



PRELIMINARY

80296SA COMMERCIAL CHMOS 16-BIT MICROCONTROLLER

- 50 MHz Operation[†]
- 6 Mbytes of Linear Address Space
- 512 Bytes of Register RAM
- 2 Kbytes of Code/Data RAM
- Register-register Architecture
- Footprint and Functionally Compatible Upgrade for the 8XC196NP and 80C196NU
- Optional Phase-locked Loop (PLL) Circuitry with 2x or 4x Clock Multiplier
- 32 I/O Port Pins
- 19 Interrupt Sources, 14 with Programmable Priorities
- 4 External Interrupt Pins and NMI Pin
- 2 Flexible 16-bit Timer/Counters with Quadrature Counting Capability
- 3 Pulse-width Modulator (PWM) Outputs with High Drive Capability
- Full-duplex Serial Port with Dedicated Baud-rate Generator
- Chip-select Unit
 - 6 Chip-select Pins
 - Dynamic Demultiplexed/Multiplexed Address/Data Bus for Each Chip Select
 - Programmable Wait States (0–15) 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) with 4 High-speed Capture/Compare Channels
- Multiply and Accumulate Executes in 80 ns Using the 40-bit Hardware Accumulator
- 880 ns 32/16 Unsigned Division
- 100-pin QFP Package
- Complete System Development Support
- High-speed CHMOS Technology

[†] 40 MHz standard; 50 MHz is Speed Premium

The 80296SA is a member of Intel's 16-bit MCS[®] 96 microcontroller family. The 80296SA features 6 Mbytes of linear address space, a demultiplexed bus, and a chip-select unit. The external bus can dynamically switch between multiplexed and demultiplexed operation. The device has hardware and instructions to support various digital signal processing algorithms.

NOTE

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**80296SA Commercial
CHMOS 16-bit Microcontroller**

1.0	Product Overview	1
2.0	Nomenclature Overview	2
3.0	Pinout	3
4.0	Signals	6
5.0	Address Map	13
6.0	Electrical Characteristics	14
6.1	DC Characteristics	14
6.2	AC Characteristics	18
6.2.1	Relationship of XTAL1 to CLKOUT	18
6.2.2	Explanation of AC Symbols	19
6.2.3	AC Characteristics — Multiplexed Bus Mode	20
6.2.3.1	System Bus Timings, Multiplexed Bus	22
6.2.3.2	READY Timing, Multiplexed Bus	23
6.2.4	AC Characteristics — Demultiplexed Bus Mode	24
6.2.4.1	System Bus Timings, Demultiplexed Bus	26
6.2.4.2	READY Timing, Demultiplexed Bus	27
6.2.4.3	80296SA Deferred Bus Timing Mode	28
6.2.5	HOLD#, HLDA# Timings	29
6.2.6	AC Characteristics — Serial Port, Synchronous Mode 0	30
6.2.7	External Clock Drive	31
7.0	Thermal Characteristics	33
8.0	80296SA Errata	33
9.0	Datasheet Revision History	33

FIGURES

1.	80296SA Block Diagram	1
2.	The 80296SA Family Nomenclature	2
3.	80296SA 100-pin QFP Package	3
4.	I_{CC} versus Frequency in Reset	17
5.	Effect of Clock Mode on CLKOUT	18
6.	System Bus Timings, Multiplexed Bus Mode	22
7.	Example READY Timings at 50 MHz, Multiplexed Bus, BUSCONx = 1 Wait State	23
8.	System Bus Timings, Demultiplexed Bus Mode	26
9.	Example READY Timings at 50 MHz, Demultiplexed Bus, BUSCONx = 1 Wait State	27
10.	Deferred Bus Mode Timing Diagram	28
11.	HOLD#, HLDA# Timing Diagram	29
12.	Serial Port Waveform — Synchronous Mode 0	30
13.	External Clock Drive Waveforms	31
14.	AC Testing Input and Output Waveforms During 5.0 Volt Testing	32
15.	Float Waveforms During 5.0 Volt Testing	32



CONTENTS

TABLES

1.	Description of Product Nomenclature	2
2.	80296SA 100-pin QFP Pin Assignment	4
3.	80296SA 100-pin QFP Pin Assignment Arranged by Functional Categories	5
4.	Signal Descriptions	6
5.	80296SA Address Map	13
6.	DC Characteristics Over Specified Operating Conditions	14
7.	AC Timing Symbol Definitions.....	19
8.	AC Characteristics the 80C296SA Will Meet, Multiplexed Bus Mode	20
9.	AC Characteristics the External Memory System Must Meet, Multiplexed Bus Mode	21
10.	AC Characteristics the 80C296SA Will Meet, Demultiplexed Bus Mode	24
11.	AC Characteristics the External Memory System Must Meet, Demultiplexed Bus Mode ..	25
12.	HOLD#, HLDA# Timings	29
13.	Serial Port Timing — Synchronous Mode 0	30
14.	External Clock Drive.....	31
15.	Thermal Characteristics	33



80296SA COMMERCIAL CHMOS 16-BIT MICROCONTROLLER

1.0 PRODUCT OVERVIEW

The 80296SA is a member of Intel's 16-bit MCS[®] 96 microcontroller family. The 80296SA features 6 Mbytes of linear address space, a demultiplexed bus, and a chip-select unit. The external bus can dynamically switch between multiplexed and demultiplexed operation. The device has hardware and instructions to support various digital signal processing algorithms.

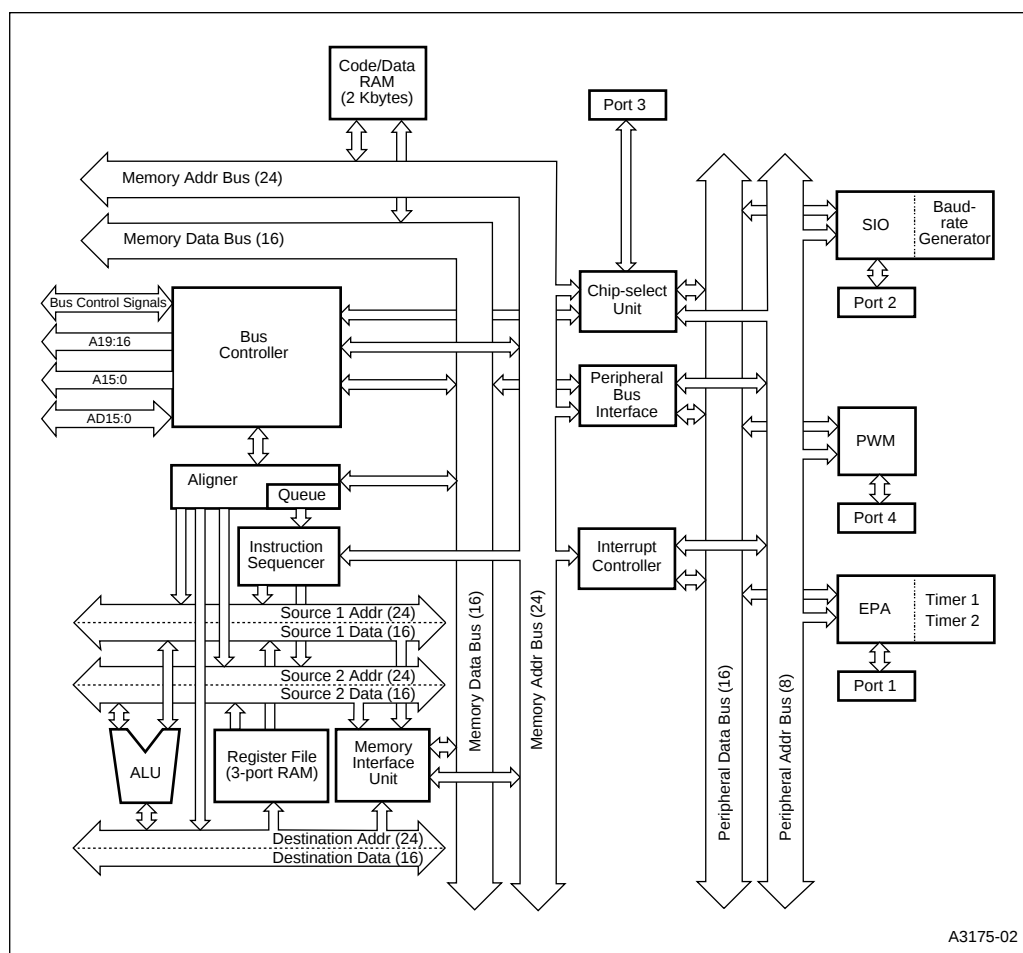


Figure 1. 80296SA Block Diagram



2.0 NOMENCLATURE OVERVIEW

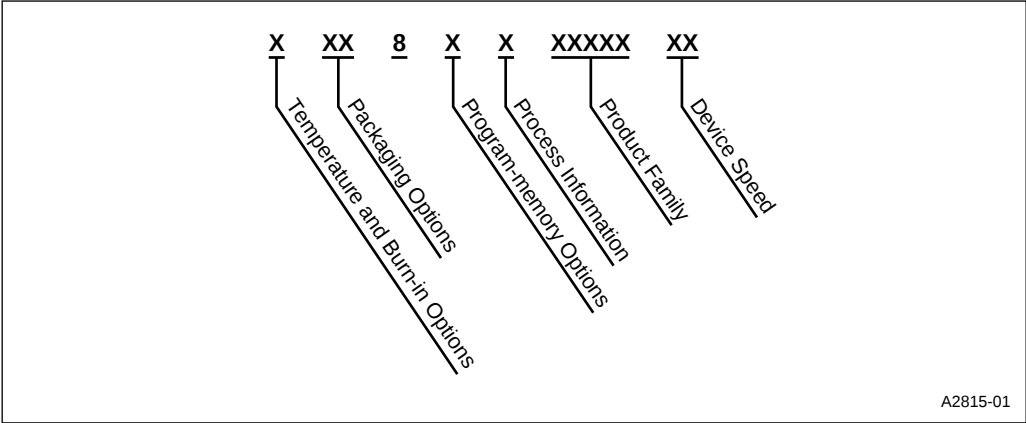


Figure 2. The 80296SA Family Nomenclature

Table 1. Description of Product Nomenclature

Parameter	Options	Description
Temperature and Burn-in Options	no mark	Commercial operating temperature range (0°C to 70°C) with Intel standard burn-in.
Packaging Options	S	QFP
Program–memory Options	0	Without ROM
Process Information	no mark	CHMOS
Product Family	296SA	—
Device Speed	40	40 MHz
	50	50 MHz



80296SA COMMERCIAL CHMOS 16-BIT MICROCONTROLLER

3.0 PINOUT

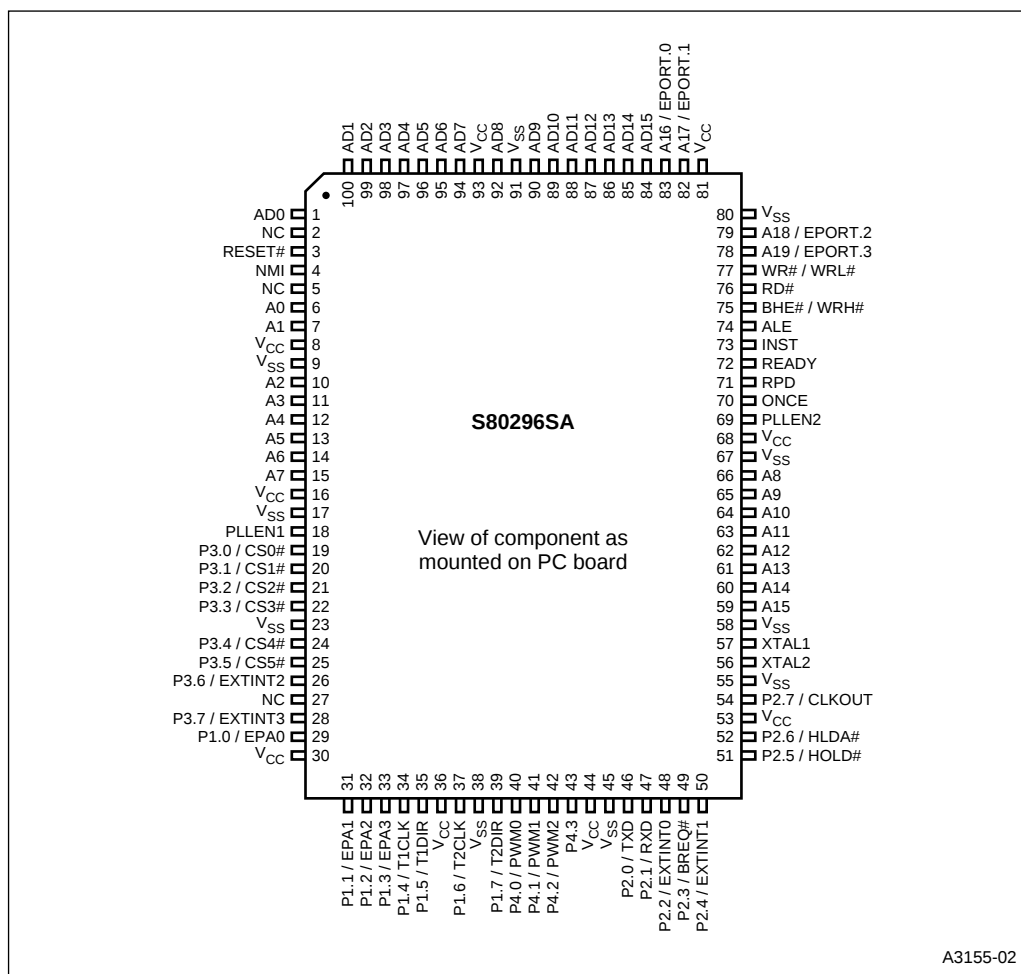


Figure 3. 80296SA 100-pin QFP Package

Table 2. 80296SA 100-pin QFP Pin Assignment

Pin	Name	Pin	Name	Pin	Name	Pin	Name
1	AD0	26	EXTINT2/P3.6	51	HOLD#/P2.5	76	RD#
2	NC (see Note)	27	NC (see Note)	52	HLDA#/P2.6	77	WR#/WRL#
3	RESET#	28	EXTINT3/P3.7	53	V _{CC}	78	EPORT.3/A19
4	NMI	29	EPA0/P1.0	54	CLKOUT/P2.7	79	EPORT.2/A18
5	NC (see Note)	30	V _{CC}	55	V _{SS}	80	V _{SS}
6	A0	31	EPA1/P1.1	56	XTAL2	81	V _{CC}
7	A1	32	EPA2/P1.2	57	XTAL1	82	EPORT.1/A17
8	V _{CC}	33	EPA3/P1.3	58	V _{SS}	83	EPORT.0/A16
9	V _{SS}	34	T1CLK/P1.4	59	A15	84	AD15
10	A2	35	T1DIR/P1.5	60	A14	85	AD14
11	A3	36	V _{CC}	61	A13	86	AD13
12	A4	37	T2CLK/P1.6	62	A12	87	AD12
13	A5	38	V _{SS}	63	A11	88	AD11
14	A6	39	T2DIR/P1.7	64	A10	89	AD10
15	A7	40	PWM0/P4.0	65	A9	90	AD9
16	V _{CC}	41	PWM1/P4.1	66	A8	91	V _{SS}
17	V _{SS}	42	PWM2/P4.2	67	V _{SS}	92	AD8
18	PLEN1	43	P4.3	68	V _{CC}	93	V _{CC}
19	CS0#/P3.0	44	V _{CC}	69	PLEN2	94	AD7
20	CS1#/P3.1	45	V _{SS}	70	ONCE	95	AD6
21	CS2#/P3.2	46	TXD/P2.0	71	RPD	96	AD5
22	CS3#/P3.3	47	RXD/P2.1	72	READY	97	AD4
23	V _{SS}	48	EXTINT0/P2.2	73	INST	98	AD3
24	CS4#/P3.4	49	BREQ#/P2.3	74	ALE	99	AD2
25	CS5#/P3.5	50	EXTINT1/P2.4	75	BHE#/WRH#	100	AD1

NOTE: For compatibility with future products, tie pin 5 to V_{CC} and leave pins 2 and 27 unconnected.



80296SA COMMERCIAL CHMOS 16-BIT MICROCONTROLLER

Table 3. 80296SA 100-pin QFP Pin Assignment Arranged by Functional Categories

Address & Data		Address & Data (continued)		Input/Output		Power & Ground	
Name	Pin	Name	Pin	Name	Pin	Name	Pin
A0	6	AD12	87	CS0#/P3.0	19	V _{CC}	8
A1	7	AD13	86	CS1#/P3.1	20	V _{CC}	16
A2	10	AD14	85	CS2#/P3.2	21	V _{CC}	30
A3	11	AD15	84	CS3#/P3.3	22	V _{CC}	36
A4	12	Bus Control & Status		CS4#/P3.4	24	V _{CC}	44
A5	13	Name	Pin	CS5#/P3.5	25	V _{CC}	53
A6	14	ALE	74	EPA0/P1.0	29	V _{CC}	68
A7	15	BHE#/WRH#	75	EPA1/P1.1	31	V _{CC}	81
A8	66	BREQ#	49	EPA2/P1.2	32	V _{CC}	93
A9	65	HOLD#	51	EPA3/P1.3	33	V _{SS}	9
A10	64	HLDA#	52	EPORT.0	83	V _{SS}	17
A11	63	INST	73	EPORT.1	82	V _{SS}	23
A12	62	RD#	76	EPORT.2	79	V _{SS}	38
A13	61	READY	72	EPORT.3	78	V _{SS}	45
A14	60	WR#/WRL#	77	P2.2	48	V _{SS}	55
A15	59	Processor Control		P2.3	49	V _{SS}	58
A16	83	Name	Pin	P2.4	50	V _{SS}	67
A17	82	CLKOUT	54	P2.5	51	V _{SS}	80
A18	79	EXTINT0	48	P2.6	52	V _{SS}	91
A19	78	EXTINT1	50	P2.7	54	No Connection	
AD0	1	EXTINT2	26	P3.6	26	Name	Pin
AD1	100	EXTINT3	28	P3.7	28	NC	2
AD2	99	NMI	4	P4.3	43	NC	5
AD3	98	ONCE	70	PWM0/P4.0	40	NC	27
AD4	97	RESET#	3	PWM1/P4.1	41		
AD5	96	RPD	71	PWM2/P4.2	42		
AD6	95	XTAL1	57	RXD/P2.1	47		
AD7	94	XTAL2	56	T1CLK/P1.4	34		
AD8	92	PLEN1	18	T1DIR/P1.5	35		
AD9	90	PLEN2	69	T2CLK/P1.6	37		
AD10	89			T2DIR/P1.7	39		
AD11	88			TXD/P2.0	46		

4.0 SIGNALS

Table 4. Signal Descriptions

Name	Type	Description												
A15:0	I/O	System Address Bus These address pins provide address bits 0–15 during the entire external memory cycle during both multiplexed and demultiplexed bus modes.												
A19:16	I/O	Address Pins 16–19 These address pins provide address bits 16–19 during the entire external memory cycle during both multiplexed and demultiplexed bus modes, supporting extended addressing of the 1-Mbyte address space. NOTE: Internally, there are 24 address bits; however, only 20 external address pins (A19:0) are implemented. The internal address space is 16 Mbytes (000000–FFFFFFH) and the external address space is 1 Mbyte (00000–FFFFFFH). The microcontroller resets to FF2080H. A19:16 share package pins with EPORT.3:0.												
AD15:0	I/O	Address/Data Lines These pins provide a multiplexed address and data bus. During the address phase of the bus cycle, address bits 0–15 are presented on the bus and can be latched using ALE or ADV#. During the data phase, 8- or 16-bit data is transferred. AD7:0 share package pins with P3.7:0. AD15:8 share package pins with P4.7:0.												
ALE	O	Address Latch Enable 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 (A19:16 and AD15:0 for a multiplexed bus; A19:0 for a demultiplexed bus). An external latch can use this signal to demultiplex address bits 0–15 from the address/data bus in multiplexed mode.												
BHE#	O	Byte High Enable [†] 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 address bit 0 (A0 for a demultiplexed address bus, AD0 for a multiplexed address/data bus), to determine which memory byte is being transferred over the system bus: <table> <tr> <th>BHE#</th><th>AD0 or A0</th><th>Byte(s) Accessed</th></tr> <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> </table> BHE# shares a package pin with WRH#. [†] Chip configuration register 0 (CCR0) determines whether this pin functions as BHE# or as WRH#. CCR0.2 = 1 selects BHE#; CCR0.2 = 0 selects WRH#.	BHE#	AD0 or A0	Byte(s) Accessed	0	0	both bytes	0	1	high byte only	1	0	low byte only
BHE#	AD0 or A0	Byte(s) Accessed												
0	0	both bytes												
0	1	high byte only												
1	0	low byte only												



80296SA COMMERCIAL CHMOS 16-BIT MICROCONTROLLER

Table 4. Signal Descriptions (Continued)

Name	Type	Description
BREQ#	O	Bus Request This active-low output signal is asserted during a hold cycle when the bus controller has a pending external memory cycle. When the bus-hold protocol is enabled (WSR.7 is set), the P2.3/BREQ# pin can function only as BREQ#, regardless of the configuration selected through the port configuration registers (P2_MODE, P2_DIR, and P2_REG). An attempt to change the pin configuration is ignored until the bus-hold protocol is disabled (WSR.7 is cleared). The microcontroller can assert BREQ# at the same time as or after it asserts HLDA#. Once it is asserted, BREQ# remains asserted until HOLD# is deasserted. BREQ# shares a package pin with P2.3.
CLKOUT	O	Clock Output Output of the internal clock generator. The CLKOUT frequency is $\frac{1}{2}$ the internal operating frequency (f). CLKOUT has a 50% duty cycle. CLKOUT shares a package pin with P2.7.
CS5:0#	O	Chip-select Lines 0–5 The active-low output CSx# is asserted during an external memory cycle when the address to be accessed is in the range programmed for chip select x or chip select x+1 if remapping is enabled. If the external memory address is outside the range assigned to the six chip selects, no chip-select output is asserted and the bus configuration defaults to the CS5# values. Immediately following reset, CS0# is automatically assigned to the range FF2000–FF20FFH. CS5:0# share package pins with P3.5:0.
EPA3:0	I/O	Event Processor Array (EPA) Capture/Compare Channels High-speed input/output signals for the EPA capture/compare channels. For high-speed PWM applications, the outputs of two EPA channels (either EPA0 and EPA1 or EPA2 and EPA3) can be remapped to produce a PWM waveform on a shared output pin. EPA3:0 share package pins with P1.3:0.
EPORT.3:0	I/O	Extended Addressing Port This is a standard 4-bit, bidirectional port. EPORT.3:0 share package pins with A19:16.

Table 4. Signal Descriptions (Continued)

Name	Type	Description
EXTINT3:0	I	External Interrupts These programmable interrupts are controlled by the EXTINT_CON register. This register controls whether the interrupt is edge-triggered or level-sensitive and whether a rising edge/high level or falling edge/low level activates the interrupt. In standby and powerdown modes, asserting the EXTINTx signal causes the device to resume normal operation. The interrupt does not need to be enabled, but the pin must be configured as a special-function input. If the EXTINTx 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. In idle mode, asserting any enabled interrupt causes the device to resume normal operation. EXTINT0 shares a package pin with P2.2, EXTINT1 shares a package pin with P2.4, EXTINT2 shares a package pin with P3.6, and EXTINT3 shares a package pin with P3.7.
HLDA#	O	Bus Hold Acknowledge This active-low output indicates that the CPU has released the bus as the result of an external device asserting HOLD#. When the bus-hold protocol is enabled (WSR.7 is set), the P2.6/HLDA# pin can function only as HLDA#, regardless of the configuration selected through the port configuration registers (P2_MODE, P2_DIR, and P2_REG). An attempt to change the pin configuration is ignored until the bus-hold protocol is disabled (WSR.7 is cleared). HLDA# shares a package pin with P2.6.
HOLD#	I	Bus Hold Request An external device uses this active-low input signal to request control of the bus. When the bus-hold protocol is enabled (WSR.7 is set), the P2.5/HOLD# pin can function only as HOLD#, regardless of the configuration selected through the port configuration registers (P2_MODE, P2_DIR, and P2_REG). An attempt to change the pin configuration is ignored until the bus-hold protocol is disabled (WSR.7 is cleared). HOLD# shares a package pin with P2.5.
INST	O	Instruction Fetch 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.



80296SA COMMERCIAL CHMOS 16-BIT MICROCONTROLLER

Table 4. Signal Descriptions (Continued)

Name	Type	Description
NMI	I	Nonmaskable Interrupt In normal operating mode, a rising edge on NMI generates a nonmaskable interrupt. NMI has the highest priority of all interrupts except trap and unimplemented opcode. Assert NMI for greater than one state time to guarantee that it is recognized. If NMI is held high during and immediately following reset, the microcontroller will execute the NMI interrupt service routine when code execution begins. To prevent an inadvertent NMI interrupt vector, the first instruction (at F2080H) must clear the NMI pending interrupt bit. ANDB INT_PEND1, #7FH. During idle mode, a rising edge on NMI causes the microcontroller to exit idle mode and branch to the interrupt service routine.
ONCE	I	On-circuit Emulation Holding ONCE high during the rising edge of RESET# places the microcontroller into on-circuit emulation (ONCE) mode. This mode puts all pins, except READY, RESET#, ONCE, and NMI, into a high-impedance state, thereby isolating the microcontroller from other components in the system. The value of ONCE is latched when the RESET# pin goes inactive. While the microcontroller is in ONCE mode, you can debug the system using a clip-on emulator. To exit ONCE mode, reset the microcontroller by pulling the RESET# signal low. To prevent inadvertent entry into ONCE mode, connect the ONCE pin to V_{SS}.
P1.7:0	I/O	Port 1 This is a standard, 8-bit, bidirectional port that shares package pins with individually selectable special-function signals. Port 1 shares package pins with the following signals: P1.0/EPA0, P1.1/EPA1, P1.2/EPA2, P1.3/EPA3, P1.4/T1CLK, P1.5/T1DIR, P1.6/T2CLK, and P1.7/T2DIR.
P2.7:0	I/O	Port 2 This is a standard, 8-bit, bidirectional port that shares package pins with individually selectable special-function signals. Port 2 shares package pins with the following signals: P2.0/TXD, P2.1/RXD, P2.2/EXTINT0, P2.3/BREQ#, P2.4/EXTINT1, P2.5/HOLD#, P2.6/HLDA#, and P2.7/CLKOUT.
P3.7:0	I/O	Port 3 This is a standard, 8-bit, bidirectional port that shares package pins with individually selectable special-function signals. Port 3 shares package pins with the following signals: P3.0/CS0#, P3.1/CS1#, P3.2/CS2#, P3.3/CS3#, P3.4/CS4#, P3.5/CS5#, P3.6/EXTINT2, and P3.7/EXTINT3.
P4.3:0	I/O	Port 4 Port 4 is a standard, 4-bit, bidirectional I/O port with high-current drive capability. Port 4 shares package pins with the following signals: P4.0/PWM0, P4.1/PWM1, and P4.2/PWM2. P4.3 has a dedicated package pin.

Table 4. Signal Descriptions (Continued)

Name	Type	Description															
PLEN2:1	I	Phase-locked Loop 1 and 2 Enable These input pins enable the on-chip clock multiplier feature and select either the doubled or the quadrupled clock speed: <table> <tr> <th>PLEN2</th><th>PLEN1</th><th>Mode</th></tr> <tr> <td>0</td><td>0</td><td>1x mode; PLL disabled; $f = F_{XTAL1}$</td></tr> <tr> <td>0</td><td>1</td><td>2x mode; PLL enabled; $f = 2F_{XTAL1}$</td></tr> <tr> <td>1</td><td>0</td><td>Reserved [†]</td></tr> <tr> <td>1</td><td>1</td><td>4x mode; PLL enabled; $f = 4F_{XTAL1}$</td></tr> </table> [†] CAUTION: This reserved combination causes the device to enter an unsupported test mode.	PLEN2	PLEN1	Mode	0	0	1x mode; PLL disabled; $f = F_{XTAL1}$	0	1	2x mode; PLL enabled; $f = 2F_{XTAL1}$	1	0	Reserved [†]	1	1	4x mode; PLL enabled; $f = 4F_{XTAL1}$
PLEN2	PLEN1	Mode															
0	0	1x mode; PLL disabled; $f = F_{XTAL1}$															
0	1	2x mode; PLL enabled; $f = 2F_{XTAL1}$															
1	0	Reserved [†]															
1	1	4x mode; PLL enabled; $f = 4F_{XTAL1}$															
PWM2:0	O	Pulse Width Modulator Outputs These are PWM output pins with high-current drive capability. The duty cycle and frequency-pulse-widths are programmable. PWM2:0 share package pins with P4.2:0.															
RD#	O	Read Read-signal output to external memory. RD# is asserted during external memory reads.															
READY	I	Ready Input This active-high input can be used to insert wait states in addition to those programmed in chip configuration byte 0 (CCB0) and the bus control x register (BUSCONx). CCB0 is programmed with the minimum number of wait states (0, 5, 10, 15) for an external fetch of CCB1, and BUSCONx is programmed with the minimum number of wait states (0–15) for all external accesses to the address range assigned to the chip-select x channel. If the programmed number of wait states is greater than zero and READY is low when this programmed number of wait states is reached, additional wait states are added until READY is pulled high. If the programmed number of wait states is equal to zero, hold the READY pin high. Programming the number of wait states equal to zero and holding the READY pin low produces unpredictable results.															
RESET#	I/O	Reset A level-sensitive reset input to, and an 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, standby, and idle modes, asserting RESET# causes the microcontroller to reset and return to normal operating mode. If the phase-locked loop (PLL) clock circuitry is enabled, you must hold RESET# low for at least 2 ms to allow the PLL to stabilize before the internal CPU and peripheral clocks are enabled. After a reset, the first instruction fetch is from FF2080H.															



80296SA COMMERCIAL CHMOS 16-BIT MICROCONTROLLER

Table 4. Signal Descriptions (Continued)

Name	Type	Description
RPD	I	Return from Powerdown Timing pin for the return-from-powerdown circuit. If your application uses powerdown mode, connect a capacitor between RPD and V_{SS} if either of the following conditions are true. • the internal oscillator is the clock source • the phase-locked loop (PLL) circuitry is enabled (see PLEN2:1 signal description) The capacitor causes a delay (at least 2 ms) that enables the oscillator and PLL circuitry to stabilize before the internal CPU and peripheral clocks are enabled. Refer to the “Special Operating Modes” chapter of the <i>80296SA Microcontroller User’s Manual</i> for details on selecting the capacitor. The capacitor is not required if your application uses powerdown mode and if both of the following conditions are true. • an external clock input is the clock source • the phase-locked loop circuitry is disabled If your application does not use powerdown mode, leave this pin unconnected.
RXD	I/O	Receive Serial Data In modes 1, 2, and 3, RXD receives serial port input data. In mode 0, it functions as either an input or an open-drain output for data. RXD shares a package pin with P2.1.
T1CLK	I	Timer 1 External Clock External clock for timer 1. Timer 1 increments (or decrements) on both rising and falling edges of T1CLK. Also used in conjunction with T1DIR for quadrature counting mode. and External clock for the serial I/O baud-rate generator input (program selectable). T1CLK shares a package pin with P1.4.
T2CLK	I	Timer 2 External Clock External clock for timer 2. Timer 2 increments (or decrements) on both rising and falling edges of T2CLK. It is also used in conjunction with T2DIR for quadrature counting mode. T2CLK shares a package pin with P1.6.
T1DIR	I	Timer 1 External Direction External direction (up/down) for timer 1. Timer 1 increments when T1DIR is high and decrements when it is low. Also used in conjunction with T1CLK for quadrature counting mode. T1DIR shares a package pin with P1.5.
T2DIR	I	Timer 2 External Direction External direction (up/down) for timer 2. Timer 2 increments when T2DIR is high and decrements when it is low. It is also used in conjunction with T2CLK for quadrature counting mode. T2DIR shares a package pin with P1.7.

Table 4. Signal Descriptions (Continued)

Name	Type	Description
TXD	O	Transmit Serial Data In serial I/O modes 1, 2, and 3, TXD transmits serial port output data. In mode 0, it is the serial clock output. TXD shares a package pin with P2.0.
V _{CC}	PWR	Digital Supply Voltage Connect each V _{CC} pin to the digital supply voltage.
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 [†] This active-low output indicates that an external write is occurring. This signal is asserted only during external memory writes. WR# shares a package pin with WRL#. [†] 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 [†] 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# shares a package pin with BHE#. [†] 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 [†] 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# shares a package pin with WR#. [†] 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, internal phase-locked loop circuitry, 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.



5.0 ADDRESS MAP

Table 5. 80296SA Address Map

Hex Address	Description (Note 1, Note 2)	Addressing Modes for Data Accesses
FFFFFF FFF800	External device (memory or I/O) in 1-Mbyte mode (CCB1.1=0) A copy of internal code RAM in 64-Kbyte mode (CCB1.1=1)	Extended
FFF7FF FF2080	External program memory (Note 3)	Extended
FF207F FF2000	External special-purpose memory (CCBs and interrupt vectors)	Extended
FF1FFF FF0400	External device (memory or I/O) connected to address/data bus	Extended
FF03FF FF0000	Reserved for in-circuit emulators	—
FEFFFF 0F0000	Overlaid memory (reserved for future devices); locations xF0000–xF03FFH are reserved for in-circuit emulators	—
0EFFFF 010000	External device (memory or I/O) connected to address/data bus	Extended
00FFFF 00F800	Internal code RAM (code or data); can be windowed by WSR1. In 64-Kbyte mode, code RAM is identically mapped into page FFH.	Indirect, indexed, extended, windowed direct
00F7FF 00F000	External device (memory or I/O) connected to address/data bus; can be windowed by WSR1	Indirect, indexed, extended, windowed direct
00EFFF 002000	External device (memory or I/O) connected to address/data bus	Indirect, indexed, extended
001FFF 001F00	Internal peripheral special-function registers (SFRs); can be windowed by WSR or WSR1	Indirect, indexed, extended, windowed direct
001EFF 001C00	Reserved (future SFR expansion)	—
001BFF 000400	External device (memory or I/O) connected to address/data bus	Indirect, indexed, extended
0003FF 000200	Reserved (future register file expansion)	—
0001FF 000100	Upper register file (general-purpose register RAM) can be windowed by WSR or WSR1	Indirect, indexed, extended windowed direct
0000FF 00001A	Lower register file (general-purpose register RAM)	Direct, indirect, indexed, extended
000019 000000	Lower register file (stack pointer and CPU SFRs)	Direct

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 occupies the boot memory partition, FF2080–FF7FFH. After reset, the default chip-select line (CS0#) is active; the first instruction fetch is from FF2080H.

6.0 ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS*

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

NOTICE: This datasheet contains information on new products in production. 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.

OPERATING CONDITIONS*

T_A (Ambient Temperature Under Bias) 0°C to +70°C
 V_{CC} (Digital 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, 2, 3) 16 MHz to 50 MHz

***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.

NOTES:

1. This device is static and should operate below 1 Hz, but has been tested only down to 16 MHz.
2. When the phase-locked loop (PLL) circuitry is enabled, the minimum input frequency on XTAL1 is 8 MHz. The PLL cannot be run at frequencies lower than 16 MHz.
3. Assumes an external clock. The maximum frequency for an external crystal oscillator is 25 MHz.

6.1 DC Characteristics

Table 6. DC Characteristics Over Specified Operating Conditions

Symbol	Parameter	Min	Typical (Note 1)	Max	Units	Test Conditions
I_{CC}	V_{CC} Supply Current		90	150	mA	XTAL1 = 50 MHz $V_{CC} = 5.5\text{ V}$ Device in Reset
I_{IDLE}	Idle Mode Current		45	60	mA	XTAL1 = 50 MHz $V_{CC} = 5.5\text{ V}$

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 temperatures below 100°C, typical is 10 μA .
3. For all pins except P4.3:0, which have higher drive capability (see V_{OL1}).
4. During normal (non-transient) conditions, the following maximum current limits apply for pin groups and individual pins:

Group	I_{OL} (mA)	I_{OH} (mA)	Individual	I_{OL} (mA)	I_{OH} (mA)
P1.7:3, P4	40	40	P1, P2, P3	10	10
P2	40	40	P4	18	10
P1.2:0, P3	40	40			

5. For all pins that were weakly pulled high during reset. This **excludes** ALE, INST, and NMI, which were weakly pulled low (see V_{OL2}) and ONCE, which was pulled medium low (see V_{OL3}).
6. Pin capacitance is not tested. This value is based on design simulations.



80296SA COMMERCIAL CHMOS 16-BIT MICROCONTROLLER

Table 6. DC Characteristics Over Specified Operating Conditions (Continued)

Symbol	Parameter	Min	Typical (Note 1)	Max	Units	Test Conditions
I_{PD}	Powerdown Mode Current		20	50	μA	$V_{CC} = 5.5 V$ (Note 2)
I_{STDBY}	Standby Mode		8	15	mA	$V_{CC} = 5.5 V$
I_{LI}	Input Leakage Current (Standard Inputs)			± 10	μA	$V_{SS} < V_{IN} < V_{CC}$
V_{IL}	Input Low Voltage (all pins)	-0.5		0.8	V	
V_{IL1}	Input Low Voltage XTAL1	-0.5		$0.3 V_{CC}$	V	
V_{IH}	Input High Voltage	$0.2 V_{CC} + 1$		$V_{CC} + 0.5$	V	
V_{IH1}	Input High Voltage XTAL1	$0.7 V_{CC}$		$V_{CC} + 0.5$	V	
V_{OL}	Output Low Voltage (output configured as complementary) (Note 3, 4)			0.3 0.45 1.5	V V V	$I_{OL} = 200 \mu A$ $I_{OL} = 3.2 mA$ $I_{OL} = 7.0 mA$
V_{OL1}	Output Low Voltage on P4.3:0 (output configured as comple- mentary) (Note 4)			0.45 0.6	V V	$I_{OL} = 8 mA$ $I_{OL} = 15 mA$
V_{OL2}	Output Low Voltage in Reset on ALE, INST, and NMI			0.45	V	$I_{OL} = 3 \mu A$
V_{OL3}	Output Low Voltage in Reset on ONCE pin			0.45	V	$I_{OL} = 30 \mu A$
V_{OL4}	Output Low Voltage on XTAL2			0.3 0.45 1.5	V V V	$I_{OL} = 100 \mu A$ $I_{OL} = 700 \mu A$ $I_{OL} = 3 mA$
V_{OH}	Output High Voltage (output configured as complementary) (Note 4)	$V_{CC} - 0.5$ $V_{CC} - 0.9$ $V_{CC} - 1.5$			V V V	$I_{OH} = -200 \mu A$ $I_{OH} = -3.2 mA$ $I_{OH} = -7.0 mA$
V_{OH1}	Output High Voltage in Reset (Note 5)	$V_{CC} - 0.7$			V	$I_{OH} = -3 \mu A$

NOTES:

1. Typical values are based on a limited number of samples and are not guaranteed. The values listed are at room temperature with $V_{CC} = 5.0 V$.
2. For temperatures below 100°C, typical is 10 μA .
3. For all pins except P4.3:0, which have higher drive capability (see V_{OL1}).
4. During normal (non-transient) conditions, the following maximum current limits apply for pin groups and individual pins:

Group	I_{OL} (mA)	I_{OH} (mA)	Individual	I_{OL} (mA)	I_{OH} (mA)
P1.7:3, P4	40	40	P1, P2, P3	10	10
P2	40	40	P4	18	10
P1.2:0, P3	40	40			

5. For all pins that were weakly pulled high during reset. This **excludes** ALE, INST, and NMI, which were weakly pulled low (see V_{OL2}) and ONCE, which was pulled medium low (see V_{OL3}).
6. Pin capacitance is not tested. This value is based on design simulations.

Table 6. DC Characteristics Over Specified Operating Conditions (Continued)

Symbol	Parameter	Min	Typical (Note 1)	Max	Units	Test Conditions
V_{OH2}	Output High Voltage on XTAL2	$V_{CC} - 0.3$ $V_{CC} - 0.7$ $V_{CC} - 1.5$			V V V	$I_{OH} = -100 \mu A$ $I_{OH} = -700 \mu A$ $I_{OH} = -3 mA$
V_{OH3}	Output High Voltage on READY in Reset	$V_{CC} - 1.1$			V	
$V_{TH+} - V_{TH-}$	Hysteresis voltage width on RESET# pin		0.3		V	
C_S	Pin Capacitance (any pin to V_{SS}) (Note 6)			10	pF	
R_{RST}	Reset Pull-up Resistor	50		150	k Ω	$V_{CC} = 5.5 V$, $V_{IN} = 4.0 V$

NOTES:

- Typical values are based on a limited number of samples and are not guaranteed. The values listed are at room temperature with $V_{CC} = 5.0 V$.
- For temperatures below 100°C, typical is 10 μA .
- For all pins except P4.3:0, which have higher drive capability (see V_{OL1}).
- During normal (non-transient) conditions, the following maximum current limits apply for pin groups and individual pins:

Group	I_{OL} (mA)	I_{OH} (mA)	Individual	I_{OL} (mA)	I_{OH} (mA)
P1.7:3, P4	40	40	P1, P2, P3	10	10
P2	40	40	P4	18	10
P1.2:0, P3	40	40			

- For all pins that were weakly pulled high during reset. This **excludes** ALE, INST, and NMI, which were weakly pulled low (see V_{OL2}) and ONCE, which was pulled medium low (see V_{OL3}).
- Pin capacitance is not tested. This value is based on design simulations.

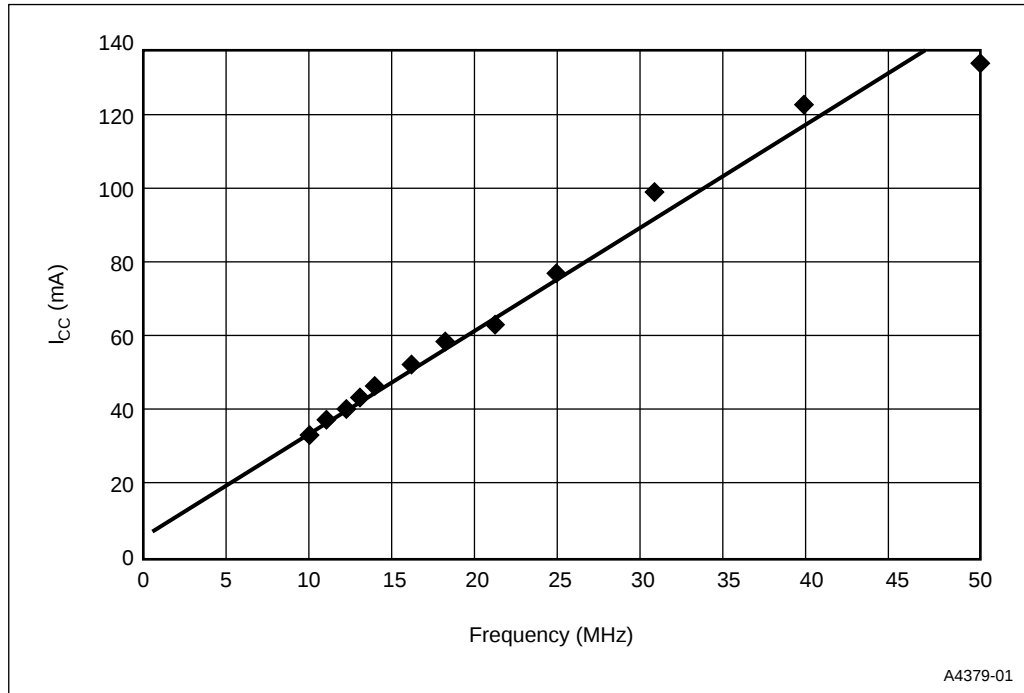


Figure 4. I_{CC} versus Frequency in Reset



6.2 AC Characteristics

6.2.1 RELATIONSHIP OF XTAL1 TO CLKOUT

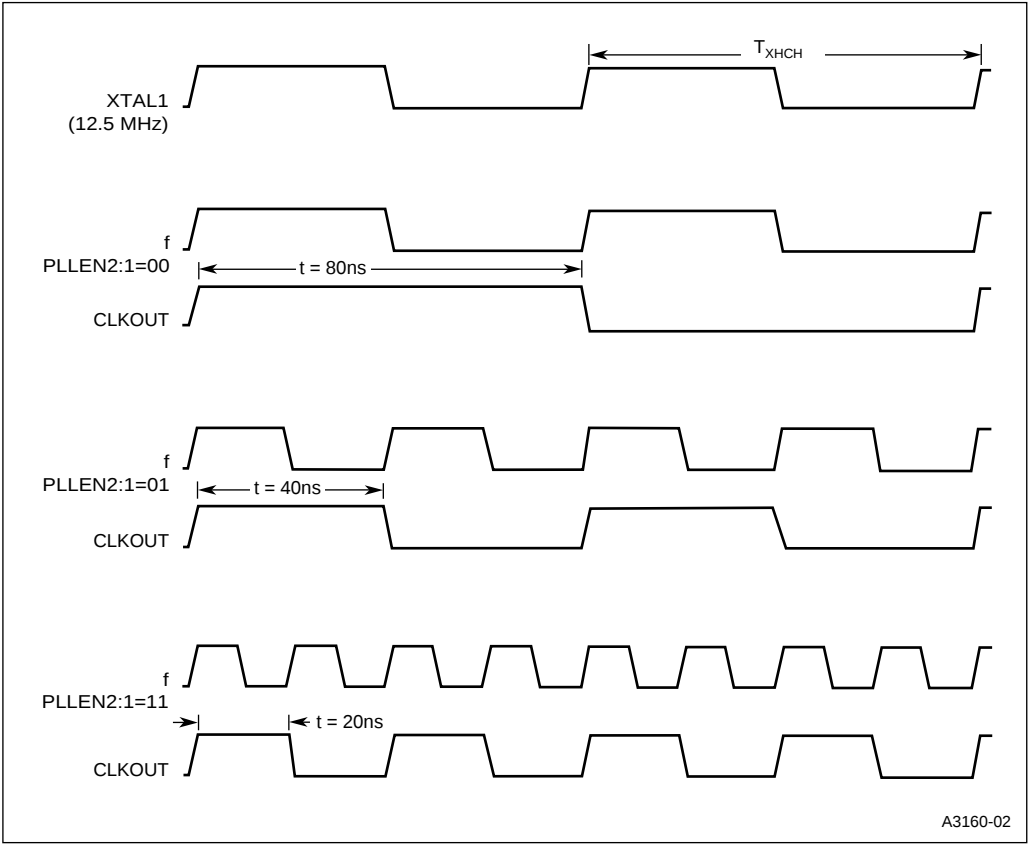


Figure 5. Effect of Clock Mode on CLKOUT



6.2.2 EXPLANATION OF AC SYMBOLS

Each AC timing symbol is two pairs of letters prefixed by "T" for time. The characters in a pair indicate a signal and its condition, respectively. Symbols represent the time between the two signal/condition points.

Table 7. AC Timing Symbol Definitions

Character	Signal(s)
A	AD15:0, A19:0
B	BHE#
BR	BREQ#
C	CLKOUT
D	AD15:0, AD7:0, RXD (SIO mode 0 input data)
H	HOLD#
HA	HLDA#
L	ALE
Q	AD15:0, AD7:0, RXD (SIO mode 0 output data)
R	RD#
S	CSx#
W	WR#, WRH#, WRL#
X	XTAL1, TXD (SIO clock)
Y	READY

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

6.2.3 AC CHARACTERISTICS — MULTIPLEXED BUS MODE

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

Table 8. AC Characteristics the 80C296SA Will Meet, Multiplexed Bus Mode

Symbol	Parameter	Min	Max	Units
F_{XTAL1}	Frequency on XTAL1, PLL in 1x mode	16	50 (1)	MHz
	Frequency on XTAL1, PLL in 2x mode	8 (2)	25	MHz
	Frequency on XTAL1, PLL in 4x mode	8 (2)	12.5	MHz
f	Operating frequency, $f = F_{XTAL1}$; PLL in 1x mode	16	50	MHz
	Operating frequency, $f = 2F_{XTAL1}$; PLL in 2x mode			
	Operating frequency, $f = 4F_{XTAL1}$; PLL in 4x mode			
t	Period, $t = 1/f$	20	62.5	ns
T_{XHCH}	XTAL1 Rising Edge to CLKOUT High or Low	3	50	ns
T_{CLCL}	CLKOUT Cycle Time	2t		ns
T_{CHCL}	CLKOUT High Period	t – 10	t + 15	ns
T_{AVWL}	Address Valid to WR# Falling Edge	2t – 25		ns
T_{CLLH}	CLKOUT Falling Edge to ALE Rising Edge	–13	10	ns
T_{LLCH}	ALE Falling Edge to CLKOUT Rising Edge	–15	15	ns
T_{LHLH}	ALE Cycle Time	4t		ns (3)
T_{LHLL}	ALE High Period	t – 10	t + 10	ns
T_{AVLL}	Address Valid to ALE Falling Edge	t – 15		ns
T_{LLAX}	Address Hold after ALE Falling Edge	1		ns
T_{LLRL}	ALE Falling Edge to RD# Falling Edge	3		ns
T_{RLCL}	RD# Low to CLKOUT Falling Edge	–10	20	ns
T_{RLRH}	RD# Low Period	2t – 25		ns (3)
T_{RHLH}	RD# Rising Edge to ALE Rising Edge	t – 5	t + 15	ns (4)
T_{RLAZ}	RD# Low to Address Float		5	ns
T_{LLWL}	ALE Falling Edge to WR# Falling Edge	4		ns
T_{QVWH}	Data Stable to WR# Rising Edge	2t – 27		ns (3)
T_{CHWH}	CLKOUT High to WR# Rising Edge	–15	5	ns
T_{WLWH}	WR# Low Period	2t – 25		ns (3)

NOTES:

1. 25 MHz is the maximum input frequency when using an external crystal oscillator; however, 50 MHz can be applied with an external clock source.
2. When the phase-locked loop (PLL) circuitry is enabled, the minimum input frequency on XTAL1 is 8 MHz. The PLL cannot be run at frequencies lower than 16 MHz.
3. If wait states are used, add $2t \times n$, where n = number of wait states.
4. Assuming back-to-back bus cycles.
5. 8-bit bus only.



80296SA COMMERCIAL CHMOS 16-BIT MICROCONTROLLER

Table 8. AC Characteristics the 80C296SA Will Meet, Multiplexed Bus Mode (Continued)

Symbol	Parameter	Min	Max	Units
T_{WHQX}	Data Hold after WR# Rising Edge	$t - 7$		ns
T_{WHLH}	WR# Rising Edge to ALE Rising Edge	$t - 15$	$t + 20$	ns
T_{WHBX}	BHE#, INST Hold after WR# Rising Edge	0		ns
T_{WHAX}	AD15:8 Hold after WR# Rising Edge	$t - 4$		ns (5)
T_{RHBX}	BHE#, INST Hold after RD# Rising Edge	0		ns
T_{RHAX}	AD15:8 Hold after RD# Rising Edge	$t - 4$		ns (5)
T_{WHSB}	A19:16, CS# Hold after WR# Rising Edge	0		ns
T_{RHSB}	A19:16, CS# Hold after RD# Rising Edge	0		ns

NOTES:

1. 25 MHz is the maximum input frequency when using an external crystal oscillator; however, 50 MHz can be applied with an external clock source.
2. When the phase-locked loop (PLL) circuitry is enabled, the minimum input frequency on XTAL1 is 8 MHz. The PLL cannot be run at frequencies lower than 16 MHz.
3. If wait states are used, add $2t \times n$, where n = number of wait states.
4. Assuming back-to-back bus cycles.
5. 8-bit bus only.

Table 9. AC Characteristics the External Memory System Must Meet, Multiplexed Bus Mode

Symbol	Parameter	Min	Max	Units
T_{AVDV}	AD15:0 Valid to Input Data Valid		$3t - 32$	ns (1, 2)
T_{RLDV}	RD# Active to Input Data Valid		$2t - 40$	ns (1, 2)
T_{SLDV}	Chip Select Low to Data Valid		$4t - 28$	ns (1, 2)
T_{CHDV}	CLKOUT High to Input Data Valid		$2t - 25$	ns
T_{RHDZ}	End of RD# to Input Data Float		$t - 3$	ns (2)
T_{RXDX}	Data Hold after RD# Inactive	0		ns
T_{AVYV}	AD15:0 Valid to READY (Inactive) Setup		$2t - 42$	ns (3)
T_{CH1YX}	First READY Hold (active) after CLKOUT High	$t - 4$	$2t - 21$	ns (4, 5)
T_{CH2YX}	Non-first READY Hold (active) after CLKOUT High	0	$2t - 21$	ns (4)
T_{YLYH}	Non-READY (Inactive) Time	$2t$	No Upper Limit	ns

NOTES:

1. If using the READY signal to insert wait states, you must program at least one wait state in the BUSCONx register because the first falling edge of READY is not synchronized with a CLKOUT edge.
2. If using the BUSCONx register **without** the READY signal to insert wait states, add $2t \times n$, where n = number of wait states.
3. If using the BUSCONx register to insert wait states, add $2t \times (n-1)$, where n = number of wait states.
4. Exceeding the maximum specification causes additional wait states.
5. If you program two or more wait states in the BUSCONx register, the T_{CH1YX} minimum does **not** apply.

6.2.3.1 System Bus Timings, Multiplexed Bus

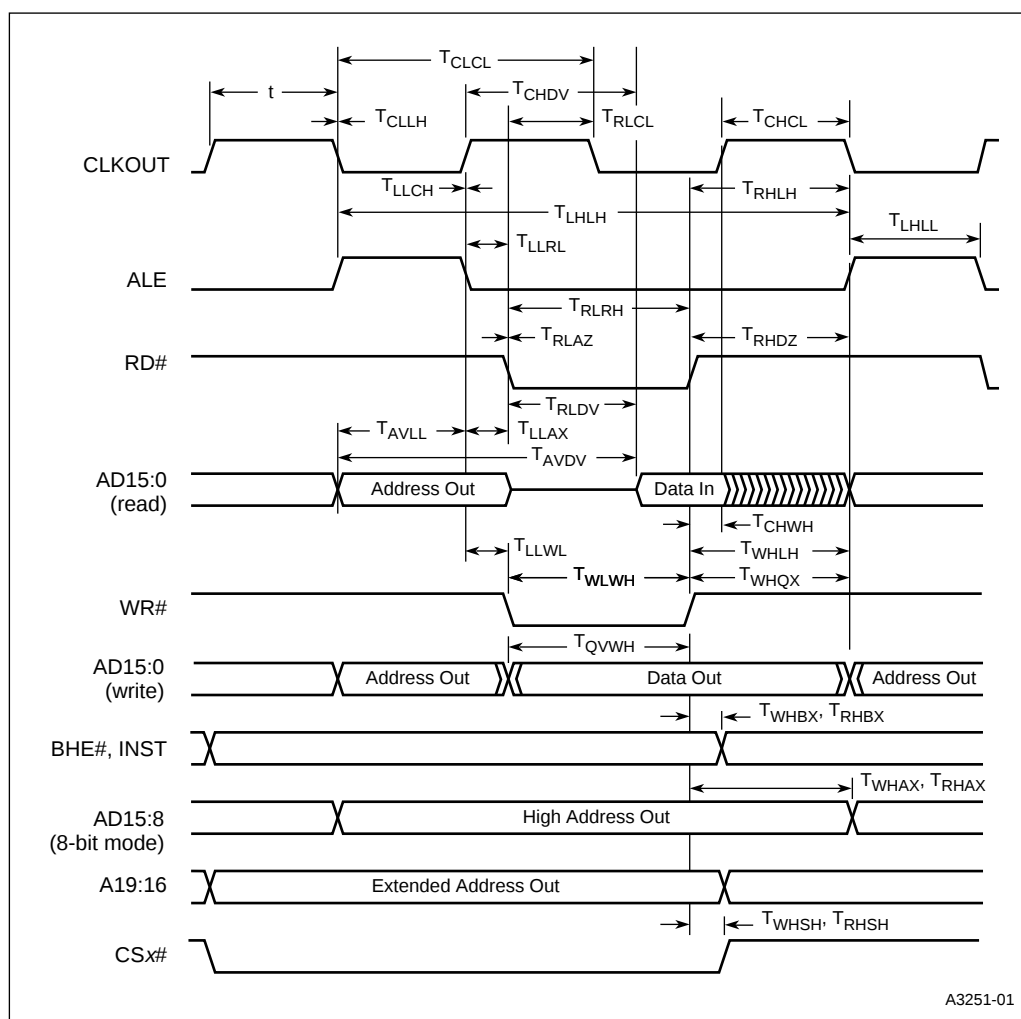


Figure 6. System Bus Timings, Multiplexed Bus Mode

6.2.3.2 READY Timing, Multiplexed Bus

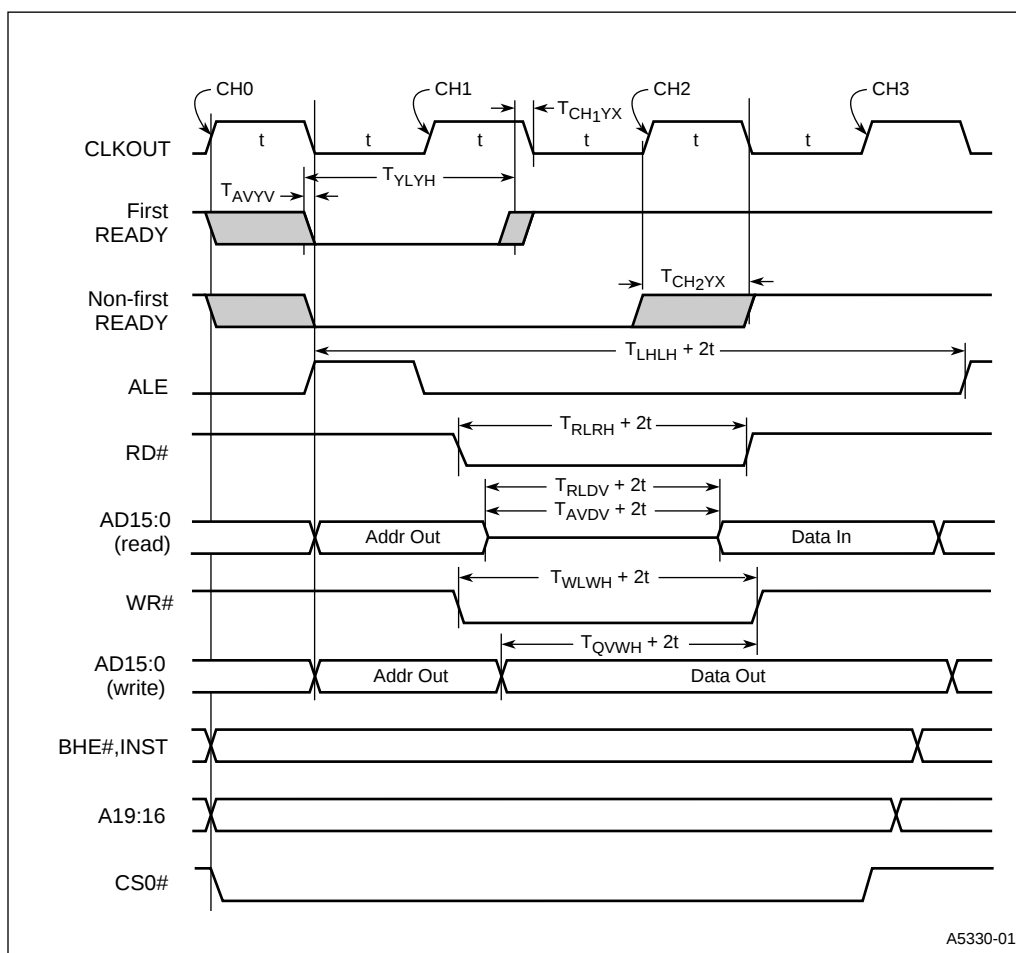


Figure 7. Example READY Timings at 50 MHz, Multiplexed Bus, BUSCONx = 1 Wait State

6.2.4 AC CHARACTERISTICS — DEMULTIPLEXED BUS MODE

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

Table 10. AC Characteristics the 80C296SA Will Meet, Demultiplexed Bus Mode

Symbol	Parameter	Min	Max	Units
F_{XTAL1}	Frequency on XTAL1, PLL in 1x mode	16	50 (1)	MHz
	Frequency on XTAL1, PLL in 2x mode	8 (2)	25	MHz
	Frequency on XTAL1, PLL in 4x mode	8 (2)	12.5	MHz
f	Operating frequency, $f = F_{XTAL1}$; PLL in 1x mode	16	50	MHz
	Operating frequency, $f = 2F_{XTAL1}$; PLL in 2x mode			
	Operating frequency, $f = 4F_{XTAL1}$; PLL in 4x mode			
t	Period, $t = 1/f$	20	62.5	ns
T_{AVWL}	Address Valid to WR# Falling Edge	$t - 10$		ns
T_{AVRL}	Address Valid to RD# Falling Edge	$t - 10$		ns
T_{RHRL}	Read High to Next Read Low	$t - 5$		ns
T_{XHCH}	XTAL1 High to CLKOUT High or Low	3	50	ns
T_{CLCL}	CLKOUT Cycle Time	$2t$		ns
T_{CHCL}	CLKOUT High Period	$t - 10$	$t + 15$	ns
T_{CLLH}	CLKOUT Falling Edge to ALE Rising Edge	-13	10	ns
T_{LLCH}	ALE Falling Edge to CLKOUT Rising Edge	-15	15	ns
T_{LHLH}	ALE Cycle Time	$4t$		ns (3,4)
T_{LHLL}	ALE High Period	$t - 10$	$t + 10$	ns
T_{RLCL}	RD# Low to CLKOUT Falling Edge	-5	11	ns
T_{RLRH}	RD# Low Period	$3t - 18$		ns (3)
T_{RHLH}	RD# Rising Edge to ALE Rising Edge	$t - 4$	$t + 15$	ns (4)
T_{WLCL}	WR# Low to CLKOUT Falling Edge	-8	9	ns
T_{QVWH}	Data Stable to WR# Rising Edge	$3t - 10$		ns (4)
T_{CHWH}	CLKOUT High to WR# Rising Edge	-11	10	ns
T_{WLWH}	WR# Low Period	$3t - 10$		ns (3)
T_{WHQX}	Data Hold after WR# Rising Edge	$t - 5$	$t + 20$	ns
T_{WHLH}	WR# Rising Edge to ALE Rising Edge	$t - 5$	$t + 10$	ns (3)

NOTES:

- 25 MHz is the maximum input frequency when using an external crystal oscillator; however, 50 MHz can be applied with an external clock source.
- When the phase-locked loop (PLL) circuitry is enabled, the minimum input frequency on XTAL1 is 8 MHz. The PLL cannot be run at frequencies lower than 16 MHz.
- If using either READY or BUSCONx to insert wait states, add $2t \times n$, where n = number of wait states.
- Assuming back-to-back bus cycles.



80296SA COMMERCIAL CHMOS 16-BIT MICROCONTROLLER

Table 10. AC Characteristics the 80C296SA Will Meet, Demultiplexed Bus Mode (Continued)

Symbol	Parameter	Min	Max	Units
T_{WHBX}	BHE#, INST Hold after WR# Rising Edge	0		ns
T_{WHAX}	A19:0, CSx# Hold after WR# Rising Edge	0		ns
T_{RHBX}	BHE#, INST Hold after RD# Rising Edge	0		ns
T_{RHAX}	A19:0, CSx# Hold after RD# Rising Edge	0		ns

NOTES:

1. 25 MHz is the maximum input frequency when using an external crystal oscillator; however, 50 MHz can be applied with an external clock source.
2. When the phase-locked loop (PLL) circuitry is enabled, the minimum input frequency on XTAL1 is 8 MHz. The PLL cannot be run at frequencies lower than 16 MHz.
3. If using either READY or BUSCONx to insert wait states, add $2t \times n$, where n = number of wait states.
4. Assuming back-to-back bus cycles.

Table 11. AC Characteristics the External Memory System Must Meet, Demultiplexed Bus Mode

Symbol	Parameter	Min	Max	Units
T_{AVDV}	A19:0 Valid to Input Data Valid		$4t - 28$	ns (1, 2, 3)
T_{RLDV}	RD# Active to Input Data Valid		$3t - 25$	ns (1, 2)
T_{SLDV}	Chip Select Low to Data Valid		$4t - 28$	ns (1, 2, 3)
T_{CHDV}	CLKOUT High to Input Data Valid		$2t - 25$	ns
T_{RHDZ}	End of RD# to Input Data Float		t	ns (2, 3)
T_{RXDX}	Data Hold after RD# Inactive	0		ns
T_{AVYV}	A19:0 Valid to READY Setup		$3t - 45$	ns (4)
T_{CH1YX}	First READY Hold (active) after CLKOUT High	$t - 4$	$2t - 21$	ns (5, 6)
T_{CH2YX}	Non-first READY Hold (active) after CLKOUT High	0	$2t - 21$	ns (5)
T_{YLYH}	Non READY (inactive) Time	$2t$	No Upper Limit	ns

NOTES:

1. If using the READY signal to insert wait states, you must program at least one wait state in the BUSCONx register because the first falling edge of READY is not synchronized with a CLKOUT edge.
2. If using the BUSCONx register **without** the READY signal to insert wait states, add $2t \times n$, where n = number of wait states.
3. If CSx# changes or if a write cycle follows a read cycle, add $2t$ (1 state).
4. If using the BUSCONx register to insert wait states, add $(2t \times n - 1)$, where n = number of wait states.
5. Exceeding the maximum specification causes additional wait states.
6. If you program two or more wait states in the BUSCONx register, the T_{CH1YX} minimum does not apply.

The diagram illustrates the timing relationships between the AD90C02 and its external components during a read cycle. The signals shown are:

- CLKOUT**: Clock output signal.
- ALE**: Address Latch Enable signal.
- RD#**: Read strobe signal.
- AD15:0 (read)**: Data bus during a read operation, labeled "Data In".
- WR#**: Write strobe signal.
- AD15:0 (write)**: Data bus during a write operation, labeled "Data Out".
- BHE#, INST**: Bus High Enable / Instruction signal.
- A19:0**: Address bus output, labeled "Address Out".
- CSx#**: Chip select signal.

Key timing parameters indicated by arrows include:

- T_{CHCL} , T_{CLLH} , T_{CHWH} , T_{LHLH} , T_{LLCH} , T_{RHLH} , T_{LHLL} , T_{RHRL} , T_{RHDZ} , T_{RHAX}
- T_{AVRL} , T_{RLRH} , T_{CHDV} , T_{RLDV} , T_{AVDV} , T_{SLDV}
- T_{WLCL} , T_{AVWL} , T_{WLWH} , T_{QVWH} , T_{WHQX} , T_{WHAX}
- T_{WHBX} , T_{RHBX}

Figure 8. System Bus Timings, Demultiplexed Bus Mode

6.2.4.2 READY Timing, Demultiplexed Bus

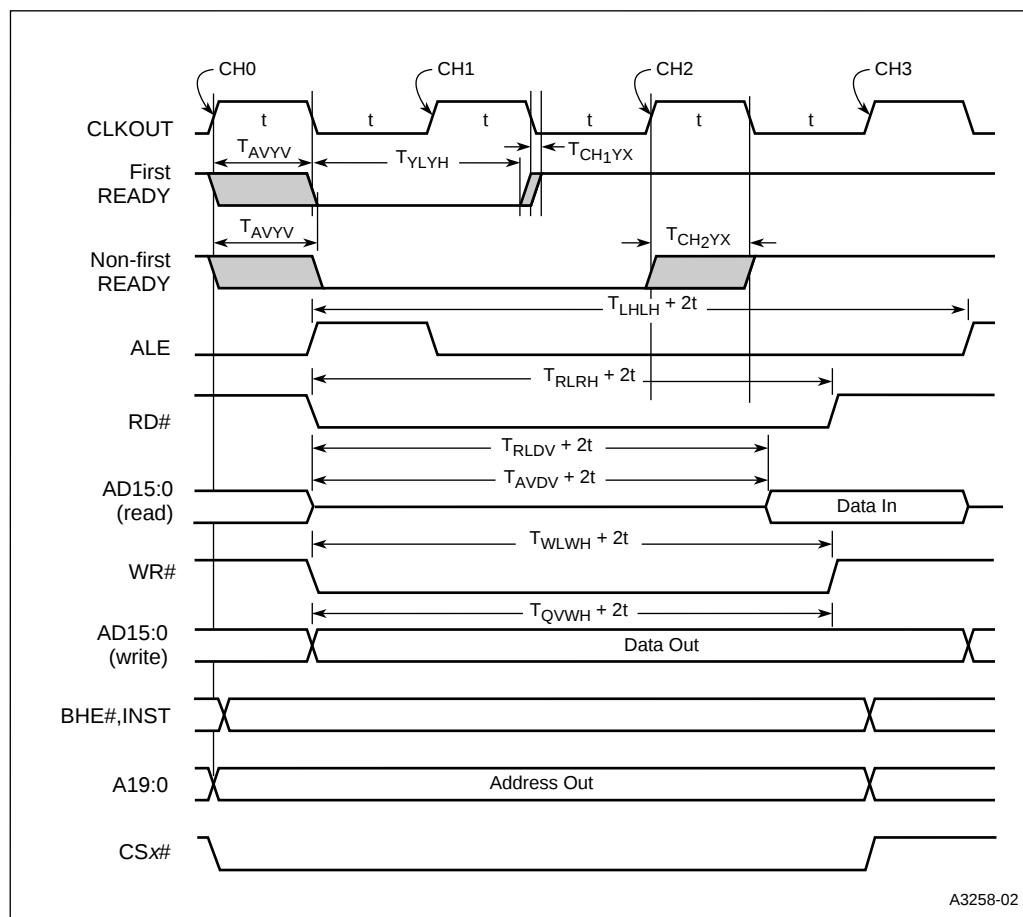


Figure 9. Example READY Timings at 50 MHz, Demultiplexed Bus, BUSCONx = 1 Wait State



6.2.4.3 80296SA Deferred Bus Timing Mode

The deferred bus cycle mode is designed to reduce bus contention when using the 80296SA in demultiplexed mode with slow memory devices. Unlike the 8XC196NU, in which this bus mode has to be enabled through the CCR to take advantage of the feature, the 80296SA **automatically invokes this mode** whenever the appropriate conditions occur. In the deferred mode, a delay of the $WR\#$ signal and the next bus cycle will occur in the first bus cycle following a chip-select change and in the first write cycle following a read cycle. This mode will work in parallel with wait states. Refer to Figure 11 to determine which control signals are affected.

Cycle 1 is a normal 4t read cycle. Cycle 2 is a write cycle that follows a read cycle, so a 2t delay of the next bus cycle is inserted. Notice that the chip-select change at the beginning of cycle 2 did not cause a double delay (4t). The chip-select change in cycle 3, a read cycle, causes a 2t delay.

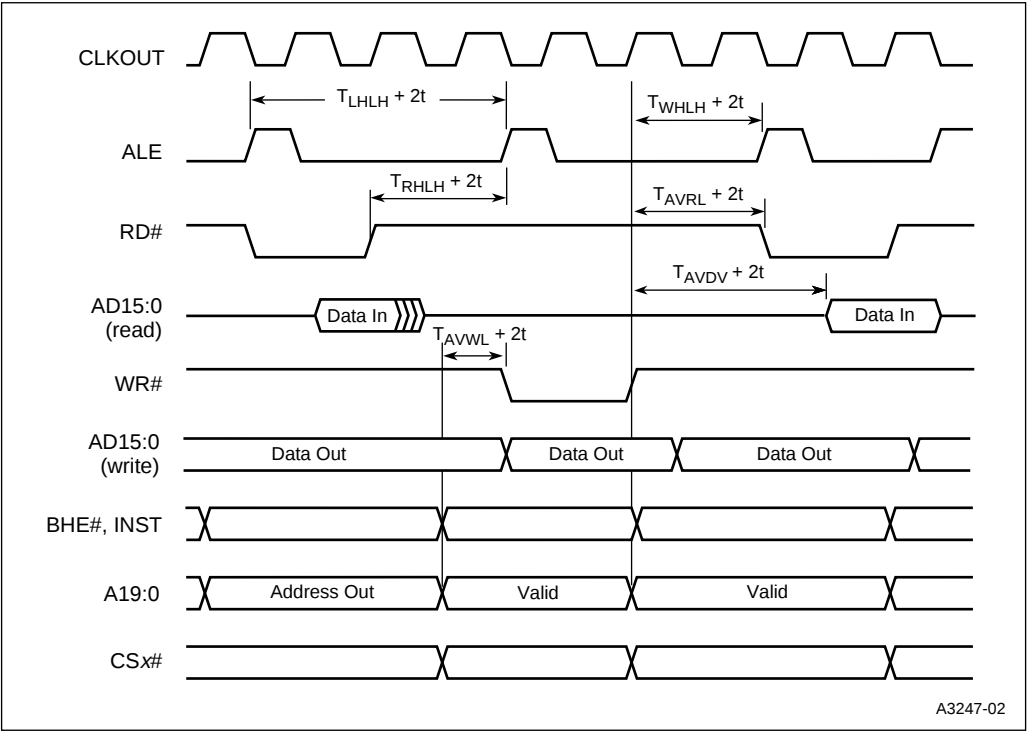


Figure 10. Deferred Bus Mode Timing Diagram



6.2.5 HOLD#, HLDA# TIMINGS

Table 12. HOLD#, HLDA# Timings

Symbol	Parameter	Min	Max	Units
T_{HVCH}	HOLD# Setup time (to guarantee recognition at next clock)	30		ns
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

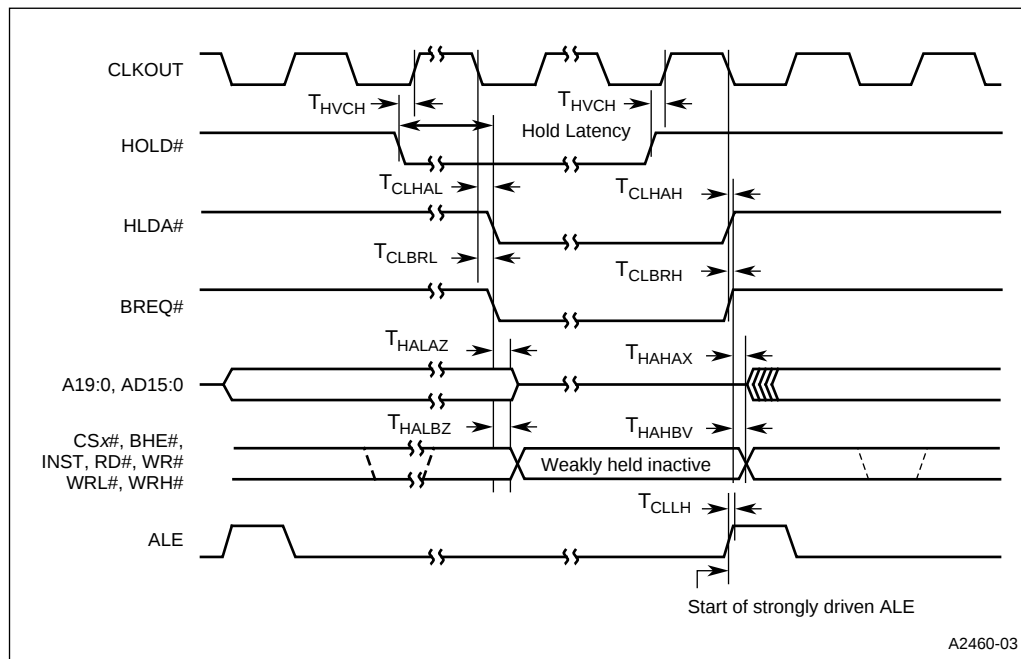


Figure 11. HOLD#, HLDA# Timing Diagram

6.2.6 AC CHARACTERISTICS — SERIAL PORT, SYNCHRONOUS MODE 0

Table 13. Serial Port Timing — Synchronous Mode 0

Symbol	Parameter	Min	Max	Units
T_{XLXL}	Serial Port Clock period [†] SP_BAUD $\geq$ x002H SP_BAUD = x001H	6t 4t		ns ns
T_{XLXH}	Serial Port Clock falling edge to rising edge [†] SP_BAUD $\geq$ x002H SP_BAUD = x001H	4t – 15 2t – 15	4t + 15 2t + 15	ns ns
T_{QVXH}	Output data setup to clock high (see Note) SP_BAUD $\geq$ x002H SP_BAUD = x001H	4t – 15 2t – 15	4t + 15 2t + 15	ns
T_{XHGX}	Output data hold after clock high	2t – 20		ns
T_{XHGV}	Next output data valid after clock high		2t + 20	ns
T_{DVXH}	Input data setup to clock high (see Note) SP_BAUD $\geq$ x002H SP_BAUD = x001H	2t + 10 t + 10		ns
T_{XHDX}	Input data hold after clock high	0		ns
T_{XHGX}	Last clock high to output float		2t + 15	ns

[†] The minimum baud-rate (SP_BAUD) register value is x002H for receptions and x001H for transmissions.

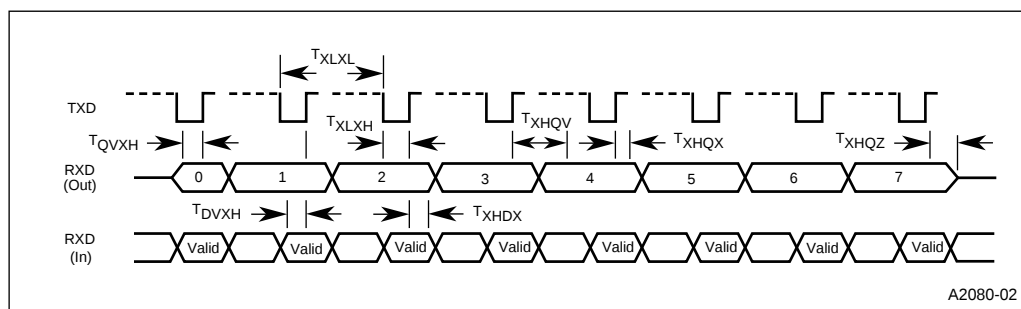


Figure 12. Serial Port Waveform — Synchronous Mode 0

6.2.7 EXTERNAL CLOCK DRIVE

Table 14. External Clock Drive

Symbol	Parameter	Min	Max	Units
F_{XTAL1}	External Input Frequency ($1/T_{XLXL}$), PLL disabled	16	50 [†]	MHz
	External Input Frequency ($1/T_{XLXL}$), PLL in 2x mode	8	25	MHz
	External Input Frequency ($1/T_{XLXL}$), PLL in 4x mode	8	12.5	MHz
T_{XTAL1}	Oscillator Period (T_{XLXL}), PLL disabled	20	62.5	ns
	Oscillator Period (T_{XLXL}), PLL in 2x mode	40	125	ns
	Oscillator Period (T_{XLXL}), PLL in 4x mode	80	125	ns
T_{XHXX}	High Time	$0.35T_{XTAL1}$	$0.65T_{XTAL1}$	ns
T_{XLXX}	Low Time	$0.35T_{XTAL1}$	$0.65T_{XTAL1}$	ns
T_{XLXH}	Rise Time		10	ns
T_{XHXL}	Fall Time		10	ns

[†] Assumes an external clock; the maximum input frequency for an external crystal oscillator is 25 MHz.

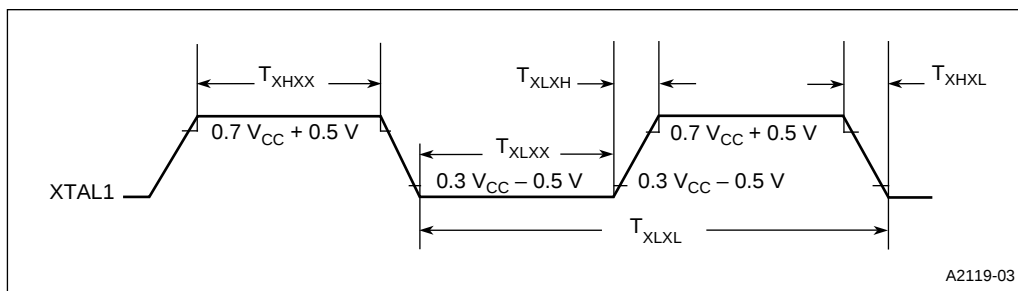


Figure 13. External Clock Drive Waveforms

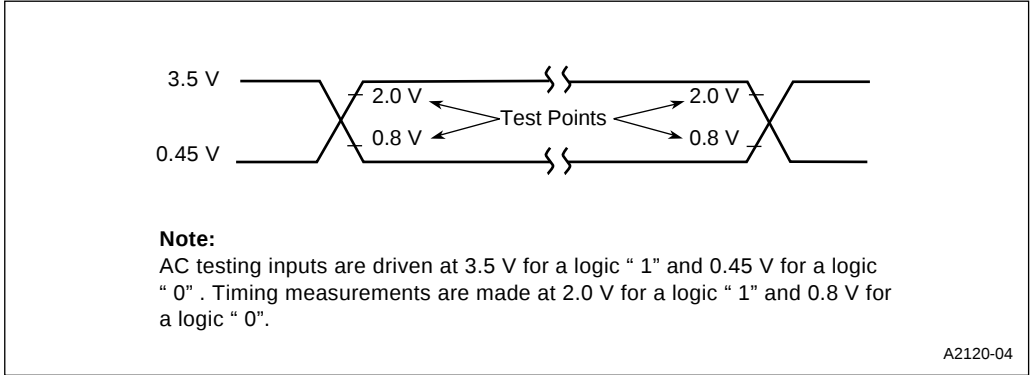


Figure 14. AC Testing Input and Output Waveforms During 5.0 Volt Testing

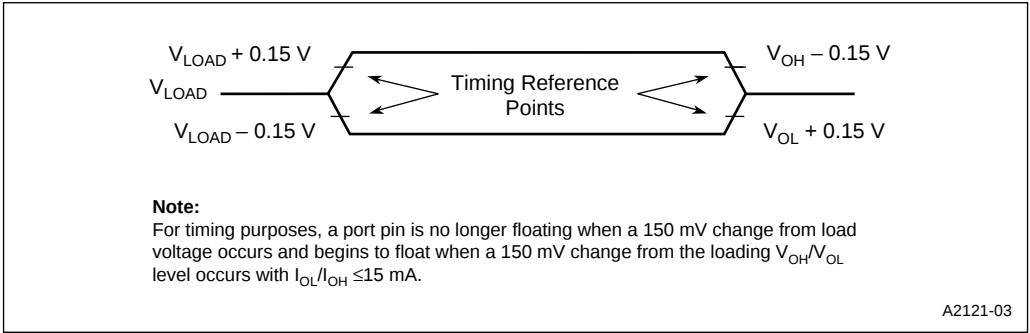


Figure 15. Float Waveforms During 5.0 Volt Testing



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7.0 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 15. Thermal Characteristics

Package Type	θ_{JA}	θ_{JC}
100-pin QFP	50°C/W	16°C/W

8.0 80296SA ERRATA

The 80296SA may contain design defects or errors known as errata. Characterized errata that may cause the 80296SA's 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

This datasheet is valid for devices with an "A" at the end of the topside tracking 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.

This is the -003 version of the datasheet. The following changes were made in this version:

1. All references to SQFP package were deleted.
2. Reference to ROM option was removed from Table 1.
3. The speed designation for 40 MHz was changed from "no mark" to "40" in Table 1.
4. The T_{RXDX} specification was changed to 0 ns (from 2 ns) in Table 11 and Table 13.
5. The T_{CHYX} specification was replaced by T_{CH1YX} and T_{CH2YX} .
6. The READY timing diagrams (Figures 8 and 10) were replaced by examples that reflect the new T_{CH1YX} and T_{CH2YX} specifications.

This is the -002 version of the datasheet. The following changes were made in this version:

1. The "Intel Confidential" designation was removed for publication.
2. A heading was added for Section 1.0, "Product Overview," and the remaining sections were renumbered.
3. The errata list was replaced with a reference to the specification update document.

The following changes were made in the -001 version of the datasheet:

1. Throughout the datasheet, the product name was changed to read "80296SA" instead of "80C296SA."
2. The feature list was clarified.
3. A table of contents was added.
4. The block diagram was changed.
5. Several sections were rearranged and section numbers were assigned. "Thermal Characteristics" was moved to Section 7.0; a section heading was added for "Nomenclature Overview," Section 2.0; a section heading was added for "Address Map" and it was moved to Section 5.0; a section heading was added for "Pinout," and it was moved to Section 3.0; the section heading "Pin Descriptions" was changed to "Signals," Section 4.0. The remaining sections were assigned section numbers: "Electrical Characteris-

- tics" is Section 6.0; "Errata" is Section 8.0, and "Datasheet Revision History" is Section 9.0.
6. Table 2 was changed to Table 1 and the "process information" was corrected to show that "no mark" signifies a CHMOS process.
 7. Table 3 was changed to Table 7 and several clarifications were made.
 8. Figure 3 was changed to correct the product name. Pin assignments did **not** change.
 9. Table 4 was changed to Table 2 and pin 3 was changed from "no connection" to "tie to V_{CC} ."
 10. Figure 4 was changed to correct the product name. Pin assignments did **not** change.
 11. Figure 5, " I_{CC} versus Frequency in Reset," was added. Remaining figure numbers were incremented.
 12. Table 6 was changed to Table 4 and a note for handling the "no connection" pins was added.
 13. Table 8 was changed to Table 6. The descriptions of BREQ#, HLDA#, and HOLD# were changed to reflect their operation during hold. The description of the ONCE signal was changed to reflect the correct states of READY, RESET#, and NMI during ONCE mode. The description of PLEN2:1 was changed to show the correct pin states to achieve each phase-locked loop (PLL) clock multiplier mode. The descriptions of RPD and RESET# were changed to reflect system requirements when using the PLL.
 14. Two notes were added to clarify the "Operating Conditions" in the "Electrical Characteristics" section.
 15. Table 9 was changed to Table 8, the notes were re-ordered, and the following specifications were changed:
 - I_{CC} max was changed to 150 mA (from 120 mA).
 - V_{OH} min was changed to $V_{CC}-0.5$ V (from $V_{CC}-0.3$ V) at $I_{OH} = -200\mu A$.
 - V_{OH} min was changed to $V_{CC}-0.9$ V (from $V_{CC}-0.7$ V) at $I_{OH} = -3.2$ mA.
 - Test condition for V_{OL1} max = 0.45 V was changed to $I_{OL} = 8$ mA (from $I_{OL} = 10$ mA).
 - R_{RST} min and max were changed to 50 k Ω and 150 k Ω (from 9 k Ω and 95 k Ω).
 - V_{OH3} min specification was added.
 16. Table 10 was divided into two tables: timing specifications that the microcontroller will meet (Table 10) and those that the external memory system must meet (Table 11). Note 7 was deleted and the remaining notes were re-ordered. The following specifications were changed or added in Table 10:
 - F_{XTAL1} min for the PLL in 4x mode was changed to 8 MHz (from 4 MHz); a clarifying note was added.
 - T_{XHCH} min was changed to 3 ns (from TBD).
 - T_{LLAX} min was changed to 1 ns (from TBD).
 - T_{LLRL} min was changed to 3 ns (from TBD).
 - T_{RHAX} min was changed to $t - 4$ ns (from t).
 - T_{AVWL} min (2t – 25) was added to Table 10.
 - T_{SLDV} min (4t – 28) was added to Table 11.
 17. Table 11 was divided into two tables: timing specifications that the microcontroller will meet (Table 12) and those that the external memory system must meet (Table 13). Note 7 was deleted and the remaining notes were re-ordered. The following specifications were changed:
 - F_{XTAL1} min for the PLL in 4x mode was changed to 8 MHz (from 4 MHz); a clarifying note was added.
 - T_{WHQX} min was changed to $t - 5$ ns (from $t - 2$ ns).
 18. Figure 6 was changed to show the correct PLEN2:1 values to select the 2x clock multiplier mode.
 19. Table 13 was changed to Table 15 and a note was added.
 20. Table 14 was changed to Table 16, $1/T_{XLXL}$ specifications for each phase-locked loop (PLL) mode were added, and Note 2 was deleted.



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