28	P10.1 / SD0	111																																						
AD6	7	P5.3	27	P10.2 / SC1	112																																						
AD7	8	P5.4	22	P10.3 / SD1	113																																						
AD8	13	P5.5	26	P10.4 / EPA16	114																																						
AD9	14	P5.6	23	P10.5	115																																						
AD10	15	P5.7	21	P11.0 / PWM0	102																																						
AD11	16	EPORT.0	32	P11.1 / PWM1	103																																						
AD12	17	EPORT.1	33	P11.2 / PWM2	104																																						
AD13	18	EPORT.2	34	P11.3 / PWM3	105																																						
AD14	19	EPORT.3	35	P11.4 / PWM4	109																																						
AD15	20	EPORT.4	31	P11.5 / PWM5	108																																						
		EPORT.5	36	P11.6 / PWM6	107																																						
		EPORT.6	37	P11.7 / PWM7	106																																						
				<table border="1"> <thead> <tr><th colspan="2">Bus Control &amp; Status</th></tr> <tr><th>Name</th><th>Pin</th></tr> </thead> <tbody> <tr><td>ALE</td><td>25</td></tr> <tr><td>BHE#/WRH#</td><td>26</td></tr> <tr><td>BREQ#</td><td>22</td></tr> <tr><td>CS0#</td><td>36</td></tr> <tr><td>CS1#</td><td>37</td></tr> <tr><td>CS2#</td><td>38</td></tr> <tr><td>HOLD#</td><td>54</td></tr> <tr><td>HLDA#</td><td>53</td></tr> <tr><td>INST</td><td>24</td></tr> <tr><td>RD#</td><td>27</td></tr> <tr><td>READY</td><td>23</td></tr> <tr><td>WR#/WRL#</td><td>28</td></tr> </tbody> </table>		Bus Control & Status		Name	Pin	ALE	25	BHE#/WRH#	26	BREQ#	22	CS0#	36	CS1#	37	CS2#	38	HOLD#	54	HLDA#	53	INST	24	RD#	27	READY	23	WR#/WRL#	28										
Bus Control & Status																																											
Name	Pin																																										
ALE	25																																										
BHE#/WRH#	26																																										
BREQ#	22																																										
CS0#	36																																										
CS1#	37																																										
CS2#	38																																										
HOLD#	54																																										
HLDA#	53																																										
INST	24																																										
RD#	27																																										
READY	23																																										
WR#/WRL#	28																																										

Table 3. Pin Assignment Arranged by Functional Categories (Continued)

Power & Ground		Processor Control	
Name	Pins	Name	Pin
ANGND	87	CLKOUT	52
V <sub>CC</sub>	9, 10, 30, 46 <sup>†</sup> , 51, 60, 66 <sup>††</sup> , 92, 100, 127, 152	EA#	45
V <sub>SS</sub>	11, 12, 29, 50, 61, 68, 69, 94, 101, 128, 151	EXTINT	57
V <sub>REF</sub>	88	NMI	89
No Connection		ONCE#	53
Name	Pins	PLLEN	47
NC <sup>†††</sup>	39–44, 67, 69, 80, 91, 93, 121	RESET#	90
		RPD	21
		TMODE#	22
		XTAL1	49
		XTAL2	48

- † This pin supplies voltage to the phase-locked loop circuitry, so use extra care to keep it stable.
- †† This pin supplies voltage to code RAM. To retain data, maintain 5 volts.
- ††† Always leave NC (no connect) pins unconnected to prevent accidental entry into test modes.

Code Debug	
Name	Pin
CRBUSY#	62
CRDCLK	65
CRIN	64
CROUT	63

### 3.0 SIGNALS

Table 4. Signal Descriptions

Name	Type	Description
A15:0	I/O	System Address Bus These address lines provide address bits 0–15 during the entire external memory cycle during both multiplexed and demultiplexed bus modes.
A20:16	I/O	Address Lines 16–20 These address lines provide address bits 16–20 during the entire external memory cycle, supporting extended addressing of the 2 Mbyte address space. <b>NOTE:</b> Internally, there are 24 address bits; however, only 21 external address pins (A20:0) are implemented. The internal address space is 16 Mbytes (000000–FFFFFFH) and the external address space is 2 Mbytes (00000–1FFFFFFH). The device resets to FF2080H in internal memory or 1F2080H in external memory. A20:16 are multiplexed with EPORT.4:0.
ACH15:0	I	Analog Channels These pins are analog inputs to the A/D converter. The ANGND and V <sub>REF</sub> pins must be connected for the A/D converter to function.

Table 4. Signal Descriptions (Continued)

Name	Type	Description												
AD15:0	I/O	<p>Address/Data Lines</p> <p>The function of these pins depend on the bus size and mode. When a bus access is not occurring, these pins revert to their I/O port function.</p> <p><b>16-bit Multiplexed Bus Mode:</b> AD15:0 drive address bits 0–15 during the first half of the bus cycle and drive or receive data during the second half of the bus cycle.</p> <p><b>8-bit Multiplexed Bus Mode:</b> AD15:8 drive address bits 8–15 during the entire bus cycle. AD7:0 drive address bits 0–7 during the first half of the bus cycle and drive or receive data during the second half of the bus cycle.</p> <p><b>16-bit Demultiplexed Mode:</b> AD15:0 drive or receive data during the entire bus cycle.</p> <p><b>8-bit Demultiplexed Mode:</b> AD7:0 drive or receive data during the entire bus cycle. AD15:8 drive the data that is currently on the high byte of the internal bus.</p>												
ALE	O	<p>Address Latch Enable</p> <p>This active-high output signal is asserted only during external memory cycles. ALE signals the start of an external bus cycle and indicates that valid address information is available on the system address/data bus (A20:16 and AD15:0 for a multiplexed bus; A20:0 for a demultiplexed bus).</p> <p>An external latch can use this signal to demultiplex address bits 0–15 from the address/data bus in multiplexed mode.</p> <p>ALE is multiplexed with P5.0.</p>												
ANGND	GND	<p>Analog Ground</p> <p>ANGND must be connected for A/D converter operation. ANGND and <math>V_{SS}</math> should be nominally at the same potential.</p>												
BHE#	O	<p>Byte High Enable<sup>†</sup></p> <p>During 16-bit bus cycles, this active-low output signal is asserted for word and high-byte reads and writes to external memory. BHE# indicates that valid data is being transferred over the upper half of the system data bus. Use BHE#, in conjunction with AD0, to determine which memory byte is being transferred over the system bus:</p> <table border="1"> <thead> <tr> <th>BHE#</th> <th>AD0</th> <th>Byte(s) Accessed</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>both bytes</td> </tr> <tr> <td>0</td> <td>1</td> <td>high byte only</td> </tr> <tr> <td>1</td> <td>0</td> <td>low byte only</td> </tr> </tbody> </table> <p>BHE# is multiplexed with P5.5 and WRH#.</p> <p><sup>†</sup> The chip configuration register 0 (CCR0) determines whether this pin functions as BHE# or WRH#. CCR0.2 = 1 selects BHE#; CCR0.2 = 0 selects WRH#.</p>	BHE#	AD0	Byte(s) Accessed	0	0	both bytes	0	1	high byte only	1	0	low byte only
BHE#	AD0	Byte(s) Accessed												
0	0	both bytes												
0	1	high byte only												
1	0	low byte only												
BREQ#	O	<p>Bus Request</p> <p>This active-low output signal is asserted during a hold cycle when the bus controller has a pending external memory cycle.</p> <p>The device can assert BREQ# at the same time as or after it asserts HLDA#.</p> <p>Once it is asserted, BREQ# remains asserted until HOLD# is removed.</p> <p>You must enable the bus-hold protocol before using this signal.</p> <p>BREQ# is multiplexed with P5.4.</p>												



**Table 4. Signal Descriptions (Continued)**

Name	Type	Description
CLKOUT	O	<p>Clock Output</p> <p>Output of the internal clock generator. The CLKOUT frequency can be programmed to one of five frequencies: the internal operating frequency (f) divided by a factor of two, four, eight, or sixteen, or the same frequency as the oscillator input (<math>F_{XTAL1}</math>). CLKOUT has a 50% duty cycle.</p> <p>CLKOUT is multiplexed with P2.7</p>
CRBUSY#	O	<p>Code RAM Busy</p> <p>This signal indicates that the serial debug unit (SDU) is not ready to conduct a transaction.</p>
CRDCLK	I	<p>Code RAM Clock</p> <p>Provides the clock signal for the serial debug unit (SDU). The maximum clock frequency equals the operating frequency (f) divided by two.</p>
CRIN	I	<p>Code RAM Data Input</p> <p>Serial input for test instructions and data into the serial debug unit (SDU). Data is transferred in 8-bit bytes with the most-significant bit (MSB) first. Each byte is sampled on the rising edge of CRDCLK.</p>
CROUT	O	<p>Code RAM Data Output</p> <p>Serial output for data from the serial debug unit (SDU). Data is transferred in 8-bit bytes with the most-significant bit (MSB) first. Each byte is valid on the rising edge of CRDCLK.</p>
CS2:0#	O	<p>Chip-select Lines 0–2</p> <p>The active-low output <math>CS_x\#</math> is asserted during an external memory cycle when the address to be accessed is in the range programmed for chip select x. If the external memory address is outside the range assigned to the three chip selects, no chip-select output is asserted and the bus configuration defaults to the CS2# values.</p> <p>Immediately following reset, CS0# is automatically assigned to the range FF2000–FF20FFH (1F2000–1F20FFH if external).</p> <p>CS2:0# are multiplexed with EPORT.7:5.</p>
EA#	I	<p>External Access</p> <p>This input determines whether memory accesses to special-purpose and program memory partitions (FF2000–FF3FFFH) are directed to internal or external memory. These accesses are directed to internal memory if EA# is held high and to external memory if EA# is held low. For an access to any other memory location, the value of EA# is irrelevant.</p> <p>EA# is sampled and latched only on the rising edge of RESET#. Changing the level of EA# after reset has no effect.</p> <p>On devices with no internal nonvolatile memory, always connect EA# to <math>V_{SS}</math>.</p>
EPA16:0	I/O	<p>Event Processor Array (EPA) Capture/Compare Channels</p> <p>High-speed input/output signals for the EPA capture/compare channels.</p> <p>EPA16:0 are multiplexed as follows: EPA0/P7.0/T1CLK, EPA1/P7.1/T1RST, EPA2/P7.2/T2CLK, EPA3/P7.3/T2RST, EPA4/P7.4/T3CLK, EPA5/P7.5/T3RST, EPA6/P7.6/T4CLK, EPA7/P7.7/T4RST, EPA8/P8.0, EPA9/P8.1, EPA10/P8.2, EPA11/P8.3, EPA12/P8.4, EPA13/P8.5, EPA14/P8.6, EPA15/P8.7, and EPA16/P10.4.</p>

Table 4. Signal Descriptions (Continued)

Name	Type	Description
EPORT.4:0	I/O	<p>Extended Addressing Port</p> <p>This is a standard 5-bit, bidirectional port that is multiplexed with the extended address lines.</p> <p>EPORT.4:0 are multiplexed with A20:16.</p>
EXTINT	I	<p>External Interrupt</p> <p>In normal operating mode, a rising edge on EXTINT sets the EXTINT interrupt pending bit. EXTINT is sampled during phase 2 (CLKOUT high). The minimum high time is one state time.</p> <p>In powerdown mode, asserting the EXTINT signal for at least 50 ns causes the device to resume normal operation. The interrupt need not be enabled, but the pin must be configured as a special-function input. If the EXTINT interrupt is enabled, the CPU executes the interrupt service routine. Otherwise, the CPU executes the instruction that immediately follows the command that invoked the power-saving mode.</p> <p>In idle mode, asserting any enabled interrupt causes the device to resume normal operation.</p> <p>EXTINT is multiplexed with P2.2.</p>
HLDA#	O	<p>Bus Hold Acknowledge</p> <p>This active-low output indicates that the CPU has released the bus as the result of an external device asserting HOLD#.</p> <p>HLDA# is multiplexed with P2.6 and ONCE#.</p>
HOLD#	I	<p>Bus Hold Request</p> <p>An external device uses this active-low input signal to request control of the bus. This pin functions as HOLD# only if the pin is configured for its special function and the bus-hold protocol is enabled. Setting bit seven of the window selection register (WSR) enables the bus-hold protocol.</p> <p>HOLD# is multiplexed with P2.5.</p>
INST	O	<p>Instruction Fetch</p> <p>This active-high output signal is valid only during external memory bus cycles. When high, INST indicates that an instruction is being fetched from external memory. The signal remains high during the entire bus cycle of an external instruction fetch. INST is low for data accesses, including interrupt vector fetches and chip configuration byte reads. INST is low during internal memory fetches.</p> <p>INST is multiplexed with P5.1.</p>
NMI	I	<p>Nonmaskable Interrupt</p> <p>In normal operating mode, a rising edge on NMI generates a nonmaskable interrupt. NMI has the highest priority of all prioritized interrupts. Assert NMI for greater than one state time to guarantee that it is recognized.</p>

**Table 4. Signal Descriptions (Continued)**

Name	Type	Description
ONCE#	I	<p>On-circuit Emulation</p> <p>Holding ONCE# low during the rising edge of RESET# places the device into on-circuit emulation (ONCE) mode. This mode puts all pins into a high-impedance state, thereby isolating the device from other components in the system. The value of ONCE# is latched when the RESET# pin goes inactive. While the device is in ONCE mode, you can debug the system using a clip-on emulator.</p> <p>To exit ONCE mode, reset the device by pulling the RESET# signal low. To prevent inadvertent entry into ONCE mode, either configure this pin as an output or hold it high during reset and ensure that your system meets the <math>V_{IH}</math> specification.</p> <p>ONCE# is multiplexed with P2.6 and HLDA#.</p>
OS7:0	O	<p>Event Processor Array (EPA) Compare-only Channels with Simulcapture</p> <p>Outputs of the EPA's compare-only channels. These pins are multiplexed with port 9 and may be configured as standard I/O.</p> <p>OS7:0 are multiplexed with P9.7:0.</p>
P2.7:0	I/O	<p>Port 2</p> <p>This is a standard, 8-bit, bidirectional port that is multiplexed with individually selectable special-function signals. P2.6 is multiplexed with ONCE#. To prevent inadvertent entry into ONCE mode, either configure this pin as an output or hold it high during reset and ensure that your system meets the <math>V_{IH}</math> specification.</p> <p>Port 2 is multiplexed as follows: P2.0/TXD0, P2.1/RXD0, P2.2/EXTINT, P2.3/TXD1, P2.4/RXD1, P2.5/HOLD#, P2.6/HLDA#/ONCE#, and P2.7/CLKOUT.</p>
P3.7:0	I/O	<p>Port 3</p> <p>This is a memory-mapped, 8-bit, bidirectional port with programmable open-drain or complementary output modes. The pins are shared with the multiplexed address/data bus, which has complementary drivers.</p> <p>P3.7:0 are multiplexed with AD7:0.</p>
P4.7:0	I/O	<p>Port 4</p> <p>This is a memory-mapped, 8-bit, bidirectional port with programmable open-drain or complementary output modes. The pins are shared with the multiplexed address/data bus, which has complementary drivers.</p> <p>P4.7:0 are multiplexed with AD15:8.</p>
P5.7:0	I/O	<p>Port 5</p> <p>This is a memory-mapped, 8-bit, bidirectional port that is multiplexed with individually selectable control signals. P5.4 is multiplexed with TMODE#. If this pin is held low during reset, the device will enter a test mode. To prevent inadvertent entry into a reserved test mode, either configure this pin as an output of hold it high during reset and ensure that your system meets the <math>V_{IH}</math> specification.</p> <p>Port 5 is multiplexed as follows: P5.0/ALE, P5.1/INST, P5.2/WR#/WRL#, P5.3/RD#, P5.4/BREQ#/TMODE#, P5.5/BHE#/WRH#, P5.6/READY, and P5.7/RPD.</p>

Table 4. Signal Descriptions (Continued)

Name	Type	Description
P7.7:0	I/O	Port 7 This is a standard, 8-bit, bidirectional port that is multiplexed with individually selectable special-function signals. Port 7 is multiplexed as follows: P7.0/EPA0/T1CLK, P7.1/EPA1/T1RST, P7.2/EPA2/T2CLK, P7.3/EPA3/T2RST, P7.4/EPA4/T3CLK, P7.5/EPA5/T3RST, P7.6/EPA6/T4CLK, and P7.7/EPA7/T4RST.
P8.7:0	I/O	Port 8 This is a standard, 8-bit, bidirectional port that is multiplexed with individually selectable special-function signals. P8.7:0 are multiplexed with EPA15:8.
P9.7:0	I/O	Port 9 This is a standard, 8-bit, bidirectional port that is multiplexed with individually selectable special-function signals. P9.7:0 are multiplexed with OS7:0.
P10.5:0	I/O	Port 10 This is a standard, 6-bit, bidirectional port that is multiplexed with individually selectable special-function signals. Port 10 is multiplexed as follows: P10.0/SC0, P10.1/SD0, P10.2/SC1, P10.3/SD1, P10.4/EPA16, and P10.5.
P11.7:0	I/O	Port 11 This is a standard, 8-bit, bidirectional port that is multiplexed with individually selectable special-function signals. P11.7:0 are multiplexed with PWM7:0.
P12.4:0	I/O	Port 12 This is a memory-mapped, 5-bit, bidirectional port. P12.2:0 select the test-ROM execution mode.
PLLEN	I	Phase-locked Loop Enable This active-high input pin enables the on-chip clock doubler.
PWM7:0	O	Pulse Width Modulator Outputs These are PWM output pins with high-current drive capability. PWM7:0 are multiplexed with P11.7:0.
RD#	O	Read Read-signal output to external memory. RD# is asserted only during external memory reads. RD# is multiplexed with P5.3.
READY	I	Ready Input This active-high input signal is used to lengthen external memory cycles for slow memory by generating wait states in addition to the wait states that are generated internally. When READY is high, CPU operation continues in a normal manner with wait states inserted as programmed in the chip configuration registers or the chip-select x bus control register. READY is ignored for all internal memory accesses. READY is multiplexed with P5.6.

**Table 4. Signal Descriptions (Continued)**

Name	Type	Description
RESET#	I/O	<p>Reset</p> <p>A level-sensitive reset input to and open-drain system reset output from the microcontroller. Either a falling edge on RESET# or an internal reset turns on a pull-down transistor connected to the RESET# pin for 16 state times. In the powerdown and idle modes, asserting RESET# causes the chip to reset and return to normal operating mode. After a device reset, the first instruction fetch is from FF2080H (or 1F2080H in external memory).</p>
RPD	I	<p>Return from Powerdown</p> <p>Timing pin for the return-from-powerdown circuit.</p> <p>If your application uses powerdown mode, connect a capacitor between RPD and V<sub>SS</sub> if <b>either</b> of the following conditions are true.</p> <ul style="list-style-type: none"> <li>• the internal oscillator is the clock source</li> <li>• the phase-locked loop (PLL) circuitry is enabled (see PLEN signal description)</li> </ul> <p>The capacitor causes a delay that enables the oscillator and PLL circuitry to stabilize before the internal CPU and peripheral clocks are enabled.</p> <p>The capacitor is not required if your application uses powerdown mode and if <b>both</b> of the following conditions are true.</p> <ul style="list-style-type: none"> <li>• an external clock input is the clock source</li> <li>• the phase-locked loop circuitry is disabled</li> </ul> <p>If your application does not use powerdown mode, leave this pin unconnected.</p> <p>RPD is multiplexed with P5.7.</p>
RXD1:0	I/O	<p>Receive Serial Data 0 and 1</p> <p>In modes 1, 2, and 3, RXD0 and 1 receive serial port input data. In mode 0, they function as either inputs or open-drain outputs for data.</p> <p>RXD0 is multiplexed with P2.1 and RXD1 is multiplexed with P2.4.</p>
SC1:0	I/O	<p>Clock Pins for SSIO0 and 1</p> <p>For handshaking mode, configure SC1:0 as open-drain outputs.</p> <p>This pin carries a signal only during receptions and transmissions. When the SSIO port is idle, the pin remains either high (with handshaking) or low (without handshaking).</p> <p>SC0 is multiplexed with P10.0, and SC1 is multiplexed with P10.2.</p>
SD1:0	I/O	<p>Data Pins for SSIO0 and 1</p> <p>These pins are the data I/O pins for SSIO0 and 1.</p> <p>SD0 is multiplexed with P10.1, and SD1 is multiplexed with P10.1.</p>
T1CLK	I	<p>Timer 1 External Clock</p> <p>External clock for timer 1. Timer 1 is programmable to increment or decrement on the rising edge, the falling edge, or both rising and falling edges of T1CLK.</p> <p>and</p> <p>External clock for the serial I/O baud-rate generator input (program selectable).</p> <p>T1CLK is multiplexed with P7.0 and EPA0.</p>

Table 4. Signal Descriptions (Continued)

Name	Type	Description
T2CLK	I	Timer 2 External Clock External clock for timer 2. Timer 2 is programmable to increment or decrement on the rising edge, the falling edge, or both rising and falling edges of T2CLK. T2CLK is multiplexed with P7.2 and EPA2.
T3CLK	I	Timer 3 External Clock External clock for timer 3. Timer 3 is programmable to increment or decrement on the rising edge, the falling edge, or both rising and falling edges of T3CLK. T3CLK is multiplexed with P7.4 and EPA4.
T4CLK	I	Timer 4 External Clock External clock for timer 4. Timer 2 is programmable to increment or decrement on the rising edge, the falling edge, or both rising and falling edges of T4CLK. T4CLK is multiplexed with P7.6 and EPA6.
T1RST	I	Timer 1 External Reset External reset for timer 1. Timer 1 is programmable to reset on the rising edge, the falling edge, or both rising and falling edges of T1RST. T1RST is multiplexed with P7.1 and EPA1.
T2RST	I	Timer 2 External Reset External reset for timer 2. Timer 2 is programmable to reset on the rising edge, the falling edge, or both rising and falling edges of T2RST. T2RST is multiplexed with P7.3 and EPA3.
T3RST	I	Timer 3 External Reset External reset for timer 3. Timer 3 is programmable to reset on the rising edge, the falling edge, or both rising and falling edges of T3RST. T3RST is multiplexed with P7.5 and EPA5.
T4RST	I	Timer 4 External Reset External reset for timer 4. Timer 4 is programmable to reset on the rising edge, the falling edge, or both rising and falling edges of T4RST. T4RST is multiplexed with P7.6 and EPA6.
TMODE#	I	Test-Mode Entry If this pin is held low during reset, the device will enter a test mode. The value of several other pins defines the actual test mode. All test modes, except test-ROM execution, are reserved for Intel factory use. If you choose to configure this signal as an input, always hold it high during reset and ensure that your system meets the $V_{IH}$ specification to prevent inadvertent entry into test mode. TMODE# is multiplexed with P5.4 and BREQ#.
TXD1:0	O	Transmit Serial Data 0 and 1 In serial I/O modes 1, 2, and 3, TXD0 and 1 transmit serial port output data. In mode 0, they are the serial clock output. TXD0 is multiplexed with P2.0 and TXD1 is multiplexed with P2.3.
V <sub>CC</sub>	PWR	Digital Supply Voltage Connect each V <sub>CC</sub> pin to the digital supply voltage.

**Table 4. Signal Descriptions (Continued)**

Name	Type	Description
$V_{REF}$	PWR	Reference Voltage for the A/D Converter This pin also supplies operating voltage to the analog portion of the A/D converter.
$V_{SS}$	GND	Digital Circuit Ground These pins supply ground for the digital circuitry. Connect each $V_{SS}$ pin to ground through the lowest possible impedance path.
WR#	O	Write <sup>†</sup> This active-low output indicates that an external write is occurring. This signal is asserted only during external memory writes. WR# is multiplexed with P5.2 and WRL#. <sup>†</sup> The chip configuration register 0 (CCR0) determines whether this pin functions as WR# or WRL#. CCR0.2 = 1 selects WR#; CCR0.2 = 0 selects WRL#.
WRH#	O	Write High <sup>†</sup> During 16-bit bus cycles, this active-low output signal is asserted for high-byte writes and word writes to external memory. During 8-bit bus cycles, WRH# is asserted for all write operations. WRH# is multiplexed with P5.5 and BHE#. <sup>†</sup> The chip configuration register 0 (CCR0) determines whether this pin functions as BHE# or WRH#. CCR0.2 = 1 selects BHE#; CCR0.2 = 0 selects WRH#.
WRL#	O	Write Low <sup>†</sup> During 16-bit bus cycles, this active-low output signal is asserted for low-byte writes and word writes to external memory. During 8-bit bus cycles, WRL# is asserted for all write operations. WRL# is multiplexed with P5.2 and WR#. <sup>†</sup> The chip configuration register 0 (CCR0) determines whether this pin functions as WR# or WRL#. CCR0.2 = 1 selects WR#; CCR0.2 = 0 selects WRL#.
XTAL1	I	Input Crystal/Resonator or External Clock Input Input to the on-chip oscillator and the internal clock generators. The internal clock generators provide the peripheral clocks, CPU clock, and CLKOUT signal. When using an external clock source instead of the on-chip oscillator, connect the clock input to XTAL1. The external clock signal must meet the $V_{IH}$ specification for XTAL1.
XTAL2	O	Inverted Output for the Crystal/Resonator Output of the on-chip oscillator inverter. Leave XTAL2 floating when the design uses an external clock source instead of the on-chip oscillator.

## 4.0 ADDRESS MAP

Table 5. 80C196EA Address Map

Hex Address	Description (Note 1, Note 2)	Addressing Modes
FFFFFF FF4000	External device (memory or I/O) connected to address/data bus	Indirect, indexed, extended
FF3FFF FF2400	Program memory (Note 3)	Indirect, indexed, extended
FF23FF FF2200	Program memory (Note 3)	Indirect, indexed, extended
FF21FF FF20C0	Special-purpose memory (PIH vectors; Note 3)	Indirect, indexed, extended
FF20BF FF2080	Program memory (Note 3); (After reset, the first instruction is fetched from FF2080H.)	Indirect, indexed, extended
FF207F FF2000	Special-purpose memory (CCBs, interrupt vectors, PTS vectors; Note 3)	Indirect, indexed, extended
FF1FFF FF1000	External device (memory or I/O) connected to address/data bus	Indirect, indexed, extended
FF0FFF FF0400	Internal code/data RAM (identically mapped from page 00H)	Indirect, indexed, extended
FF03FF FF0000	Reserved for in-circuit emulators	—
FEFFFF 1F0000	Overlaid memory (reserved for future devices); locations xF0000–xF03FFH are reserved for in-circuit emulators	Indirect, indexed, extended
1EFFFF 004000	External device (memory or I/O) connected to address/data bus	Indirect, indexed, extended
003FFF 002400	A copy of internal ROM (FF2400–FF3FFFH) if CCB1.2=0 External memory if CCB1.2=1	Indirect, indexed, extended
0023FF 002000	External device (memory or I/O) connected to address/data bus	Indirect, indexed, extended
001FFF 001FE0	Memory-mapped special-function registers (SFRs)	Indirect, indexed, extended
001FDF 001C00	Peripheral special-function registers (SFRs)	Indirect, indexed, extended, windowed direct
001BFF 001000	External device (memory or I/O) connected to address/data bus	Indirect, indexed, extended
000FFF 000400	Internal code/data RAM (identically mapped into page FFH)	Indirect, indexed, extended

### NOTES:

1. Unless otherwise noted, write 0FFH to reserved memory locations and write 0 to reserved SFR bits.
2. The contents or functions of reserved locations may change in future device revisions, in which case a program that relies on one or more of these locations might not function properly.
3. External memory if EA# is low; internal ROM if EA# is high.



**Table 5. 80C196EA Address Map (Continued)**

Hex Address	Description (Note 1, Note 2)	Addressing Modes
0003FF 000100	Upper register file (general-purpose register RAM)	Indirect, indexed, windowed direct
0000FF 00001A	Lower register file (general-purpose register RAM)	Direct, indirect, indexed
000019 000000	Lower register file (stack pointer and CPU SFRs)	Direct, indirect, indexed

**NOTES:**

1. Unless otherwise noted, write 0FFH to reserved memory locations and write 0 to reserved SFR bits.
2. The contents or functions of reserved locations may change in future device revisions, in which case a program that relies on one or more of these locations might not function properly.
3. External memory if EA# is low; internal ROM if EA# is high.

## 5.0 ELECTRICAL CHARACTERISTICS

### ABSOLUTE MAXIMUM RATINGS<sup>†</sup>

Storage Temperature .....	-60°C to +150°C
Supply Voltage with Respect to $V_{SS}$ .....	-0.5 V to +7.0 V
Power Dissipation .....	1.5 W

### OPERATING CONDITIONS<sup>†</sup>

$T_C$ (Case Temperature Under Bias) .....	-40°C to +125°C
$V_{CC}$ (Digital Supply Voltage) .....	4.5 V to 5.5 V
$V_{REF}$ (Analog Supply Voltage) .....	4.5 V to 5.5 V
$F_{XTAL1}$ (Input frequency for $V_{CC} = 4.5\text{ V} - 5.5\text{ V}$ ) (Note 1) .....	16 MHz to 32 MHz

### NOTE:

- This device is static and should operate below 1 Hz, but has been tested only down to 8 MHz.

**NOTICE:** This document contains information on products in the design phase 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.

**†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.*

## 5.1 DC Characteristics

Table 6. DC Characteristics at  $V_{CC} = 4.5\text{ V} - 5.5\text{ V}$

Symbol	Parameter	Min	Typical (Note 1)	Max	Units	Test Conditions
$I_{CC}$	$V_{CC}$ supply current		120	175	mA	XTAL1 = 32 MHz $V_{CC} = 5.5\text{ V}$ Device in Reset
$I_{IDLE}$	Idle mode current		60	85	mA	XTAL1 = 32 MHz $V_{CC} = 5.5\text{ V}$
$I_{PD}$	Powerdown mode current		20	50	$\mu\text{A}$	$V_{CC} = 5.5\text{ V}$
$I_{REF}$	A/D reference supply current			TBD	mA	XTAL1 = 32 MHz $V_{CC} = V_{REF} = 5.5\text{ V}$ Device in Reset
$I_{INJD}$	Maximum injection current per port on bidirectional pins (Note 4)	-10		10	mA	
$I_{LI}$	Input leakage current (Standard inputs except analog inputs)	-10		10	$\mu\text{A}$	$V_{SS} < V_{IN} < V_{CC}$

### NOTES:

- Typical values are based on a limited number of samples and are not guaranteed. The values listed are at room temperature with  $V_{CC} = 5.0\text{ V}$ .
- For P2.7:0, P3.7:0, P4.7:0, P5.7:0, P6.7:0, P10.3:0, P11.7:0, P12.4:0, AD15:0, EA#, RESET#, PLEN, NMI, TDI, TCLK, ONCE#, and XTAL1.
- For P7.7:0, P8.7:0, P9.7:0, and P10.5:4.
- The maximum injection current is not tested. The device is designed to meet this specification.
- Pin capacitance is not tested. This value is based on design simulations.

**Table 6. DC Characteristics at  $V_{CC} = 4.5\text{ V} - 5.5\text{ V}$  (Continued)**

Symbol	Parameter	Min	Typical (Note 1)	Max	Units	Test Conditions
$I_{LI1}$	Input leakage current (analog inputs)	-300		300	nA	$V_{SS} + 100\text{ mV} < V_{IN} < V_{REF} - 100\text{ mV}$
$I_{IH}$	Input high current (NMI only)			175	$\mu\text{A}$	$NMI = V_{CC} = 5.5\text{V}$
$V_{IL1}$	Input low voltage (Note 2)	-0.5		$0.3 V_{CC}$	V	
$V_{IH1}$	Input high voltage (Note 2)	$0.7 V_{CC}$		$V_{CC} + 0.5$	V	
$V_{IL2}$	Input low voltage (Note 3)	-0.5		$0.4 V_{CC}$	V	
$V_{IH2}$	Input high voltage (Note 3)	$0.7 V_{CC}$		$V_{CC} + 0.5$	V	
$V_{OL1}$	Output low voltage (output configured as complementary)			0.3 0.45 1.5	V V V	$I_{OL} = 200\ \mu\text{A}$ $I_{OL} = 3.2\ \text{mA}$ $I_{OL} = 7.0\ \text{mA}$
$V_{OH1}$	Output high voltage (output configured as complementary)	$V_{CC} - 0.3$ $V_{CC} - 0.7$ $V_{CC} - 1.5$			V V V	$I_{OH} = -200\ \mu\text{A}$ $I_{OH} = -3.2\ \text{mA}$ $I_{OH} = -7.0\ \text{mA}$
$V_{OL2}$	Output low voltage in reset			0.5	V	$I_{OL} = 15\ \mu\text{A}$
$V_{OH2}$	Output high voltage in reset	$V_{CC} - 1$			V	$I_{OH} = -15\ \mu\text{A}$
$V_{HYS}$	Hysteresis voltage on all inputs except XTAL1	700			mV	
$C_S$	Pin Capacitance (any pin to $V_{SS}$ ) (Note 5)			10	pF	
$R_{RST}$	Pull-up resistor on RESET# pin	9		95	$\text{k}\Omega$	$V_{CC} = 5.5\text{ V}$ , $V_{IN} = 4.0\text{ V}$

**NOTES:**

1. Typical values are based on a limited number of samples and are not guaranteed. The values listed are at room temperature with  $V_{CC} = 5.0\text{ V}$ .
2. For P2.7:0, P3.7:0, P4.7:0, P5.7:0, P6.7:0, P10.3:0, P11.7:0, P12.4:0, AD15:0, EA#, RESET#, PLEN, NMI, TDI, TCLK, ONCE#, and XTAL1.
3. For P7.7:0, P8.7:0, P9.7:0, and P10.5:4.
4. The maximum injection current is not tested. The device is designed to meet this specification.
5. Pin capacitance is not tested. This value is based on design simulations.

## 5.2 AC Characteristics — Multiplexed Bus Mode

Test Conditions: Capacitive load on all pins = 50 pF, Rise and Fall Times = 3 ns.

**Table 7. AC Characteristics, Multiplexed Bus Mode**

Symbol	Parameter	Min	Max	Units
F <sub>XTAL1</sub>	Frequency on XTAL1, PLL in 1x mode	8	32	MHz (1, 8)
	Frequency on XTAL1, PLL in 2x mode	8	16	MHz (8)
f	Operating frequency, $f = F_{XTAL1}$ ; PLL in 1x mode	8	32	MHz
	Operating frequency, $f = 2F_{XTAL1}$ ; PLL in 2x mode			
t	Period, $t = 1/f$	31.25	125	ns
T <sub>AVDV</sub>	Address Valid to Input Data Valid		3t – 40	ns (2)
T <sub>RLDV</sub>	RD# Low to Input Data Valid		t – 20	ns (2)
T <sub>CHDV</sub>	CLKOUT High to Input Data valid		2t – 35	ns (9)
T <sub>RHDZ</sub>	RD# High to Input Data Float		t + 5	ns
T <sub>RXDX</sub>	Data Hold after RD# Inactive	0		ns
T <sub>XHCH</sub>	XTAL1 Rising Edge to CLKOUT High or Low	3	50	ns (9)
T <sub>CLCL</sub>	CLKOUT Cycle Time	2t		ns (9)
T <sub>CHCL</sub>	CLKOUT High Period	t – 10	t + 15	ns (9)
T <sub>CLLH</sub>	CLKOUT Falling to ALE Rising	– 10	10	ns (9)
T <sub>LLCH</sub>	ALE Falling to CLKOUT Rising	– 15	15	ns (9)
T <sub>LHLH</sub>	ALE Cycle Time	4t		ns (2)
T <sub>LHLL</sub>	ALE High Period	t – 10	t + 10	ns
T <sub>AVLL</sub>	Address Setup to ALE Low	t – 15		ns
T <sub>LLAX</sub>	Address Hold after ALE Low	t – 10		ns
T <sub>LLRL</sub>	ALE Low to RD# Low	t – 15		ns
T <sub>RLCL</sub>	RD# Low to CLKOUT Low	– 10	20	ns (9)
T <sub>RLRH</sub>	RD# Low to RD# High	t – 10		ns (2)
T <sub>RHLH</sub>	RD# High to ALE Rising	t – 5	t + 15	ns (3)

### NOTES:

- 16 MHz is the maximum input frequency when using an external crystal oscillator; however, 32MHz can be applied with an external clock source.
- If wait states are used, add  $2t \times n$ , where  $n$  = number of wait states.
- Assuming back-to-back bus cycles.
- When forcing wait states using the BUSCON register, add  $2t \times n$ .
- Exceeding the maximum specification causes additional wait states.
- 8-bit bus only.
- The first falling edge of READY is not synchronized to a CLKOUT edge; therefore, one programmed wait state is required.
- Device is static by design but has been tested only down to 8 MHz.
- Assumes CLKOUT is operating in divide-by-two mode ( $f/2$ ).

**Table 7. AC Characteristics, Multiplexed Bus Mode (Continued)**

Symbol	Parameter	Min	Max	Units
$T_{RLAZ}$	RD# Low to Address Float		5	ns
$T_{LLWL}$	ALE Low to WR# Low	$t - 12$		ns
$T_{QVWH}$	Data Stable to WR# Rising Edge	$t - 14$		ns (2)
$T_{CHWH}$	CLKOUT High to WR# Rising Edge	- 15	5	ns (9)
$T_{WLWH}$	WR# Low to WR# High	$t - 10$		ns (2)
$T_{WHQX}$	Data Hold after WR# High	$t - 7$		ns
$T_{WHLH}$	WR# High to ALE High	$t - 15$	$t + 20$	ns
$T_{WHBX}$	BHE#, INST Hold after WR# High	$t - 4$		ns
$T_{WHAX}$	AD15:8, CSx# Hold after WR# High	$t - 4$		ns (6)
$T_{RHBX}$	BHE#, INST Hold after RD# High	$t - 5$		ns
$T_{RHAX}$	AD15:8, CSx# Hold after RD# High	$t - 5$		ns (6)
$T_{WHSB}$	A20:0, CSx# Hold after WR# High	0		ns
$T_{RHSH}$	A20:0, CSx# Hold after RD# High	0		ns
$T_{AVVY}$	AD15:0 Valid to READY Setup		$2t - 55$	ns (4)
$T_{CLYX}$	READY Hold after CLKOUT Low	0	$2t - 45$	ns (5, 7, 9)
$T_{YLYH}$	Non-READY Time	No Upper Limit		ns

**NOTES:**

- 16 MHz is the maximum input frequency when using an external crystal oscillator; however, 32MHz can be applied with an external clock source.
- If wait states are used, add  $2t \times n$ , where  $n$  = number of wait states.
- Assuming back-to-back bus cycles.
- When forcing wait states using the BUSCON register, add  $2t \times n$ .
- Exceeding the maximum specification causes additional wait states.
- 8-bit bus only.
- The first falling edge of READY is not synchronized to a CLKOUT edge; therefore, one programmed wait state is required.
- Device is static by design but has been tested only down to 8 MHz.
- Assumes CLKOUT is operating in divide-by-two mode ( $f/2$ ).

**Table 8. AC Timing Symbol Definitions**

Signals				Conditions			
A <sup>†</sup>	Address	H	HOLD#	S	CSx#	H	High
B	BHE#	HA	HLDA#	W	WR#, WRH#, WRL#	L	Low
C	CLKOUT	L	ALE	X	XTAL1	V	Valid
D	Input Data	Q	Output Data	Y	READY	X	No Longer Valid
		R	RD#			Z	Floating

<sup>†</sup> Address bus (demultiplexed mode) or address/data bus (multiplexed mode)

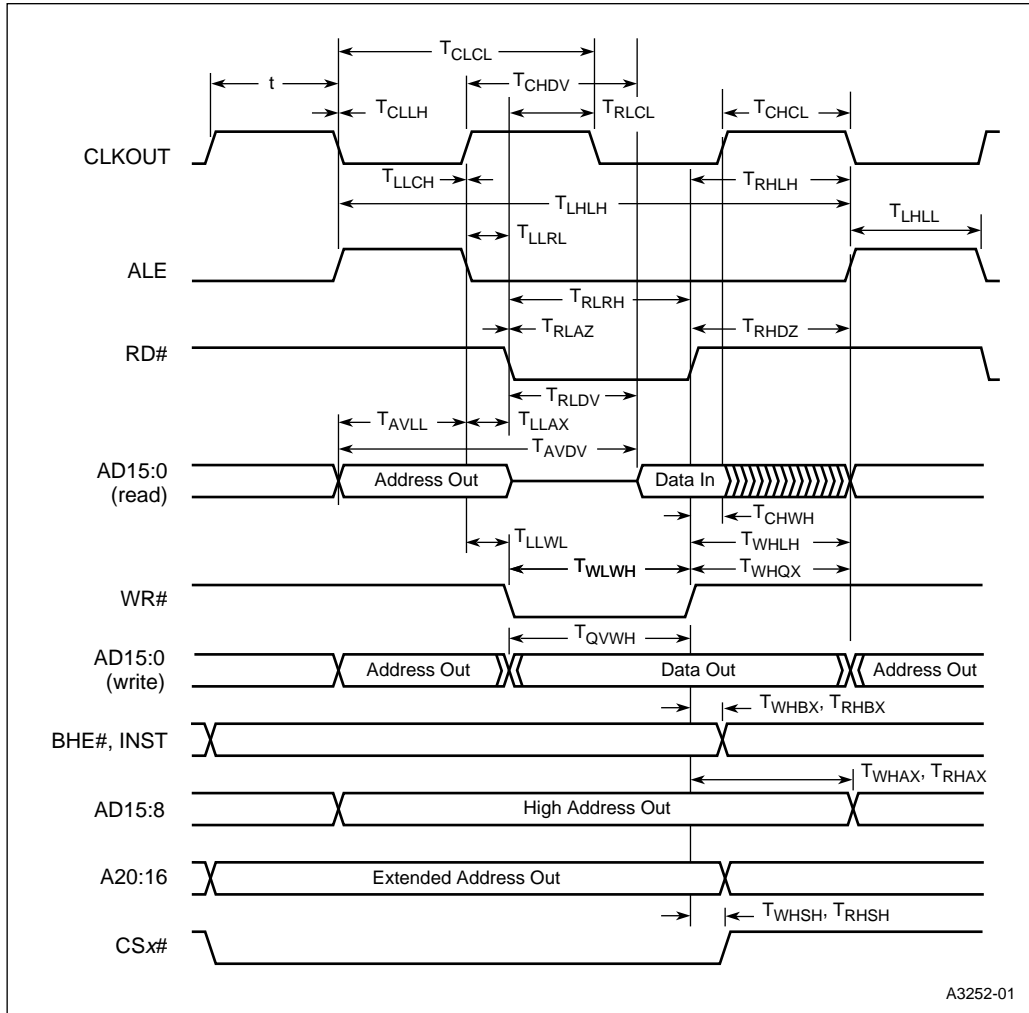


Figure 4. System Bus Timing Diagram (Multiplexed Bus Mode)

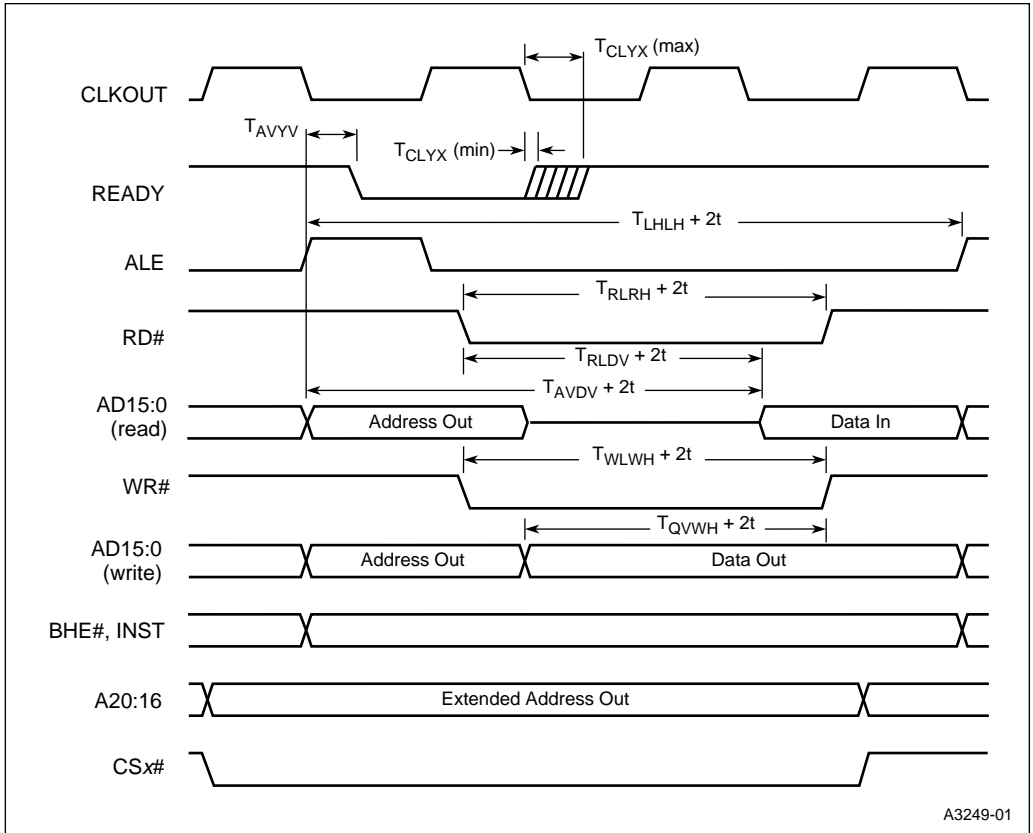


Figure 5. READY Timing Diagram (Multiplexed Bus Mode)

### 5.3 AC Characteristics — Demultiplexed Bus Mode

Test Conditions: Capacitive load on all pins = 50 pF, Rise and Fall Times = 3 ns.

**Table 9. AC Characteristics, Demultiplexed Bus Mode**

Symbol	Parameter	Min	Max	Units
F <sub>XTAL1</sub>	Frequency on XTAL1, PLL in 1x mode	8 (8)	32 (1)	MHz
	Frequency on XTAL1, PLL in 2x mode	8 (8)	16	MHz
f	Operating frequency, $f = F_{XTAL1}$ ; PLL in 1x mode	8	32	Mhz
	Operating frequency, $f = 2F_{XTAL1}$ ; PLL in 2x mode			
t	Period, $t = 1/f$	31.25	125	ns
T <sub>AVDV</sub>	Address Valid to Input Data Valid		4t – 40	ns (2)
T <sub>RLDV</sub>	RD# Low to Input Data Valid		3t – 35	ns (2)
T <sub>AVWL</sub>	Address Valid to WR# Low	t		ns
T <sub>AVRL</sub>	Address Valid to RD# Low	t – 8		ns
T <sub>SLDV</sub>	Chip Select Low to Data Valid		4t – 40	ns (2)
T <sub>CHDV</sub>	CLKOUT Rising Edge to Input Data Valid		2t – 35	ns (9)
T <sub>RHDZ</sub>	RD# High to Input Data Float		t - 5	ns
T <sub>RHRL</sub>	Read High to Next Read Low	t – 5		ns
T <sub>RXDX</sub>	Data Hold after RD# Inactive	0		ns
T <sub>XHCH</sub>	XTAL1 High to CLKOUT High or Low	3	50	ns (9)
T <sub>CLCL</sub>	CLKOUT Cycle Time	2t		ns (9)
T <sub>CHCL</sub>	CLKOUT High Period	t – 10	t + 15	ns (9)
T <sub>CLLH</sub>	CLKOUT Falling ALE Rising	– 10	10	ns (9)
T <sub>LLCH</sub>	ALE Falling to CLKOUT Rising	– 15	15	ns (9)
T <sub>LHLH</sub>	ALE Cycle Time	4t		ns (2,3)
T <sub>LHLL</sub>	ALE High Period	t – 10	t + 10	ns
T <sub>RLCL</sub>	RD# Low to CLKOUT Low	– 15	5	ns (9)
T <sub>RLRH</sub>	RD# Low to RD# High	3t – 18		ns (2)

- 16 MHz is the maximum input frequency when using an external crystal oscillator; however, 32 MHz can be applied with an external clock source.
- If wait states are used, add  $2t \times n$ , where  $n$  = number of wait states.
- Assuming back-to-back bus cycles.
- When forcing wait states using the BUSCON register, add  $2t \times n$ .
- Exceeding the maximum specification causes additional wait states.
- 8-bit bus only.
- The first falling edge of READY is not synchronized to a CLKOUT edge; therefore, one programmed wait state is required.
- Device is static by design but has been tested only down to 8 MHz.
- Assumes CLKOUT is operating in divide-by-two mode ( $f/2$ ).



**Table 9. AC Characteristics, Demultiplexed Bus Mode (Continued)**

Symbol	Parameter	Min	Max	Units
$T_{RHLH}$	RD# Rising to ALE Rising	$t - 4$	$t + 15$	ns (3)
$T_{WLCL}$	WR# Low to CLKOUT Falling	$- 15$	5	ns (9)
$T_{QVWH}$	Data Stable to WR# Rising Edge	$3t - 25$		ns (3)
$T_{CHWH}$	CLKOUT High to WR# Rising Edge	$- 11$	10	ns (9)
$T_{WLWH}$	WR# Low to WR# High	$3t - 18$		ns (2)
$T_{WHQX}$	Data Hold after WR# Rising Edge	$t$	$t + 20$	ns
$T_{WHLH}$	WR# High to ALE High	$t - 5$	$t + 10$	ns (2)
$T_{WHBX}$	BHE#, INST Hold after WR# High	$t - 5$		ns
$T_{WHAX}$	A20:0, CSx# Hold after WR# High	0		ns
$T_{RHBX}$	BHE#, INST Hold after RD# High	$t - 5$		ns
$T_{RHAX}$	A20:0, CSx# Hold after RD# High	0		ns
$T_{AVYV}$	A20:0 Valid to READY Setup		$3t - 45$	ns (4)
$T_{CLYX}$	READY Hold after CLKOUT Low	0	$2t - 36$	ns (5, 7, 9)
$T_{VLYH}$	Non READY Time	No Upper Limit		ns

- 16 MHz is the maximum input frequency when using an external crystal oscillator; however, 32 MHz can be applied with an external clock source.
- If wait states are used, add  $2t \times n$ , where  $n$  = number of wait states.
- Assuming back-to-back bus cycles.
- When forcing wait states using the BUSCON register, add  $2t \times n$ .
- Exceeding the maximum specification causes additional wait states.
- 8-bit bus only.
- The first falling edge of READY is not synchronized to a CLKOUT edge; therefore, one programmed wait state is required.
- Device is static by design but has been tested only down to 8 MHz.
- Assumes CLKOUT is operating in divide-by-two mode ( $f/2$ ).

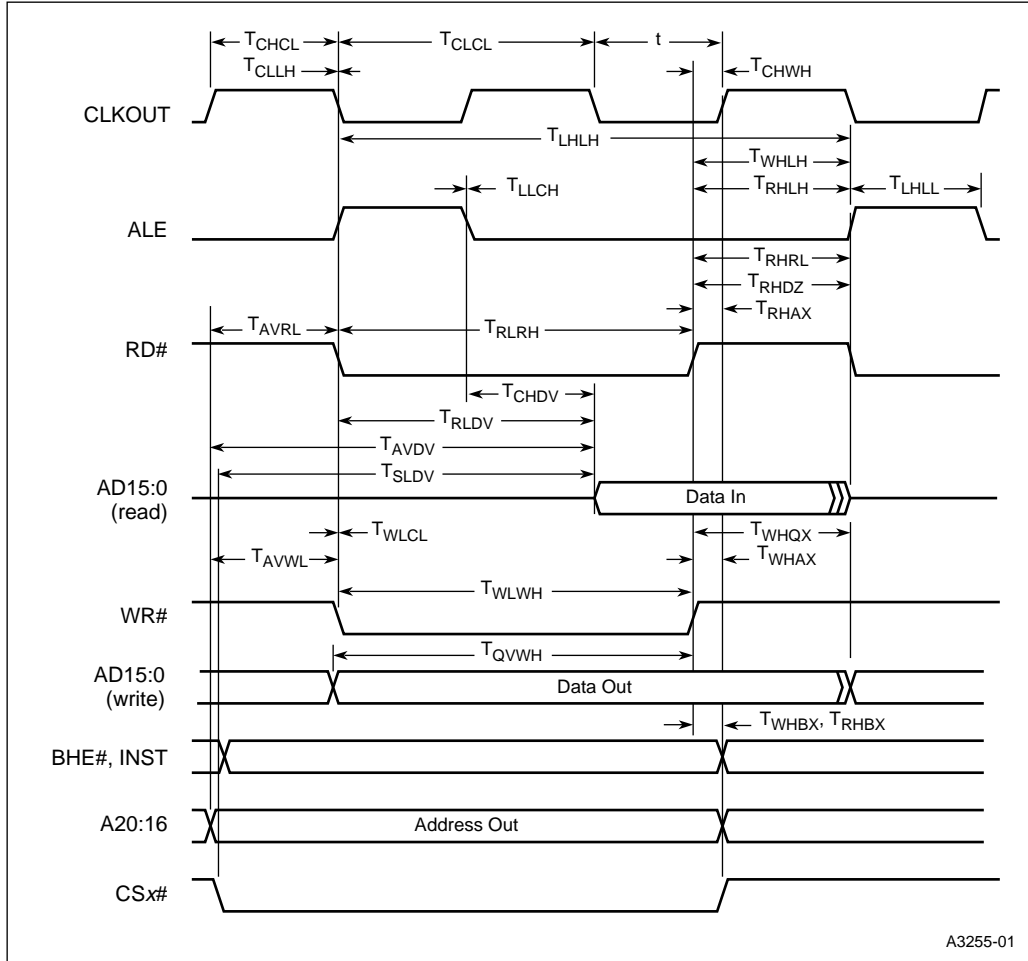


Figure 6. System Bus Timing Diagram (Demultiplexed Bus Mode)

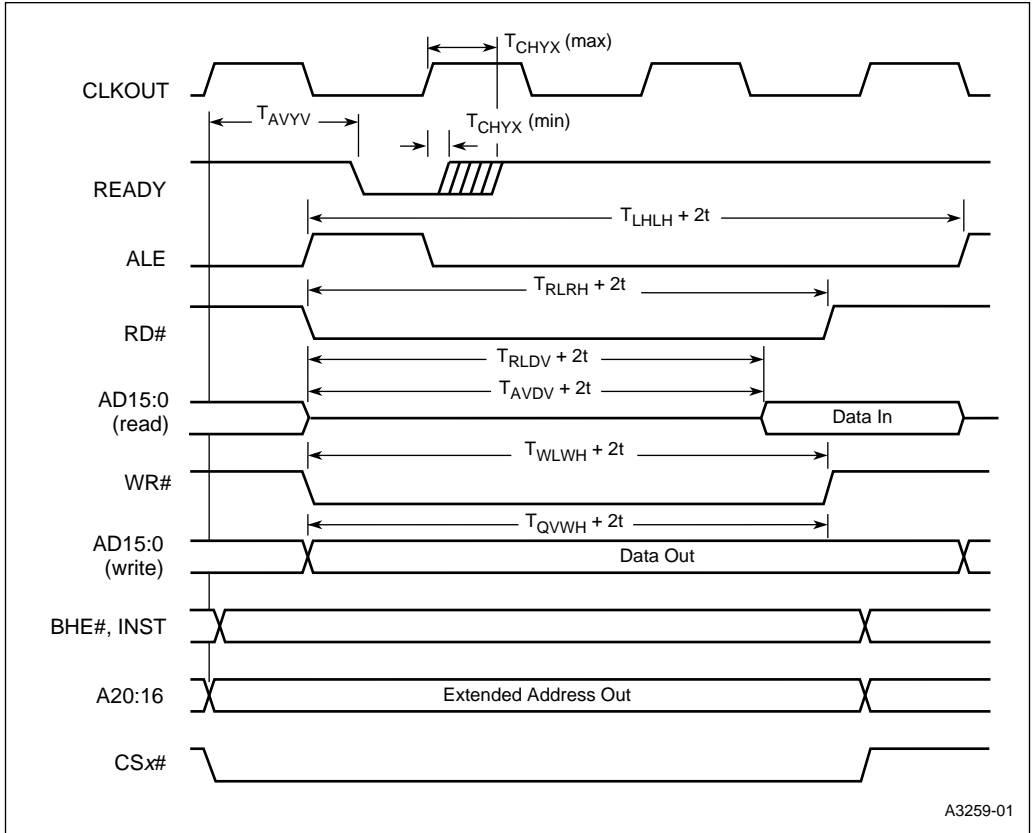


Figure 7. READY Timing Diagram (Demultiplexed Bus Mode)

## 5.4 Deferred Bus Timing Mode

Deferred Bus Cycle Mode: This bus mode (enabled by setting CCB1.5) reduces bus contention when using the 83C196EA in demultiplexed mode with slow memories. As shown in Figure 8, a delay of  $2t$  occurs in the first bus cycle following a chip-select output change and the first write cycle following a read cycle.

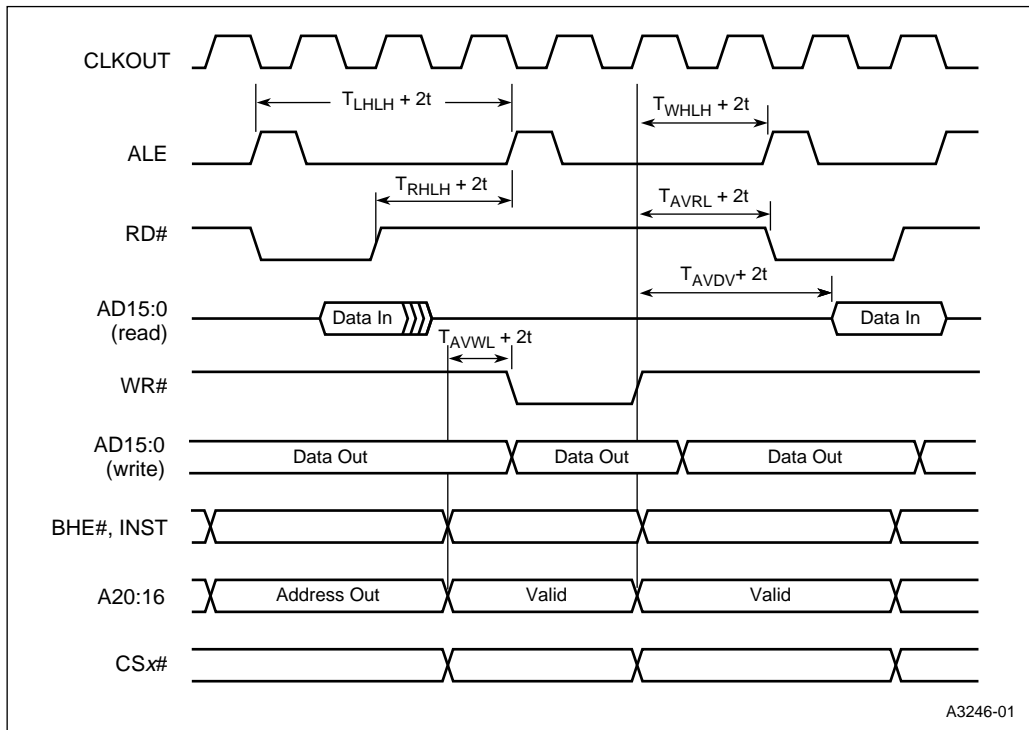


Figure 8. Deferred Bus Mode Timing Diagram

### 5.5 HOLD#/HLDA# Timings

Table 10. HOLD#/HLDA# Timings

Symbol	Parameter	Min	Max	Units
$T_{HVCH}$	HOLD# Setup Time	65		ns <sup>†</sup>
$T_{CLHAL}$	CLKOUT Low to HLDA# Low	-15	15	ns
$T_{CLBRL}$	CLKOUT Low to BREQ# Low	-15	15	ns
$T_{HALAZ}$	HLDA# Low to Address Float		33	ns
$T_{HALBZ}$	HLDA# Low to BHE#, INST, RD#, WR# Weakly Driven		25	ns
$T_{CLHAH}$	CLKOUT Low to HLDA# High	-25	15	ns
$T_{CLBRH}$	CLKOUT Low to BREQ# High	-25	25	ns
$T_{HAHAX}$	HLDA# High to Address No Longer Float	-20		ns
$T_{HAHBV}$	HLDA# High to BHE#, INST, RD#, WR# Valid	-20		ns

<sup>†</sup> To guarantee recognition at next clock.

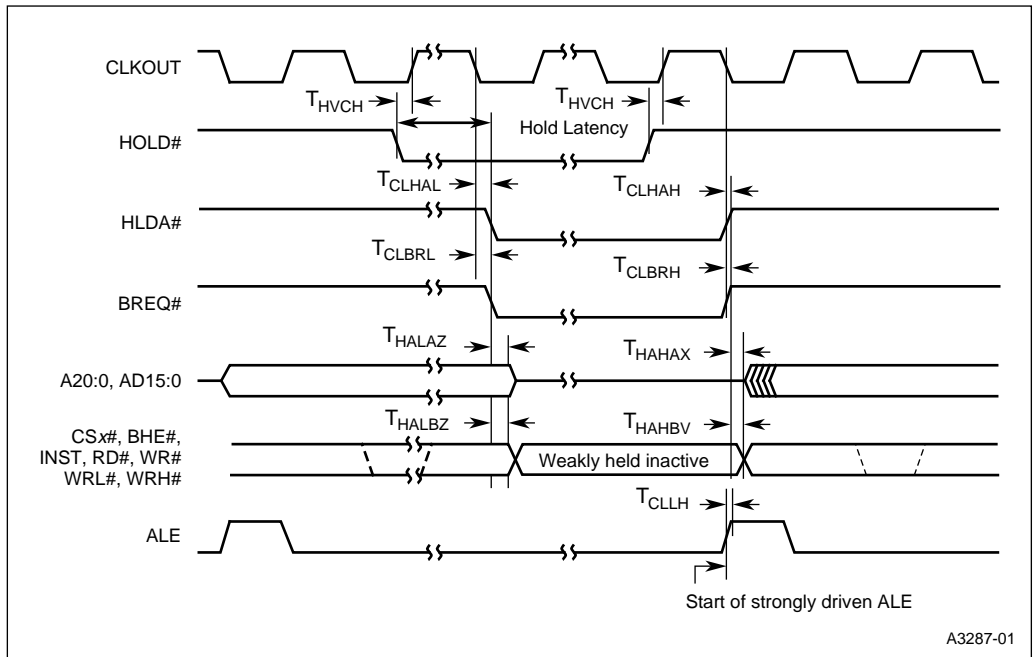


Figure 9. HOLD#/HLDA# Timing Diagram

## 5.6 AC Characteristics — Serial Port, Shift Register Mode

Table 11. Serial Port Timing — Shift Register Mode

Symbol	Parameter	Min	Max	Units
$T_{XLXL}$	Serial Port Clock period SP_BAUD $\geq$ x002H SP_BAUD = x001H <sup>†</sup>	6t 4t		ns ns
$T_{XLXH}$	Serial Port Clock falling edge to rising edge SP_BAUD $\geq$ x002H SP_BAUD = x001H <sup>†</sup>	4t - 27 2t - 27	4t + 27 2t + 27	ns ns
$T_{QVXH}$	Output data setup to clock high	4t - 30		ns
$T_{XHQX}$	Output data hold after clock high	2t - 30		ns
$T_{XHQV}$	Next output data valid after clock high		2t + 30	ns
$T_{DVXH}$	Input data setup to clock high	2t + 30		ns
$T_{XHDX}$	Input data hold after clock high	0		ns
$T_{XHQZ}$	Last clock high to output float		t + 30	ns

<sup>†</sup> The minimum baud-rate (SP\_BAUD) register value for receive is x002H and the minimum baud-rate (SP\_BAUD) register value for transmit is x001H.

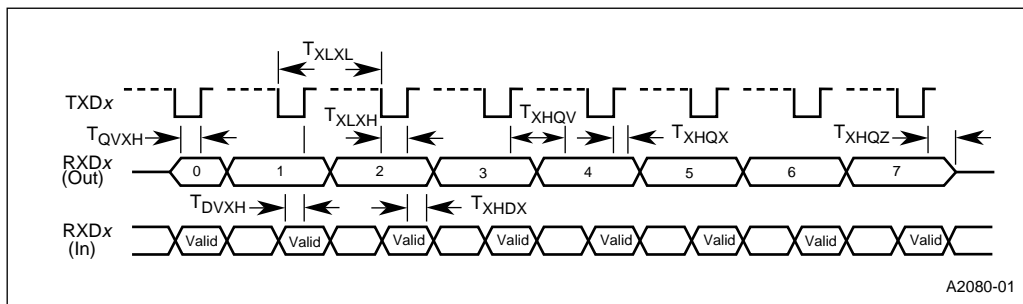


Figure 10. Serial Port Waveform — Shift Register Mode

### 5.7 AC Characteristics — Synchronous Serial Port

Table 12. Synchronous Serial Port Timing

Symbol	Parameter	Min	Max	Units
$T_{CLCL}$	Synchronous Serial Port Clock period	TBD	TBD	ns
$T_{CLCH}$	Synchronous Serial Port Clock falling edge to rising edge	TBD	TBD	ns
$T_{D1VD}$	Setup time for MSB output	TBD		ns
$T_{CXDV}$	Setup time for D6:0 output	$1.5t + 20$		ns
$T_{CXDX}$	Output data hold after clock high	$0.5t$		ns
$T_{DVCX}$	Setup time for input data	10		ns
$T_{DXCX}$	Input data hold after clock high	$t + 5$		ns

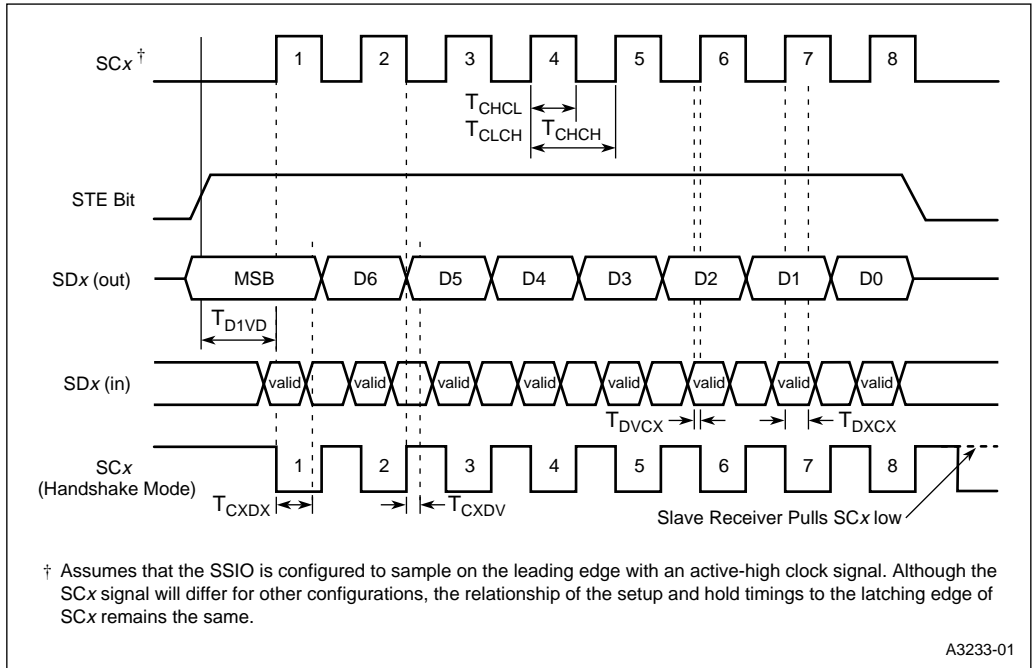


Figure 11. Synchronous Serial Port

## 5.8 A/D Sample and Conversion Times

Two parameters, sample time and conversion time, control the time required for an A/D conversion. The sample time is the length of time that the analog input voltage is actually connected to the sample capacitor. If this time is too short, the sample capacitor will not charge completely. If the sample time is too long, the input voltage may change and cause conversion errors. The conversion time is the length of time required to convert the analog input voltage stored on the sample capacitor to a digital value. The conversion time must be long enough for the comparator and circuitry to settle and resolve the voltage. Excessively long conversion times allow the sample capacitor to discharge, degrading accuracy.

The AD\_TIME register programs the A/D sample and conversion times. Use the  $T_{\text{SAM}}$  and  $T_{\text{CONV}}$  specifications in Tables 13 and 15 to determine appropriate values for SAM and CONV; otherwise, erroneous conversion results may occur.

When the SAM and CONV values are known, write them to the AD\_TIME register. Do not write to this register while a conversion is in progress; the results are unpredictable.

Use the following formulas to determine the SAM and CONV values.

$$\text{SAM} = \frac{T_{\text{SAM}} \times f - 2}{8} \quad \text{CONV} = \left[ \frac{T_{\text{CONV}} \times f - 3}{2 \times B} \right] - 1$$

where:

- SAM equals a number, 1 to 7
- CONV equals a number, 2 to 31
- $T_{\text{SAM}}$  is the sample time, in  $\mu\text{sec}$   
(Tables 13 and 15)
- $T_{\text{CONV}}$  is the conversion time, in  $\mu\text{sec}$   
(Tables 13 and 15)
- f is the operating frequency, in MHz
- B is the number of bits to be converted  
(8 or 10)

### 5.8.1 AC CHARACTERISTICS — A/D CONVERTER, 10-BIT MODE

Table 13. 10-bit A/D Operating Conditions (1)

Symbol	Description	Min	Max	Units	Notes
$T_{\text{C}}$	Case Temperature	- 40	+ 125	$^{\circ}\text{C}$	
$V_{\text{CC}}$	Digital Supply Voltage	4.50	5.50	V	
$V_{\text{REF}}$	Analog Supply Voltage	4.50	5.50	V	2

#### NOTES:

- ANGND and  $V_{\text{SS}}$  should nominally be at the same potential.
- $V_{\text{REF}}$  must not exceed  $V_{\text{CC}}$  by more than + 0.5 V because  $V_{\text{REF}}$  supplies both the resistor ladder and the analog portion of the converter and input port pins.
- Program the AD\_TIME register to meet the  $T_{\text{SAM}}$  and  $T_{\text{CONV}}$  specifications.



**Table 13. 10-bit A/D Operating Conditions (1) (Continued)**

Symbol	Description	Min	Max	Units	Notes
$T_{SAM}$	Sample Time	1.0		$\mu\text{s}$	3
$T_{CONV}$	Conversion Time	10.0	15.0	$\mu\text{s}$	3

**NOTES:**

1.  $ANGND$  and  $V_{SS}$  should nominally be at the same potential.
2.  $V_{REF}$  must not exceed  $V_{CC}$  by more than + 0.5 V because  $V_{REF}$  supplies both the resistor ladder and the analog portion of the converter and input port pins.
3. Program the  $AD\_TIME$  register to meet the  $T_{SAM}$  and  $T_{CONV}$  specifications.

**Table 14. 10-bit Mode A/D Characteristics Over Specified Operating Conditions (7)**

Parameter	Typical (2)	Min	Max	Units (1)	Notes
Resolution		1024 10	1024 10	Levels Bits	
Absolute Error		0	$\pm 3.0$	LSBs	
Full-scale Error	$0.25 \pm 0.5$			LSBs	
Zero Offset Error	$0.25 \pm 0.5$			LSBs	
Nonlinearity	$1.0 \pm 2.0$		$\pm 3.0$	LSBs	
Differential Nonlinearity		- 0.75	+ 0.75	LSBs	
Channel-to-channel Matching	$\pm 0.1$	0	$\pm 1.0$	LSBs	
Repeatability	$\pm 0.25$	0		LSBs	
Temperature Coefficients: Offset Full-scale Differential Nonlinearity	0.009 0.009 0.009			LSB/C LSB/C LSB/C	
Off-isolation		- 60		dB	2, 3, 4
Feedthrough	- 60			dB	2, 3
$V_{CC}$ Power Supply Rejection	- 60			dB	2, 3
Input Series Resistance		750	1.2K	$\Omega$	5

**NOTES:**

1. An *LSB*, as used here, has a value of approximately 5 mV.
2. Most parts will need these values at 25°C, but they are not tested or guaranteed.
3. DC to 100 KHz.
4. Multiplexer break-before-make guaranteed.
5. Resistance from device pin, through internal multiplexer, to sample capacitor.
6. Applying voltage beyond these specifications will degrade the accuracy of other channels being converted.
7. All conversions were performed with processor in idle mode.
8.  $100\text{ mV} < V_{IN} < V_{REF} - 100\text{ mV}$ .

Table 14. 10-bit Mode A/D Characteristics Over Specified Operating Conditions (7) (Continued)

Parameter	Typical (2)	Min	Max	Units (1)	Notes
Voltage on Analog Input Pin		ANGND	$V_{REF}$	V	6
Sampling Capacitor	3.0			pF	
DC Input Leakage	$\pm 100$	0	$\pm 300$	nA	8

**NOTES:**

1. An *LSB*, as used here, has a value of approximately 5 mV.
2. Most parts will need these values at 25°C, but they are not tested or guaranteed.
3. DC to 100 KHz.
4. Multiplexer break-before-make guaranteed.
5. Resistance from device pin, through internal multiplexer, to sample capacitor.
6. Applying voltage beyond these specifications will degrade the accuracy of other channels being converted.
7. All conversions were performed with processor in idle mode.
8.  $100 \text{ mV} < V_{IN} < V_{REF} - 100 \text{ mV}$ .

**5.8.2 AC CHARACTERISTICS — A/D CONVERTER, 8-BIT MODE**
**Table 15. 8-bit A/D Operating Conditions (1)**

Symbol	Description	Min	Max	Units	Notes
$T_C$	Case Temperature	- 40	+ 125	°C	
$V_{CC}$	Digital Supply Voltage	4.50	5.50	V	
$V_{REF}$	Analog Supply Voltage	4.50	5.50	V	2
$T_{SAM}$	Sample Time	1.0		μs	3
$T_{CONV}$	Conversion Time	8.0	15.0	μs	3

**NOTES:**

1. ANGNDD and  $V_{SS}$  should nominally be at the same potential.
2.  $V_{REF}$  must not exceed  $V_{CC}$  by more than + 0.5 V because  $V_{REF}$  supplies both the resistor ladder and the analog portion of the converter and input port pins.
3. Program the AD\_TIME register to meet the  $T_{SAM}$  and  $T_{CONV}$  specifications.

**Table 16. 8-bit Mode A/D Characteristics Over Specified Operating Conditions (7)**

Parameter	Typical (2)	Min	Max	Units (1)	Notes
Resolution		256 8	256 8	Levels Bits	
Absolute Error		0	± 1.0	LSBs	
Full-scale Error	± 0.5			LSBs	
Zero Offset Error	± 0.5			LSBs	
Nonlinearity		0	± 1.0	LSBs	
Differential Nonlinearity		- 0.5	+ 0.5	LSBs	
Channel-to-channel Matching		0	± 1.0	LSBs	
Repeatability	± 0.25	0		LSBs	
Temperature Coefficients:					
Offset	0.003			LSB/°C	
Full-scale	0.003			LSB/°C	
Differential Nonlinearity	0.003			LSB/°C	

**NOTES:**

1. An LSB, as used here, has a value of approximately 5 mV.
2. Most parts will need these values at 25°C, but they are not tested or guaranteed.
3. DC to 100 KHz.
4. Multiplexer break-before-make guaranteed.
5. Resistance from device pin, through internal multiplexer, to sample capacitor.
6. Applying voltage beyond these specifications will degrade the accuracy of other channels being converted.
7. All conversions were performed with processor in idle mode.
8.  $100\text{ mV} < V_{IN} < V_{REF} - 100\text{ mV}$ .

Table 16. 8-bit Mode A/D Characteristics Over Specified Operating Conditions (7) (Continued)

Parameter	Typical (2)	Min	Max	Units (1)	Notes
Off Isolation		- 60		dB	2, 3, 4
Feedthrough	- 60			dB	2, 3
V <sub>CC</sub> Power Supply Rejection	- 60			dB	2, 3
Input Series Resistance		750	1.2K	Ω	5
Voltage on Analog Input Pin		ANGND	V <sub>REF</sub>	V	6
Sampling Capacitor	3.0			pF	
DC Input Leakage	100	0	300	nA	8

**NOTES:**

1. An *LSB*, as used here, has a value of approximately 5 mV.
2. Most parts will need these values at 25°C, but they are not tested or guaranteed.
3. DC to 100 KHz.
4. Multiplexer break-before-make guaranteed.
5. Resistance from device pin, through internal multiplexer, to sample capacitor.
6. Applying voltage beyond these specifications will degrade the accuracy of other channels being converted.
7. All conversions were performed with processor in idle mode.
8. 100 mV < V<sub>IN</sub> < V<sub>REF</sub> - 100 mV.

## 5.9 External Clock Drive

Table 17. External Clock Drive

Symbol	Parameter	Min	Max	Units
1/T <sub>XLXL</sub>	Oscillator Frequency (F <sub>XTAL1</sub> )	8	32 (1)	MHz (2)
T <sub>XLXL</sub>	Oscillator Period (T <sub>XTAL1</sub> )	62.5	125	ns
T <sub>XHXX</sub>	High Time	0.35T <sub>XTAL1</sub>	0.65T <sub>XTAL1</sub>	ns
T <sub>XLXX</sub>	Low Time	0.35T <sub>XTAL1</sub>	0.65T <sub>XTAL1</sub>	ns
T <sub>XLXH</sub>	Rise Time		10	ns
T <sub>XHXL</sub>	Fall Time		10	ns

**NOTE:**

1. 16 MHz is the maximum input frequency when using an external crystal oscillator; however, 32 MHz can be applied with an external clock source.
2. These values represent PLL-bypass mode.

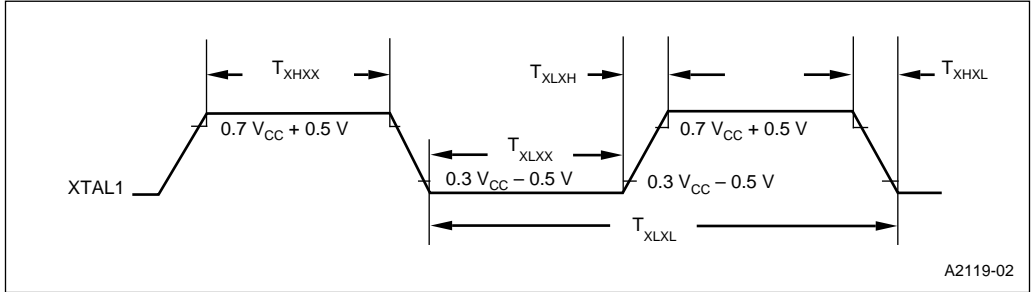


Figure 12. External Clock Drive Waveforms

### 5.10 Test Output Waveforms

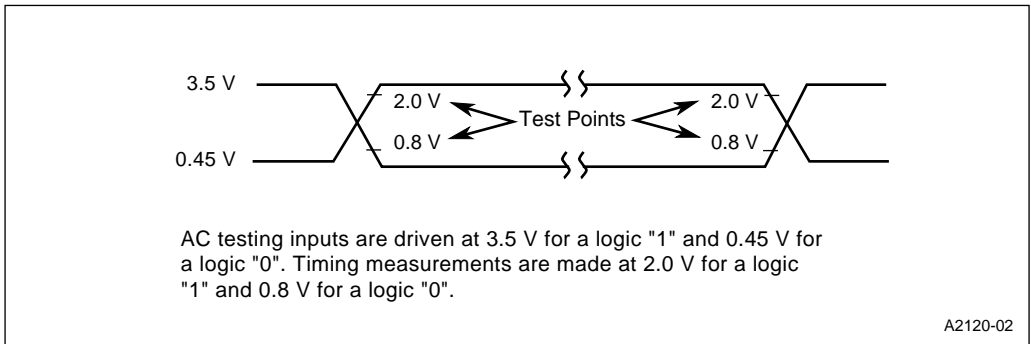


Figure 13. AC Testing Output Waveforms

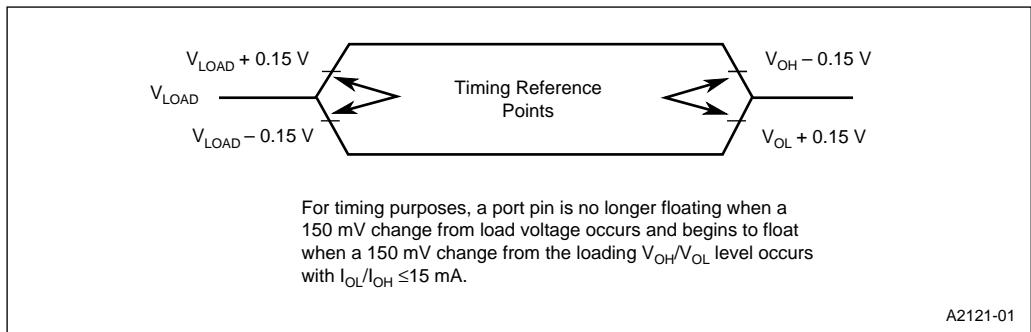


Figure 14. Float Waveforms During 5.0 Volt Testing

## 6.0 THERMAL CHARACTERISTICS

All thermal impedance data is approximate for static air conditions at 1 watt of power dissipation. Values will change depending on operating conditions and the application. 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 18. Thermal Characteristics**

Package Type	$\theta_{JA}$	$\theta_{JC}$
160-pin QFP	34°C/W	5°C/W

## 7.0 DATASHEET REVISION HISTORY

This datasheet is valid for devices with an "A" at the end of the topside field process order (FPO) number. 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.

1. The input frequency on XTAL1, formerly called  $F_{OSC}$ , is now called  $F_{XTAL1}$ . The internal operating frequency and operating period are denoted by (f) and (t), respectively.