8XC196KD/8XC196KD20
COMMERCIAL CHMOS MICROCONTROLLER

87C196KD/32 Kbytes of On-Chip OTPROM
83C196KD/32 Kbytes of ROM

- 16 MHz and 20 MHz Available
- 1000 Byte Register RAM
- Register-to-Register Architecture
- 28 Interrupt Sources/16 Vectors
- Peripheral Transaction Server
- 1.4 µs 16 x 16 Multiply (20 MHz)
- 2.4 µs 32/16 Divide (20 MHz)
- Powerdown and Idle Modes
- Five 8-Bit I/O Ports
- 16-Bit Watchdog Timer
- Dynamically Configurable 8-Bit or 16-Bit Buswidth
- Full Duplex Serial Port
- High Speed I/O Subsystem
- 16-Bit Timer
- 16-Bit Up/Down Counter with Capture
- 3 Pulse-Width-Modulated Outputs
- Four 16-Bit Software Timers
- 8- or 10-Bit A/D Converter with Sample/Hold
- $\overline{\text{HOLD}}/\overline{\text{HLDA}}$ Bus Protocol
- OTP One-Time Programmable Version
- Extended Temperature Available

The 8XC196KD 16-bit microcontroller is a high performance member of the MCS® 96 microcontroller family. The 8XC196KD is an enhanced 80C196KC device with 1000 bytes RAM, 16 MHz operation and an optional 32 Kbytes of ROM/EPROM. Intel's CHMOS III process provides a high performance processor along with low power consumption.

The 8XC196KD has a maximum guaranteed frequency of 16 MHz. The 8XC196KD20 has a maximum guaranteed frequency of 20 MHz. Unless otherwise noted, all references to the 8XC196KD also refer to the 8XC196KD20.

Four high-speed capture inputs are provided to record times when events occur. Six high-speed outputs are available for pulse or waveform generation. The high-speed output can also generate four software timers or start an A/D conversion. Events can be based on the timer or up/down counter.

With the commercial (standard) temperature option, operational characteristics are guaranteed over the temperature range of the 0°C to +70°C. With the extended (express) temperature range option, operational characteristics are guaranteed over the temperature range of -40°C to +85°C. Unless otherwise noted, the specifications are the same for both options.

See the packaging information for extended temperature designators.

July 2004 Order Number: 272145-005

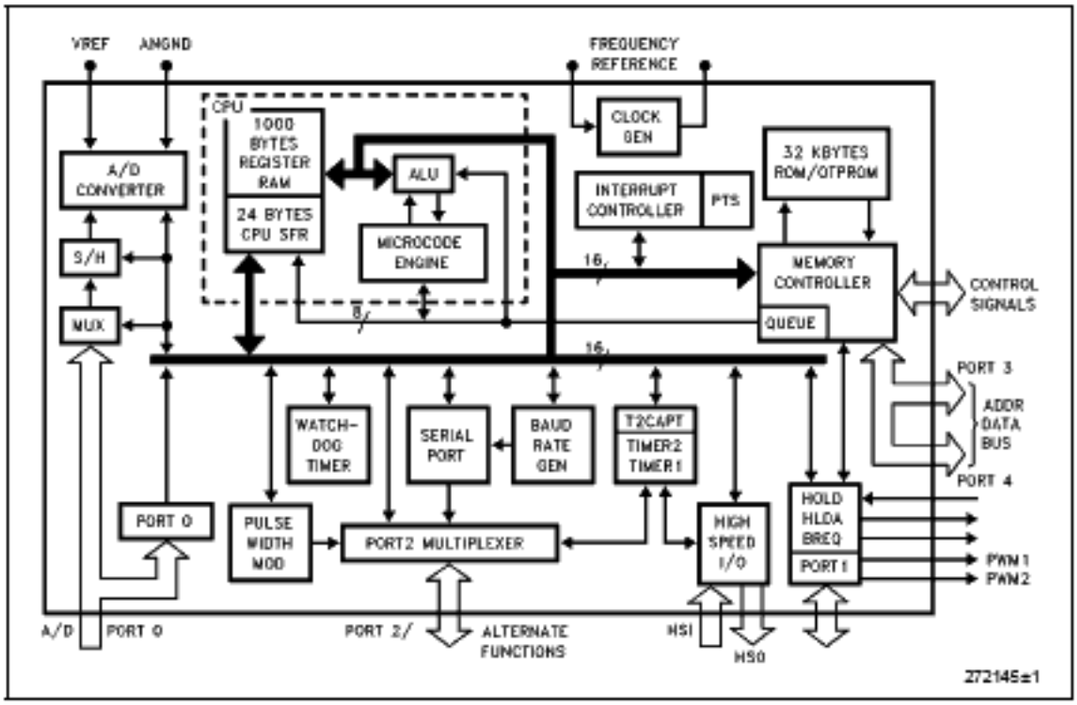


Figure 1. 8XC196KD Block Diagram

87C196KD ENHANCED FEATURE SET OVER THE 87C196KC

1. The 87C196KD has twice the RAM and twice the OTPROM space of the 87C196KC.
2. The vertical windowing scheme has been extended to allow all 1000 bytes of register RAM to be windowed into the lower register file.

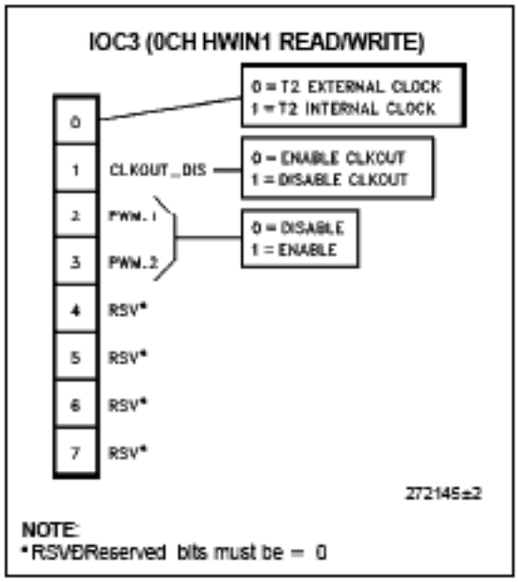


Figure 2. 87C196KD New SFR Bit (CLKOUT Disable)

8XC196KD VERTICAL WINDOWING MAP

Table 1. 128-Byte Windows

Address to Remap	Device Series	WSR Contents
0380H	KD	X001 0111B = 17H
0300H	KD	X001 0110B = 16H
0280H	KD	X001 0101B = 15H
0200H	KD	X001 0100B = 14H
0180H	KC, KD	X001 0011B = 13H
0100H	KC, KD	X001 0010B = 12H
0080H	KC, KD	X001 0001B = 11H
0000H	KC, KD	X001 0000B = 10H

Window in Lower Register File: 80H±FFH

Table 2. 64-Byte Windows

Address to Remap	Device Series	WSR Contents
03C0H	KD	X010 1111B = 2FH
0380H	KD	X010 1110B = 2EH
0340H	KD	X010 1101B = 2DH
0300H	KD	X010 1100B = 2CH
02C0H	KD	X010 1011B = 2BH
0280H	KD	X010 1010B = 2AH
0240H	KD	X010 1001B = 29H
0200H	KD	X010 1000B = 28H
01C0H	KC, KD	X010 0111B = 27H
0180H	KC, KD	X010 0110B = 26H
0140H	KC, KD	X010 0101B = 25H
0100H	KC, KD	X010 0100B = 24H
00C0H	KC, KD	X010 0011B = 23H
0080H	KC, KD	X010 0010B = 22H
0040H	KC, KD	X010 0001B = 21H
0000H	KC, KD	X010 0000B = 20H

Window in Lower Register File: C0H±FFH

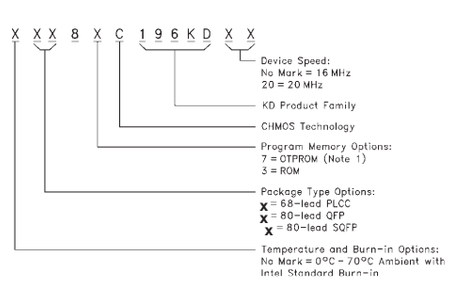
Table 3. 32-Byte Windows

Address to Remap	Device Series	WSR Contents
03E0H	KD	X101 1111B = 5FH
03C0H	KD	X101 1110B = 5EH
03A0H	KD	X101 1101B = 5DH
0380H	KD	X101 1100B = 5CH
0360H	KD	X101 1011B = 5BH
0340H	KD	X101 1010B = 5AH
0320H	KD	X101 1001B = 59H
0300H	KD	X101 1000B = 58H
02E0H	KD	X101 0111B = 57H
02C0H	KD	X101 0110B = 56H
02A0H	KD	X101 0101B = 55H
0280H	KD	X101 0100B = 54H
0260H	KD	X101 0011B = 53H
0240H	KD	X101 0010B = 52H
0220H	KD	X101 0001B = 51H
0200H	KD	X101 0000B = 50H
01E0H	KC, KD	X100 1111B = 4FH
01C0H	KC, KD	X100 1110B = 4EH
01A0H	KC, KD	X100 1101B = 4DH
0180H	KC, KD	X100 1100B = 4CH
0160H	KC, KD	X100 1011B = 4BH
0140H	KC, KD	X100 1010B = 4AH
0120H	KC, KD	X100 1001B = 49H
0100H	KC, KD	X100 1000B = 48H
00E0H	KC, KD	X100 0111B = 47H
00C0H	KC, KD	X100 0110B = 46H
00A0H	KC, KD	X100 0101B = 45H
0080H	KC, KD	X100 0100B = 44H
0060H	KC, KD	X100 0011B = 43H
0040H	KC, KD	X100 0010B = 42H
0020H	KC, KD	X100 0001B = 41H
0000H	KC, KD	X100 0000B = 40H

Window in Lower Register File: E0H±FFH

PROCESS INFORMATION

This device is manufactured on PX29.5 or PX29.9, a CHMOS III process. Additional process and reliability information is available in the Intel® Quality *System Handbook:*
http://developer.intel.com/design/quality/quality.htm



NOTE:
1. EPROMs are available as One Time Programmable (OTPROM) only.

Figure 3. The 8XC196KD Family Nomenclature

Table 4. Thermal Characteristics

Package Type	θ_{ja}	θ_{jc}
PLCC	35°C/W	13 °C/W
QFP	56°C/W	12 °C/W
SQFP	68°C/W	15.5 °C/W

All thermal impedance data is approximate for static air conditions at 1W of power dissipation. Values will change depending on operation conditions and application. See the Intel *Packaging Handbook* (order number 240800) for a description of Intel's thermal impedance test methodology.

Table 5. 8XC196KD Memory Map

Description	Address
External Memory or I/O	0FFFFH 0A000H
Internal ROM/OTPROM or External Memory (Determined by EA)	9FFFH 2080H
Reserved. Must contain FFH. (Note 5)	207FH 205EH
PTS Vectors	205DH 2040H
Upper Interrupt Vectors	203FH 2030H
ROM/OTPROM Security Key	202FH 2020H
Reserved. Must contain FFH. (Note 5)	201FH 201AH
Reserved. Must Contain 20H (Note 5)	2019H
CCB	2018H
Reserved. Must contain FFH. (Note 5)	2017H 2014H
Lower Interrupt Vectors	2013H 2000H
Port 3 and Port 4	1FFFH 1FFEH
External Memory	1FFDH 0400H
1000 Bytes Register RAM (Note 1)	03FFH 0018H
CPU SFR's (Notes 1, 3)	0017H 0000H

NOTES:
1. Code executed in locations 0000H to 03FFH will be forced external.
2. Reserved memory locations must contain 0FFH unless noted.
3. Reserved SFR bit locations must contain 0.
4. Refer to 8XC196KC for SFR descriptions.
5. WARNING: Reserved memory locations must not be written or read. The contents and/or function of these locations may change with future revisions of the device. Therefore, a program that relies on one or more of these locations may not function properly.

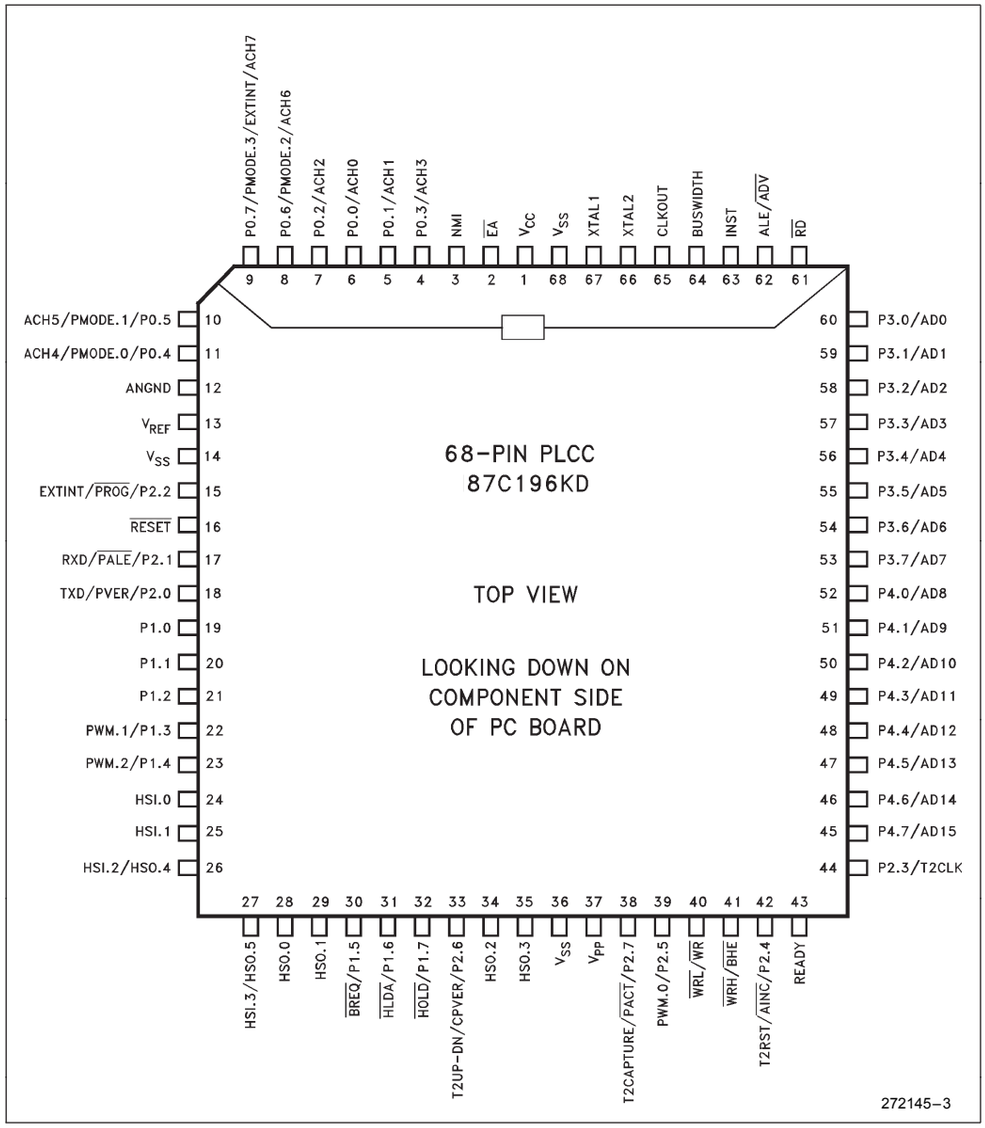
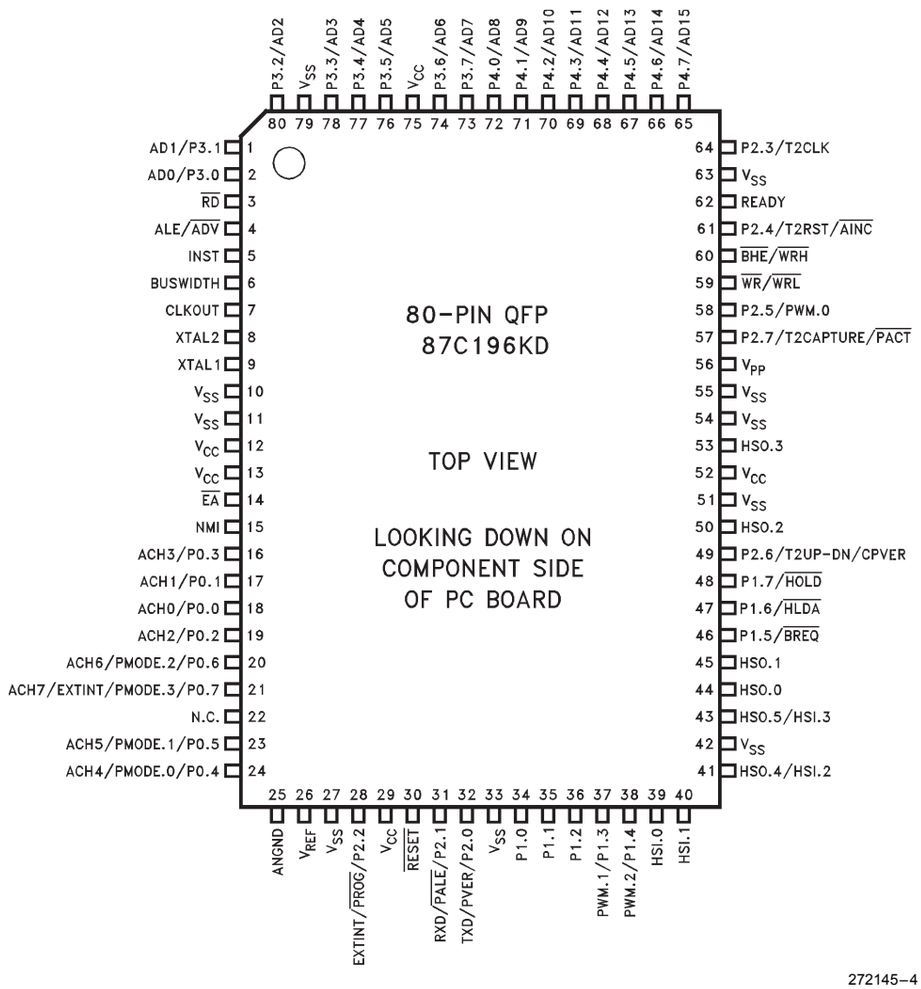
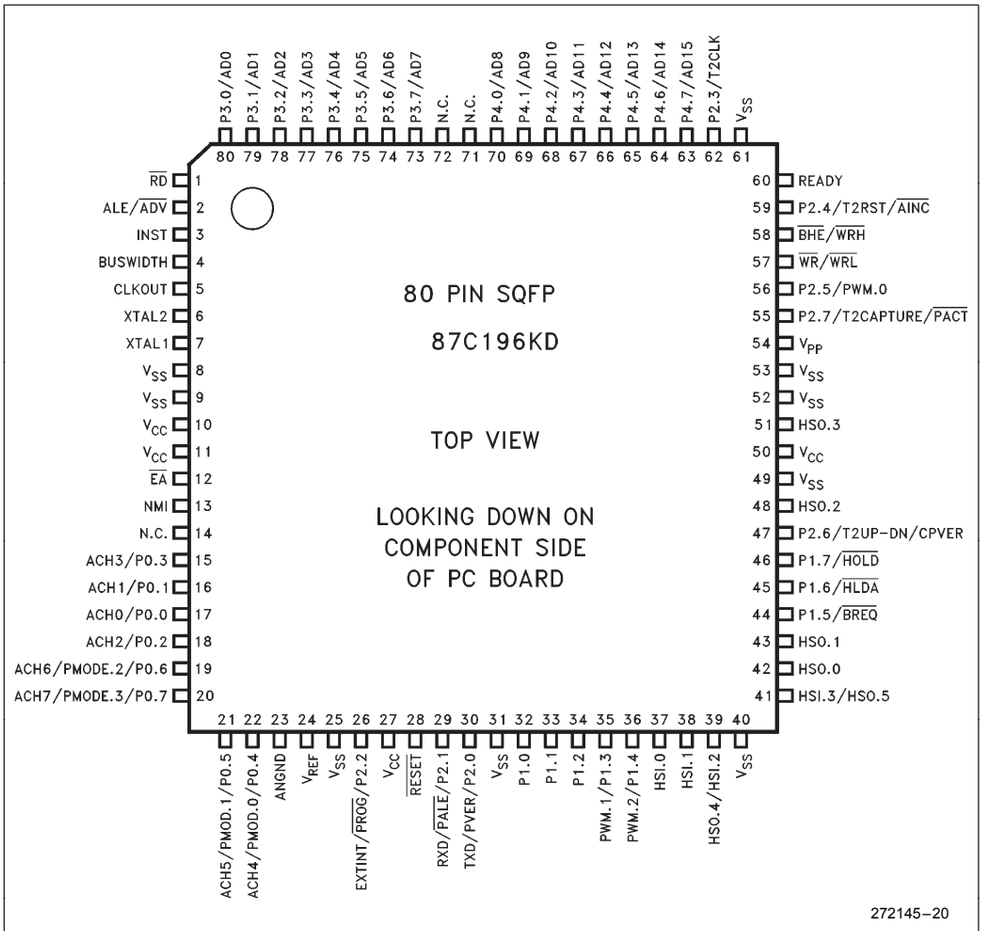


Figure 4. 68-Pin PLCC Package



NOTE:
N.C. means No Connect (do not connect these pins).

Figure 5. 80-Pin QFP Package



NOTE:
N.C. means No Connect (do not connect these pins).

Figure 6. 80-Pin SQFP Package

PIN DESCRIPTIONS

Symbol	Name and Function
V_{CC}	Main supply voltage (5V).
V_{SS}	Digital circuit ground (0V). There are multiple V_{SS} pins, all of which must be connected.
V_{REF}	Reference voltage for the A/D converter (5V). V_{REF} is also the supply voltage to the analog portion of the A/D converter and the logic used to read Port 0. Must be connected for A/D and Port 0 to function.
ANGND	Reference ground for the A/D converter. Must be held at nominally the same potential as V_{SS}.
V_{PP}	Timing pin for the return from powerdown circuit. This pin also supplies the programming voltage on the EPROM device.
XTAL1	Input of the oscillator inverter and of the internal clock generator.
XTAL2	Output of the oscillator inverter.
CLKOUT	Output of the internal clock generator. The frequency of CLKOUT is ½ the oscillator frequency.
$\overline{\text{RESET}}$	Reset input and open drain output.
BUSWIDTH	Input for buswidth selection. If CCR bit 1 is a one, this pin selects the bus width for the bus cycle in progress. If BUSWIDTH is a 1, a 16-bit bus cycle occurs. If BUSWIDTH is a 0 an 8-bit cycle occurs. If CCR bit 1 is a 0, the bus is always an 8-bit bus.
NMI	A positive transition causes a vector through 203EH.
INST	Output high during an external memory read indicates the read is an instruction fetch. INST is valid throughout the bus cycle. INST is activated only during external memory accesses and output low for a data fetch.
$\overline{\text{EA}}$	Input for memory select (External Access). $\overline{\text{EA}}$ equal high causes memory accesses to locations 2000H through 9FFFH to be directed to on-chip ROM/E PROM. $\overline{\text{EA}}$ equal low causes accesses to those locations to be directed to off-chip memory. Also used to enter programming mode.
ALE/$\overline{\text{ADV}}$	Address Latch Enable or Address Valid output, as selected by CCR. Both pin options provide a signal to demultiplex the address from the address/data bus. When the pin is $\overline{\text{ADV}}$, it goes inactive high at the end of the bus cycle. ALE/$\overline{\text{ADV}}$ is activated only during external memory accesses.
$\overline{\text{RD}}$	Read signal output to external memory. $\overline{\text{RD}}$ is activated only during external memory reads.
$\overline{\text{WR}}$/$\overline{\text{WRL}}$	Write and Write Low output to external memory, as selected by the CCR. $\overline{\text{WR}}$ will go low for every external write, while $\overline{\text{WRL}}$ will go low only for external writes where an even byte is being written. $\overline{\text{WR}}$/$\overline{\text{WRL}}$ is activated only during external memory writes.
$\overline{\text{BHE}}$/$\overline{\text{WRH}}$	Bus High Enable or Write High output to external memory, as selected by the CCR. $\overline{\text{BHE}}$ will go low for external writes to the high byte of the data bus. $\overline{\text{WRH}}$ will go low for external writes where an odd byte is being written. $\overline{\text{BHE}}$/$\overline{\text{WRH}}$ is activated only during external memory writes.
READY	Ready input to lengthen external memory cycles, for interfacing to slow or dynamic memory, or for bus sharing. When the external memory is not being used, READY has no effect.
HSI	Inputs to High Speed Input Unit. Four HSI pins are available: HSI.0, HSI.1, HSI.2 and HSI.3. Two of them (HSI.2 and HSI.3) are shared with the HSO Unit.
HSO	Outputs from High Speed Output Unit. Six HSO pins are available: HSO.0, HSO.1, HSO.2, HSI.3, HSO.4 and HSO.5. Two of them (HSO.4 and HSO.5) are shared with the HSI Unit.

PIN DESCRIPTIONS (Continued)

Symbol	Name and Function
Port 0	8-bit high impedance input-only port. These pins can be used as digital inputs and/or as analog inputs to the on-chip A/D converter.
Port 1	8-bit quasi-bidirectional I/O port.
Port 2	8-bit multi-functional port. All of its pins are shared with other functions in the 8XC196KD. Pins 2.6 and 2.7 are quasi-bidirectional.
Ports 3 and 4	8-bit bidirectional I/O ports with open drain outputs. These pins are shared with the multiplexed address/data bus which has strong internal pullups.
$\overline{\text{HOLD}}$	Bus Hold input requesting control of the bus.
$\overline{\text{HLDA}}$	Bus Hold acknowledge output indicating release of the bus.
$\overline{\text{BREQ}}$	Bus Request output activated when the bus controller has a pending external memory cycle.
PMODE	Determines the EPROM programming mode.
$\overline{\text{PACT}}$	A low signal in Auto Programming mode indicates that programming is in process. A high signal indicates programming is complete.
$\overline{\text{PALE}}$	A falling edge in Slave Programming Mode and Auto Configuration Byte Programming Mode indicates that ports 3 and 4 contain valid programming address/command information (input to slave).
$\overline{\text{PROG}}$	A falling edge in Slave Programming Mode indicates that ports 3 and 4 contain valid programming data (input to slave).
PVER	A high signal in Slave Programming Mode and Auto Configuration Byte Programming Mode indicates the byte programmed correctly.
CPVER	Cummulative Program Output Verification. Pin is high if all locations have programmed correctly since entering a programming mode.
$\overline{\text{AINC}}$	Auto Increment. Active low input enables the auto increment mode. Auto increment allows reading or writing sequential EPROM locations without address transactions across the PBUS for each read or write.

ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS*

Ambient Temperature
Under Bias..... − 55°C to + 125°C
Storage Temperature..... − 65°C to + 150°C
Voltage On Any Pin to V_{SS}
Except EA and V_{PP}..... − 0.5V to + 7.0V(1)
Voltage from $\overline{EA}$ or
V_{PP} to V_{SS} or ANGND..... − 0.5V to + 13.00V
Power Dissipation.....1.5W(2)

NOTES:
1. This includes V_{PP} and $\overline{EA}$ on ROM or CPU only devices.
2. Power dissipation is based on package heat transfer limitations, not device power consumption.

NOTICE: This data sheet contains information on products in the sampling and initial production phases of development. It is valid for the devices indicated in the revision history. The specifications are subject to change without notice.

**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.*

OPERATING CONDITIONS

Symbol	Description	Min	Max	Units
T_A	Ambient Temperature Under Bias **Commercial** Temp.	0	+ 70	°C
T_A	Ambient Temperature Under Bias **Extended** Temp.	-40	+85	°C
V_{CC}	Digital Supply Voltage	4.50	5.50	V
V_{REF}	Analog Supply Voltage	4.00	5.50	V
ANGND	Analog Ground Voltage	V_{SS} − 0.4	V_{SS} + 0.4	V(1)
F_{OSC}	Oscillator Frequency (**8XC196KD**)	8	16	MHz
F_{OSC}	Oscillator Frequency (**8XC196KD20**)	8	20	MHz

NOTE:
1. ANGND and V_{SS} should be nominally at the same potential.

DC CHARACTERISTICS (Over Specified Operating Conditions)

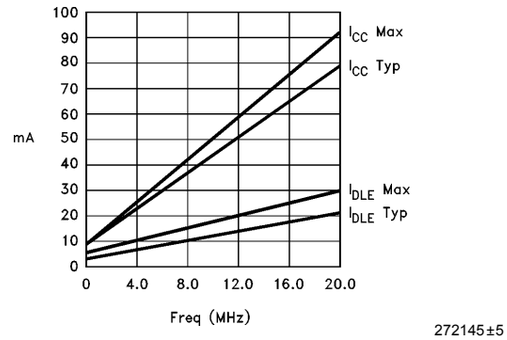
Symbol	Description	Min	Max	Units	Test Conditions
V_{IL}	Input Low Voltage	−0.5	0.8	V	
V_{IH}	Input High Voltage (Note 1)	0.2 V_{CC} + 1.0	V_{CC} + 0.5	V	
V_{HYS}	Hysteresis on $\overline{RESET}$	300		mV	V_{CC} = 5.0V
V_{IH1}	Input High Voltage on XTAL 1	0.7 V_{CC}	V_{CC} + 0.5	V	
V_{IH2}	Input High Voltage on RESET	2.2	V_{CC} + 0.5	V	
V_{OL}	Output Low Voltage		0.3 0.45 1.5	V V V	I_{OL} = 200 μA I_{OL} = 2.8 mA I_{OL} = 7 mA
V_{OL1}	Output Low Voltage in RESET on P2.5 (Note 2)		0.8	V	I_{OL} = + 0.4 mA
V_{OH}	Output High Voltage (Standard Outputs) (Note 4)	V_{CC} − 0.3 V_{CC} − 0.7 V_{CC} − 1.5		V V V	I_{OH} = −200 μA I_{OH} = −3.2 mA I_{OH} = −7 mA
V_{OH1}	Output High Voltage (Quasi-bidirectional Outputs) (Note 3)	V_{CC} − 0.3 V_{CC} − 0.7 V_{CC} − 1.5		V V V	I_{OH} = −10 μA I_{OH} = −30 μA I_{OH} = −60 μA

DC CHARACTERISTICS (Over Specified Operating Conditions) (Continued)

Symbol	Description	Min	Typ	Max	Units	Test Conditions
I_{OH1}	Logical 1 Output Current in Reset on P2.0. Do not exceed this or device may enter test modes.	−0.8			mA	$V_{IH} = V_{CC} - 1.5V$
I_{IL2}	Logical 0 Input Current in Reset on P2.0. Maximum current that must be sunk by external device to ensure test mode entry.			−12.0	mA	$V_{IN} = 0.45V$
I_{IH1}	Logical 1 Input Current. Maximum current that external device must source to initiate NMI.			+200	µA	$V_{IN} = 2.4V$
I_{LI}	Input Leakage Current (Std. Inputs) (Note 5)			±10	µA	$0 < V_{IN} < V_{CC} - 0.3V$
I_{LI1}	Input Leakage Current (Port 0)			±3	µA	$0 < V_{IN} < V_{REF}$
I_{TL}	1 to 0 Transition Current (QBD Pins)			−650	µA	$V_{IN} = 2.0V$
I_{IL}	Logical 0 Input Current (QBD Pins)			−70	µA	$V_{IN} = 0.45V$
I_{IL1}	AD Bus in Reset			−70	µA	$V_{IN} = 0.45V$
I_{CC}	Active Mode Current in Reset (**8XC196KD**)		65	75	mA	XTAL1 = 16 MHz $V_{CC} = V_{PP} = V_{REF} = 5.5V$
I_{CC}	Active Mode Current in Reset (**8XC196KD20**)		80	92	mA	XTAL1 = 20 MHz $V_{CC} = V_{PP} = V_{REF} = 5.5V$
I_{IDLE}	Idle Mode Current (**8XC196KD**)		17	25	mA	XTAL1 = 16 MHz $V_{CC} = V_{PP} = V_{REF} = 5.5V$
I_{IDLE}	Idle Mode Current (**8XC196KD20**)		21	30	mA	XTAL1 = 20 MHz $V_{CC} = V_{PP} = V_{REF} = 5.5V$
I_{PD}	Powerdown Mode Current		8	15	µA	$V_{CC} = V_{PP} = V_{REF} = 5.5V$
I_{REF}	A/D Converter Reference Current		2	5	mA	$V_{CC} = V_{PP} = V_{REF} = 5.5V$
R_{RST}	Reset Pullup Resistor	6K		65K	Ω	$V_{CC} = 5.5V, V_{IN} = 4.0V$
C_S	Pin Capacitance (Any Pin to V_{SS})			10	pF	

NOTES:
1. All pins except RESET and XTAL1.
2. Violating these specifications in Reset may cause the part to enter test modes.
3. QBD (Quasi-bidirectional) pins include Port 1, P2.6 and P2.7.
4. Standard Outputs include AD0±15, $\overline{RD}$, $\overline{WR}$, ALE, $\overline{BHE}$, INST, HSO pins, PWM/P2.5, CLKOUT, RESET, Ports 3 and 4, TXD/P2.0 and RXD (in serial mode 0). The V_{OH} specification is not valid for RESET. Ports 3 and 4 are open-drain outputs.
5. Standard Inputs include HSI pins, READY, BUSWIDTH, RXD/P2.1, EXTINT/P2.2, T2CLK/P2.3 and T2RST/P2.4.
6. Maximum current per pin must be externally limited to the following values if V_{OL} is held above 0.45V or V_{OH} is held below $V_{CC} - 0.7V$:
   I_{OL} on Output pins: 10 mA
   I_{OH} on quasi-bidirectional pins: self limiting
   I_{OH} on Standard Output pins: 10 mA
7. Maximum current per bus pin (data and control) during normal operation is ±3.2 mA.
8. During normal (non-transient) conditions the following total current limits apply:

Port 1, P2.6	I_{OL}: 29 mA	I_{OH} is self limiting
HSO, P2.0, RXD, $\overline{RESET}$	I_{OL}: 29 mA	I_{OH}: 26 mA
P2.5, P2.7, $\overline{WR}$, $\overline{BHE}$	I_{OL}: 13 mA	I_{OH}: 11 mA
AD0±AD15	I_{OL}: 52 mA	I_{OH}: 52 mA
$\overline{RD}$, ALE, INST±CLKOUT	I_{OL}: 13 mA	I_{OH}: 13 mA



I_{CC} Max = 4.13 × Frequency + 9 mA
I_{CC} Typ = 3.50 × Frequency + 9 mA
I_{IDLE} Max = 1.25 × Frequency + 5 mA
I_{IDLE} Typ = 0.88 × Frequency + 3 mA

NOTE:
Frequencies below 8 MHz are shown for reference only; no testing is performed.

Figure 7. I_{CC} and I_{IDLE} vs Frequency

AC CHARACTERISTICS

For use over specified operating conditions.

Test Conditions: Capacitive load on all pins = 100 pF, Rise and fall times = 10 ns, F_{OSC} = 16/20 MHz

The system must meet these specifications to work with the 80C196KD:

Symbol	Description	Min	Max	Units	Notes
T_{AVYV}	Address Valid to READY Setup		2 T_{OSC} − 68	ns	
T_{YLYH}	Non READY Time	No upper limit		ns	
T_{CLYX}	READY Hold after CLKOUT Low	0	T_{OSC} − 30	ns	(Note 1)
T_{LLYX}	READY Hold after ALE Low	T_{OSC} − 15	2 T_{OSC} − 40	ns	(Note 1)
T_{AVGV}	Address Valid to Buswidth Setup		2 T_{OSC} − 68	ns	
T_{CLGX}	Buswidth Hold after CLKOUT Low	0		ns	
T_{AVDV}	Address Valid to Input Data Valid		3 T_{OSC} − 55	ns	(Note 2)
T_{RLDV}	$\overline{RD}$ Active to Input Data Valid		T_{OSC} − 22	ns	(Note 2)
T_{CLDV}	CLKOUT Low to Input Data Valid		T_{OSC} − 45	ns	
T_{RHDZ}	End of $\overline{RD}$ to Input Data Float		T_{OSC}	ns	
T_{RXDX}	Data Hold after $\overline{RD}$ Inactive	0		ns	

NOTES:
1. If max is exceeded, additional wait states will occur.
2. If wait states are used, add 2 T_{OSC} * N, where N = number of wait states.

AC CHARACTERISTICS (Continued)

For use over specified operating conditions.

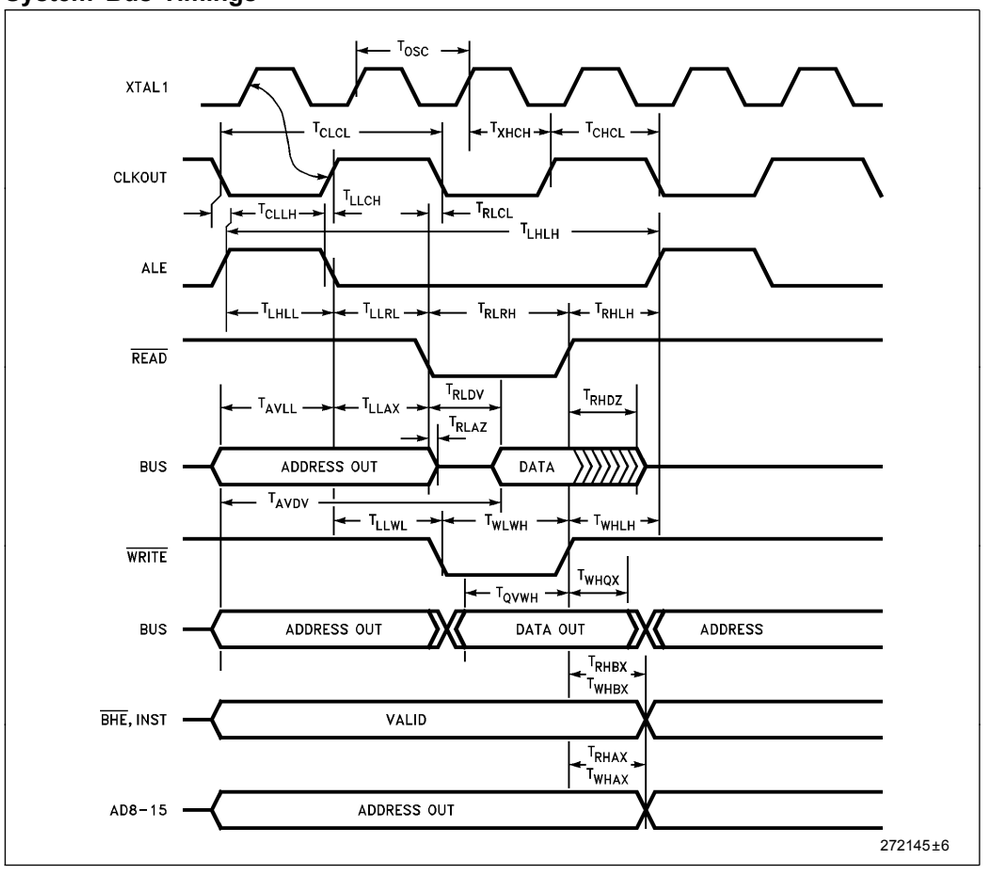
Test Conditions: Capacitive load on all pins = 100 pF, Rise and fall times = 10 ns, F_{OSC} = 16/20 MHz

The 80C196KD will meet these specifications:

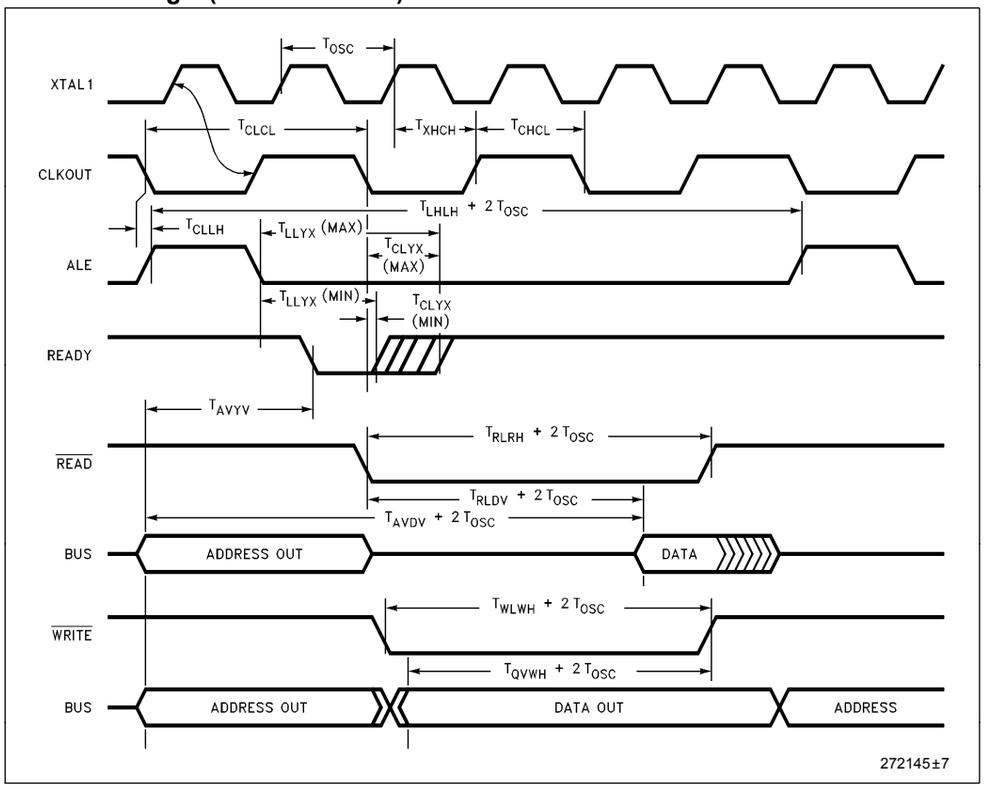
Symbol	Description	Min	Max	Units	Notes
F_{XTAL}	Frequency on XTAL1 (**8XC196KD**)	8	16	MHz	(Note 1)
F_{XTAL}	Frequency on XTAL1 (**8XC196KD20**)	8	20	MHz	(Note 1)
T_{OSC}	I/F $_{XTAL}$ (**8XC196KD**)	62.5	125	ns	
T_{OSC}	I/F $_{XTAL}$ (**8XC196KD20**)	50	125	ns	
T_{XHCH}	XTAL1 High to CLKOUT High or Low	+20	+110	ns	
T_{CLCL}	CLKOUT Cycle Time	2 T_{OSC}		ns	
T_{CHCL}	CLKOUT High Period	T_{OSC} − 10	T_{OSC}+15	ns	
T_{CLLH}	CLKOUT Falling Edge to ALE Rising	−5	+15	ns	
T_{LLCH}	ALE Falling Edge to CLKOUT Rising	−20	+15	ns	
T_{LHLH}	ALE Cycle Time	4 T_{OSC}		ns	(Note 4)
T_{LHLL}	ALE High Period	T_{OSC} − 10	T_{OSC}+10	ns	
T_{AVLL}	Address Setup to ALE Falling Edge	T_{OSC} − 15			
T_{LLAX}	Address Hold after ALE Falling Edge	T_{OSC} − 35		ns	
T_{LLRL}	ALE Falling Edge to $\overline{RD}$ Falling Edge	T_{OSC} − 30		ns	
T_{RLCL}	$\overline{RD}$ Low to CLKOUT Falling Edge	+4	+30	ns	
T_{RLRH}	$\overline{RD}$ Low Period	T_{OSC} − 5		ns	(Note 4)
T_{RHLH}	$\overline{RD}$ Rising Edge to ALE Rising Edge	T_{OSC}	T_{OSC} + 25	ns	(Note 2)
T_{RLAZ}	$\overline{RD}$ Low to Address Float		+5	ns	
T_{LLWL}	ALE Falling Edge to $\overline{WR}$ Falling Edge	T_{OSC} − 10		ns	
T_{CLWL}	CLKOUT Low to $\overline{WR}$ Falling Edge	0	+25	ns	
T_{QVWH}	Data Stable to $\overline{WR}$ Rising Edge	T_{OSC} − 23			(Note 4)
T_{CHWH}	CLKOUT High to $\overline{WR}$ Rising Edge	−5	+15	ns	
T_{WLWH}	$\overline{WR}$ Low Period	T_{OSC} − 20		ns	(Note 4)
T_{WHQX}	Data Hold after $\overline{WR}$ Rising Edge	T_{OSC} − 25		ns	
T_{WHLH}	$\overline{WR}$ Rising Edge to ALE Rising Edge	T_{OSC} − 10	T_{OSC} + 15	ns	(Note 2)
T_{WHBX}	$\overline{BHE}$, INST after $\overline{WR}$ Rising Edge	T_{OSC} − 10		ns	
T_{WHAX}	AD8±15 HOLD after $\overline{WR}$ Rising	T_{OSC} − 30		ns	(Note 3)
T_{RHBX}	$\overline{BHE}$, INST after $\overline{RD}$ Rising Edge	T_{OSC} − 10		ns	
T_{RHAX}	AD8±15 HOLD after $\overline{RD}$ Rising	T_{OSC} − 25		ns	(Note 3)

NOTES:
1. Testing performed at 8 MHz. However, the device is static by design and will typically operate below 1 Hz.
2. Assuming back-to-back bus cycles.
3. 8-Bit bus only.
4. If wait states are used, add 2 T_{OSC} * N, where N = number of wait states.

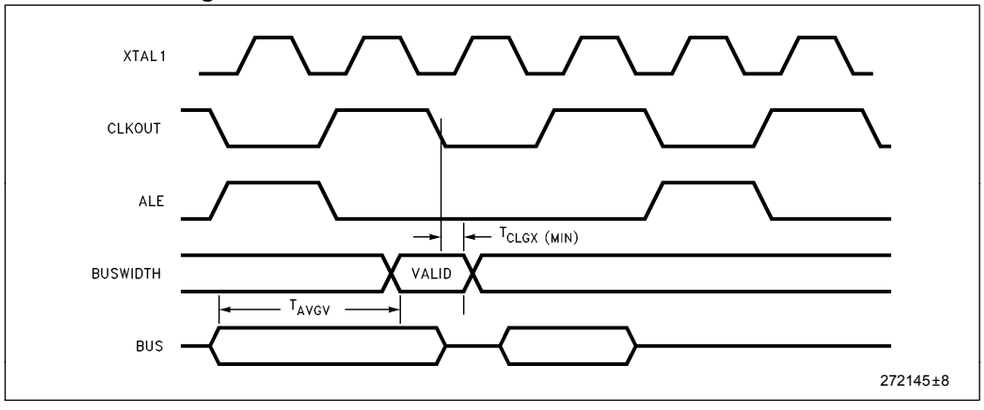
System Bus Timings



READY Timings (One Wait State)



Buswidth Timings



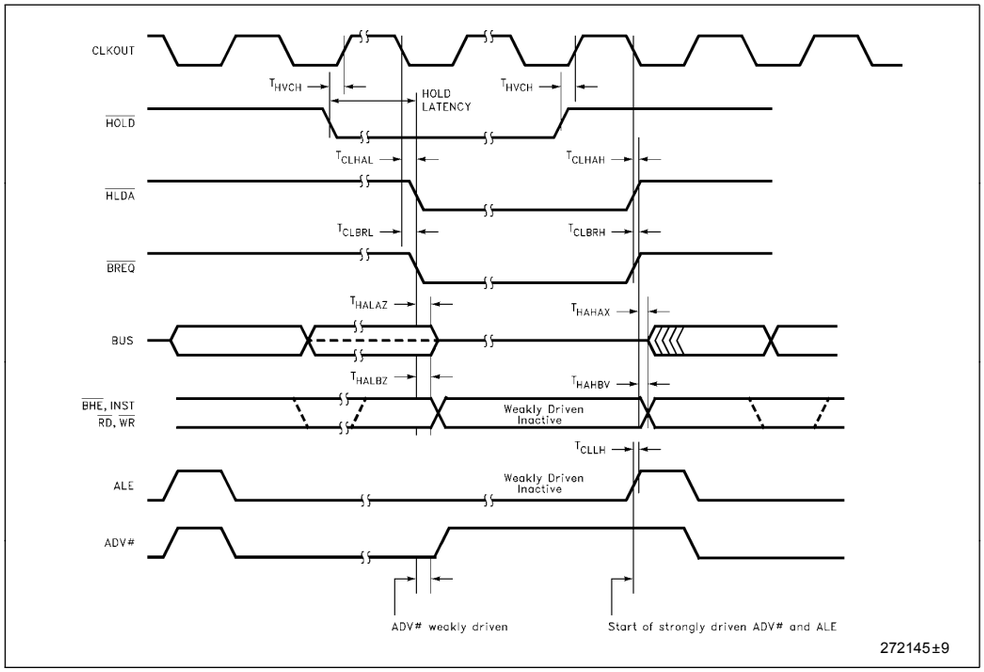
$\overline{HOLD}$/$\overline{HLDA}$ TIMINGS

Symbol	Description	Min	Max	Units	Notes
T_{HVCH}	$\overline{HOLD}$ Setup	+55		ns	(Note 1)
T_{CLHAL}	CLKOUT Low to $\overline{HLDA}$ Low	−15	+15	ns	
T_{CLBRL}	CLKOUT Low to $\overline{BREQ}$ Low	−15	+15	ns	
T_{HALAZ}	$\overline{HLDA}$ Low to Address Float		+15	ns	
T_{HALBZ}	$\overline{HLDA}$ Low to $\overline{BHE}$, INST, $\overline{RD}$, $\overline{WR}$ Weakly Driven		+20	ns	
T_{CLHAH}	CLKOUT Low to $\overline{HLDA}$ High	−15	+15	ns	
T_{CLBRH}	CLKOUT Low to $\overline{BREQ}$ High	−15	+15	ns	
T_{HAHAX}	$\overline{HLDA}$ High to Address No Longer Float	−15		ns	
T_{HAHBV}	$\overline{HLDA}$ High to $\overline{BHE}$, INST, $\overline{RD}$, $\overline{WR}$ Valid	−10	+15	ns	
T_{CLLH}	CLKOUT Low to ALE High	−5	+15	ns	

NOTE:
1. To guarantee recognition at next clock.

DC SPECIFICATIONS IN HOLD

Description	Min	Max	Units
Weak Pullups on $\overline{ADV}$, $\overline{RD}$, $\overline{WR}$, $\overline{WRL}$, $\overline{BHE}$	50K	250K	V_{CC} = 5.5V, V_{IN} = 0.45V
Weak Pulldowns on ALE, INST	10K	50K	V_{CC} = 5.5V, V_{IN} = 2.4



MAXIMUM HOLD LATENCY

Bus Cycle Type	
Internal Execution	1.5 States
16-Bit External Execution	2.5 States
8-Bit External Execution	4.5 States

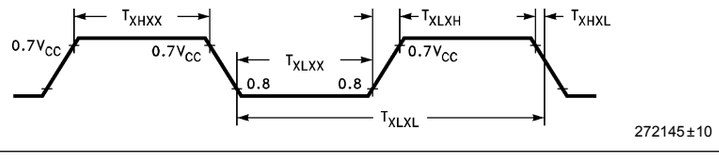
EXTERNAL CLOCK DRIVE (8XC196KD)

Symbol	Parameter	Min	Max	Units
$1/T_{XLXL}$	Oscillator Frequency	8	16.0	MHz
T_{XLXL}	Oscillator Period	62.5	125	ns
T_{XHXX}	High Time	20		ns
T_{XLXX}	Low Time	20		ns
T_{XLXH}	Rise Time		10	ns
T_{XHXL}	Fall Time		10	ns

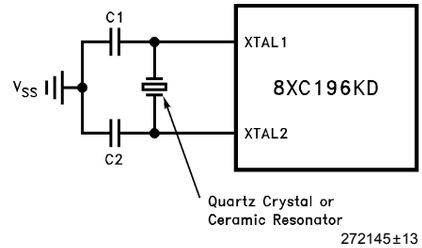
EXTERNAL CLOCK DRIVE (8XC196KD20)

Symbol	Parameter	Min	Max	Units
$1/T_{XLXL}$	Oscillator Frequency	8	20.0	MHz
T_{XLXL}	Oscillator Period	50	125	ns
T_{XHXX}	High Time	17		ns
T_{XLXX}	Low Time	17		ns
T_{XLXH}	Rise Time		8	ns
T_{XHXL}	Fall Time		8	ns

EXTERNAL CLOCK DRIVE WAVEFORMS

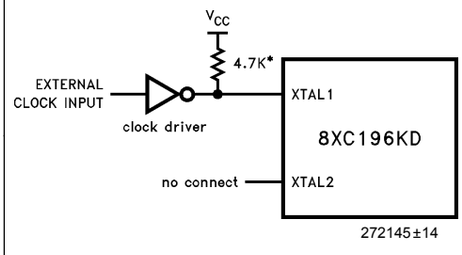


EXTERNAL CRYSTAL CONNECTIONS



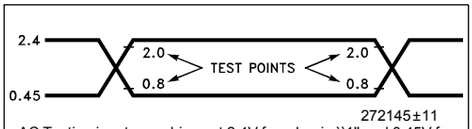
NOTE:
Keep oscillator components close to chip and use short, direct traces to XTAL1, XTAL2 and V_{SS}. When using ceramic crystals, C1 = 20 pF, C2 = 20 pF. When using ceramic resonators consult manufacturer for recommended capacitor values.

EXTERNAL CLOCK CONNECTIONS



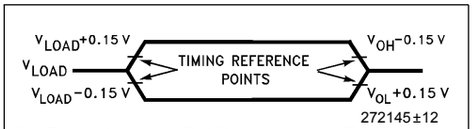
NOTE:
*Required if TTL driver used.
Not needed if CMOS driver is used.

AC TESTING INPUT, OUTPUT WAVEFORMS



AC Testing inputs are driven at 2.4V for a Logic ``1'' and 0.45V for a Logic ``0'' Timing measurements are made at 2.0V for a Logic ``1'' and 0.8V for a Logic ``0''.

FLOAT WAVEFORMS



For Timing Purposes a Port Pin is no Longer Floating when a 150 mV change from Load Voltage Occurs, and Begins to Float when a 150 mV change from the Loaded V_{OH}/V_{OL} Level occurs; $I_{OL}/I_{OH} = \pm 15$ mA.

EXPLANATION OF AC SYMBOLS

Each 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.

Conditions:

H - High
L - Low
V - Valid
X - No Longer Valid
Z - Floating

Signals:

A - Address
B - $\overline{BHE}$
C - CLKOUT
D - DATA
G - Buswidth
H - $\overline{HOLD}$
HA - $\overline{HLDA}$
L - ALE/$\overline{ADV}$
BR - $\overline{BREQ}$
R - $\overline{RD}$
W - $\overline{WR}/\overline{WRH}/\overline{WRL}$
X - XTAL1
Y - READY
Q - Data Out

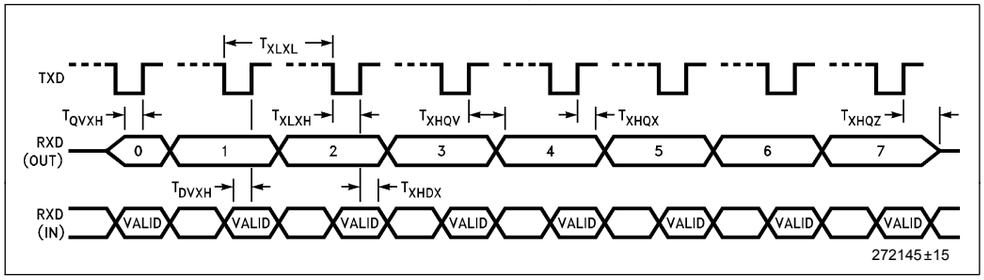
AC CHARACTERISTICS-SERIAL PORT-SHIFT REGISTER MODE

SERIAL PORT TIMING-SHIFT REGISTER MODE (MODE0)

Symbol	Parameter	Min	Max	Units
T_{XLXL}	Serial Port Clock Period (BRR ≥ 8002H)	6 T_{OSC}		ns
T_{XLXH}	Serial Port Clock Falling Edge to Rising Edge (BRR ≥ 8002H)	4 T_{OSC} −50	4 T_{OSC} +50	ns
T_{XLXL}	Serial Port Clock Period (BRR = 8001H)	4 T_{OSC}		ns
T_{XLXH}	Serial Port Clock Falling Edge to Rising Edge (BRR = 8001H)	2 T_{OSC} −50	2 T_{OSC} +50	ns
T_{QVXH}	Output Data Valid to Clock Rising Edge	2 T_{OSC} − 50		ns
T_{XHQX}	Output Data Hold after Clock Rising Edge	2 T_{OSC} − 50		ns
T_{XHQV}	Next Output Data Valid after Clock Rising Edge		2 T_{OSC} + 50	ns
T_{DVXH}	Input Data Setup to Clock Rising Edge	T_{OSC} +50		ns
T_{XHDX}	Input Data Hold after Clock Rising Edge	0		ns
T_{XHQZ}	Last Clock Rising to Output Float		1 T_{OSC}	ns

WAVEFORM-SERIAL PORT-SHIFT REGISTER MODE

SERIAL PORT WAVEFORM-SHIFT REGISTER MODE (MODE 0)



A to D CHARACTERISTICS

The A/D converter is ratiometric, so absolute accuracy is dependent on the accuracy and stability of V_{REF}.

10-BIT MODE A/D OPERATING CONDITIONS

Symbol	Description	Min	Max	Units
T_A	Ambient Temperature **Commercial** Temp.	0	+70	°C
T_A	Ambient Temperature **Extended** Temp.	-40	+85	°C
V_{CC}	Digital Supply Voltage	4.50	5.50	V
V_{REF}	Analog Supply Voltage	4.00	5.50	V
ANGND	Analog Ground Voltage	V_{SS} − 0.40	V_{CC} + 0.40	V
T_{SAM}	Sample Time	1.0		μs(1)
T_{CONV}	Conversion Time	10	20	μs(1)
F_{OSC}	Oscillator Frequency (**8XC196KD**)	8.0	16.0	MHz
F_{OSC}	Oscillator Frequency (**8XC196KD20**)	8.0	20.0	MHz

NOTE:
1. The value of AD_TIME is selected to meet these specifications.

10-BIT MODE A/D CHARACTERISTICS (Over Specified Operating Conditions)

Parameter	Typical(1)	Minimum	Maximum	Units*	Notes
Resolution		1024 10	1024 10	Levels Bits	
Absolute Error		0	±3	LSBs	
Full Scale Error	0.25 ± 0.5			LSBs	
Zero Offset Error	0.25 ± 0.5			LSBs	
Non-Linearity	1.0 ± 2.0	0	±3	LSBs	
Differential Non-Linearity Error		> −1	+2	LSBs	
Channel-to-Channel Matching	±0.1	0	±1	LSBs	
Repeatability	±0.25			LSBs	
Temperature Coefficients: Offset Full Scale Differential Non-Linearity	 0.009 0.009 0.009			 LSB/°C LSB/°C LSB/°C	
Off Isolation		−60		dB	2, 3
Feedthrough	−60			dB	2
V_{CC} Power Supply Rejection	−60			dB	2
Input Series Resistance		750	1.2K	Ω	4
Voltage on Analog Input Pin		ANGND − 0.5	V_{REF} + 0.5	V	5, 6
DC Input Leakage		0	±3.0	μA	
Sampling Capacitor	3			pF	

NOTES:
*An ``LSB'' as used here has a value of approxiimately 5 mV. (See Embedded Microcontrollers and Processors Handbook for A/D glossary of terms.)
1. These values are expected for most parts at 25°C but are not tested or guaranteed.
2. DC to 100 KHz.
3. Multiplexer Break-Before-Make is guaranteed.
4. Resistance from device pin, through internal MUX, to sample capacitor.
5. These values may be exceeded if the pin current is limited to ±2 mA.
6. Applying voltages beyond these specifications will degrade the accuracy of other channels being converted.
7. All conversions performed with processor in IDLE mode.

8-BIT MODE A/D OPERATING CONDITIONS

Symbol	Description	Min	Max	Units
T_A	Ambient Temperature **Commercial** Temp.	0	+70	°C
T_A	Ambient Temperature **Extended** Temp.	-40	+85	°C
V_{CC}	Digital Supply Voltage	4.50	5.50	V
V_{REF}	Analog Supply Voltage	4.00	5.50	V
ANGND	Analog Ground Voltage	V_{SS} −0.40	V_{SS} + 0.40	V
T_{SAM}	Sample Time	1.0		μs(1)
T_{CONV}	Conversion Time	7	20	μs(1)
F_{OSC}	Oscillator Frequency (**8XC196KD**)	8.0	16.0	MHz
F_{OSC}	Oscillator Frequency (**8XC196KD20**)	8.0	20.0	MHz

NOTE:
1. The value of AD_TIME is selected to meet these specifications.

8-BIT MODE A/D CHARACTERISTICS (Over Specified Operating Conditions)

Parameter	Typical(1)	Minimum	Maximum	Units*	Notes
Resolution		256 8	256 8	Levels Bits	
Absolute Error		0	±1	LSBs	
Full Scale Error	±0.5			LSBs	
Zero Offset Error	±0.5			LSBs	
Non-Linearity		0	±1	LSBs	
Differential Non-Linearity Error		>−1	+1	LSBs	
Channel-to-Channel Matching			±1	LSBs	
Repeatability	±0.25			LSBs	
Temperature Coefficients: Offset Full Scale Differential Non-Linearity	 0.003 0.003 0.003			 LSB/°C LSB/°C LSB/°C	
Off Isolation		−60		dB	2, 3
Feedthrough	−60			dB	2
V_{CC} Power Supply Rejection	−60			dB	2
Input Series Resistance		750	1.2K	Ω	4
Voltage on Analog Input Pin		V_{SS} − 0.5	V_{REF} + 0.5	V	5, 6
DC Input Leakage		0	±3.0	μA	
Sampling Capacitor	3			pF	

NOTES:
*An ``LSB" as used here has a value of approximately 20 mV. (See Embedded Microcontrollers and Processors Handbook for A/D glossary of terms).
1. These values are expected for most parts at 25°C but are not tested or guaranteed.
2. DC to 100 KHz.
3. Multiplexer Break-Before-Make is guaranteed.
4. Resistance from device pin, through internal MUX, to sample capacitor.
5. These values may be exceeded if pin current is limited to ±2 mA.
6. Applying voltages beyond these specifications will degrade the accuracy of other channels being converted.
7. All conversions performed with processor in IDLE mode.

OTPROM SPECIFICATIONS

OPERATING CONDITIONS

Symbol	Description	Min	Max	Units
T_A	Ambient Temperature During Programming	20	30	C
V_{CC}	Supply Voltage During Programming	4.5	5.5	V(1)
V_{REF}	Reference Supply Voltage During Programming	4.5	5.5	V(1)
V_{PP}	Programming Voltage	12.25	12.75	V(2)
V_{EA}	EA Pin Voltage	12.25	12.75	V(2)
F_{OSC}	Oscillator Frequency during Auto and Slave Mode Programming	6.0	8.0	MHz
F_{OSC}	Oscillator Frequency during Run-Time Programming (**8XC196KD**)	6.0	16.0	MHz
F_{OSC}	Oscillator Frequency during Run-Time Programming (**8XC196KD20**)	6.0	20.0	MHz

NOTES:
1. V_{CC} and V_{REF} should nominally be at the same voltage during programming.
2. V_{PP} and V_{EA} must never exceed the maximum specification, or the device may be damaged.
3. V_{SS} and ANGND should nominally be at the same potential (0V).
4. Load capacitance during Auto and Slave Mode programming = 150 pF.

AC OTPROM PROGRAMMING CHARACTERISTICS (SLAVE MODE)

Symbol	Description	Min	Max	Units
T_{SHLL}	Reset High to First $\overline{PALE}$ Low	1100		T_{OSC}
T_{LLLH}	$\overline{PALE}$ Pulse Width	50		T_{OSC}
T_{AVLL}	Address Setup Time	0		T_{OSC}
T_{LLAX}	Address Hold Time	100		T_{OSC}
T_{PLDV}	$\overline{PROG}$ Low to Word Dump Valid		50	T_{OSC}
T_{PHDX}	Word Dump Data Hold		50	T_{OSC}
T_{DVPL}	Data Setup Time	0		T_{OSC}
T_{PLDX}	Data Hold Time	400		T_{OSC}
T_{PLPH}(1)	$\overline{PROG}$ Pulse Width	50		T_{OSC}
T_{PHLL}	$\overline{PROG}$ High to Next $\overline{PALE}$ Low	220		T_{OSC}
T_{LHPL}	$\overline{PALE}$ High to $\overline{PROG}$ Low	220		T_{OSC}
T_{PHPL}	$\overline{PROG}$ High to Next $\overline{PROG}$ Low	220		T_{OSC}
T_{PHIL}	$\overline{PROG}$ High to AINC Low	0		T_{OSC}
T_{ILIH}	$\overline{AINC}$ Pulse Width	240		T_{OSC}
T_{ILVH}	PVER Hold after $\overline{AINC}$ Low	50		T_{OSC}
T_{ILPL}	$\overline{AINC}$ Low to $\overline{PROG}$ Low	170		T_{OSC}
T_{PHVL}	$\overline{PROG}$ High to $\overline{PVER}$ Valid		220	T_{OSC}

NOTE:
1. This specification is for the Word Dump Mode. For programming pulses, use the Modified Quick Pulse Algorithm.

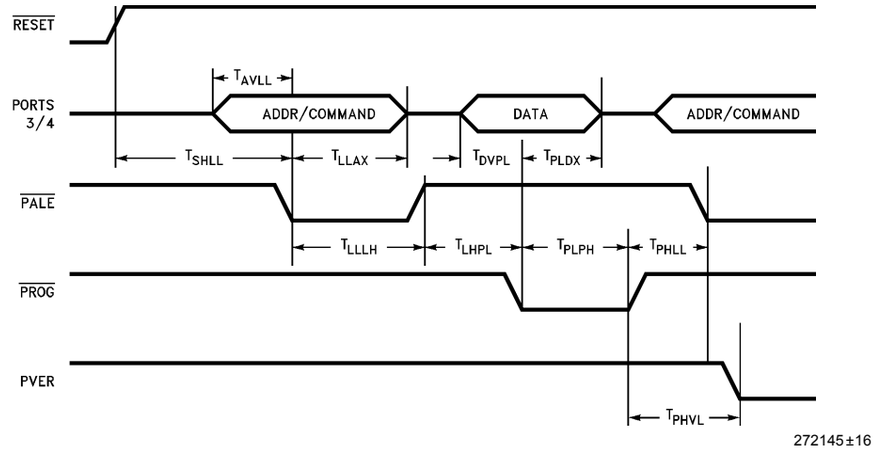
DC OTPROM PROGRAMMING CHARACTERISTICS

Symbol	Description	Min	Max	Units
I_{PP}	V_{PP} Supply Current (When Programming)		100	mA

NOTE:
Do not apply V_{PP} until V_{CC} is stable and within specifications and the oscillator/clock has stabilized or the device may be damaged.

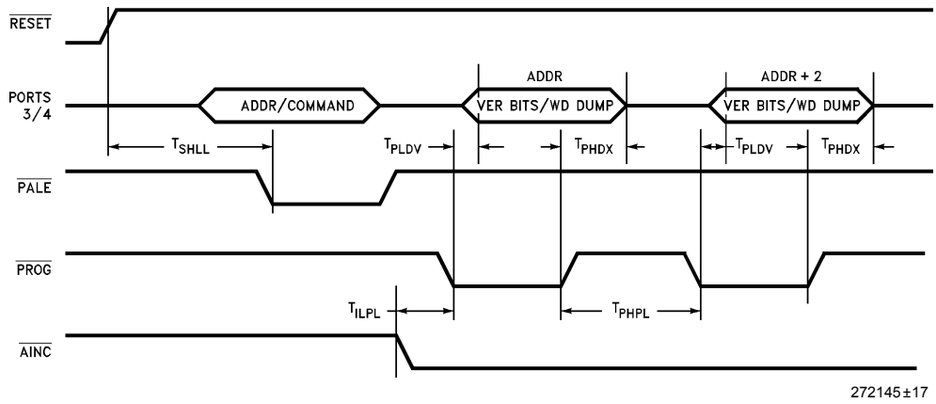
OTPROM PROGRAMMING WAVEFORMS

SLAVE PROGRAMMING MODE DATA PROGRAM MODE WITH SINGLE PROGRAM PULSE



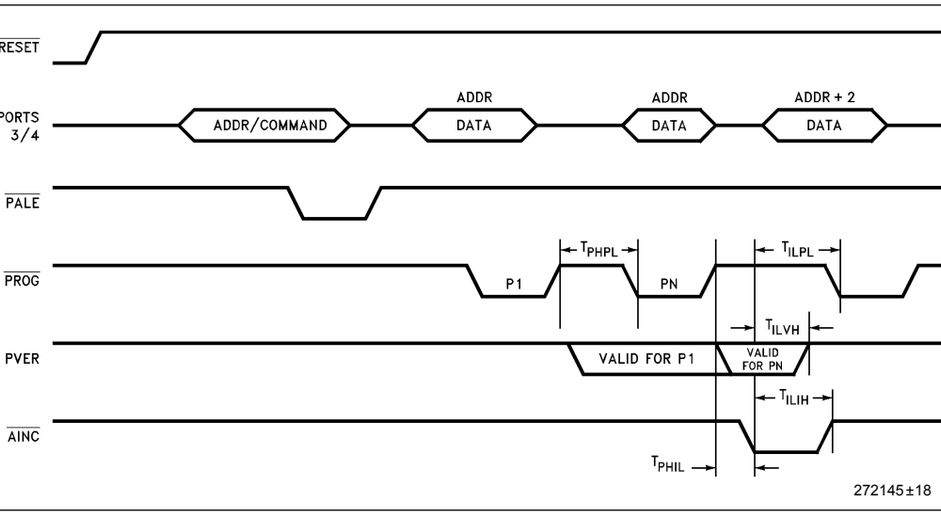
NOTE:
P3.0 must be high (``1'')

SLAVE PROGRAMMING MODE IN WORD DUMP WITH AUTO INCREMENT



NOTE:
P3.0 must be low (``0'')

SLAVE PROGRAMMING MODE TIMING IN DATA PROGRAM WITH REPEATED PROG PULSE AND AUTO INCREMENT



8XC196KC TO 8XC196KD DESIGN CONSIDERATIONS

1. Memory Map. The 8XC196KD has 1024 bytes of RAM/SFRs and 32K of OTPROM. The extra 512 bytes of RAM reside in locations 0200H to 03FFH, and the extra 16 Kbytes of OTPROM reside in locations 6000H to 9FFFH. On the 87C196KC these locations are always external, so KC code may have to be modified to run on the KD.
2. The vertical window scheme has been extended to include all on-chip RAM.
3. IOC3.1 controls the CLKOUT signal. This bit must be 0 to enable CLKOUT.
4. The 87C196KD has a different autoprogramming algorithm to support 32K of on-chip OTPROM.

8XC196KD ERRATA

1. 83C196KD can possibly miss interrupts on P0.7. See techbit MC0893.

DATA SHEET REVISION HISTORY

This data sheet is valid for devices with a ``D'' and ``E'' at the end of the topside tracking number. Data sheets 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.

The following are important differences between the

272145-004 and 272145-005 datasheets:

1. Package prefix variables have been changed.

   Variables are now indicated with an "x".

The following are important differences between the 272145-002 and 272145-003 data sheets:

1. I_{IL1} specification (logic 0 input current in reset) was misnamed. It is renamed I_{IL2}.
2. T_{LLYV} and T_{LLGV} were removed. These specifications are not necessary for high-speed system designs.
3. An errata with 83C196KD P0.7 EXTINT was added to the errata section.

The following are important differences between the 272145-001 and 272145-002 data sheets:

1. Added 20 MHz specifications.
2. Added 80-lead SQFP package pinout.
3. Changed QFP Package θ_{JA} to 56°C/W from 42°C/W.
4. Changed V_{HYS} to 300 mV from 150 mV.
5. Changed I_{CC} Typical specification at 16 MHz to 65 mA from 50 mA.
6. Changed I_{CC} Maximum specification at 16 MHz to 75 mA from 70 mA.
7. Changed I_{IDLE} Typical specification to 17 mA from 15 mA.
8. Changed I_{IDLE} Maximum specification to 25 mA from 30 mA.
9. Changed I_{PD} Typical specification to 8 μA from 15 μA.
10. Added I_{PD} Maximum specification.
11. Changed T_{CLDV} Maximum specification to $T_{OSC} - 45$ from $T_{OSC} - 50$.
12. Changed T_{LLAX} Minimum specification to $T_{OSC} - 35$ from $T_{OSC} - 40$.
13. Changed T_{CHWH} Minimum specification to -5 from -10.
14. Changed T_{RHAX} Minimum specification to $T_{OSC} - 25$ from $T_{OSC} - 30$.
15. Changed T_{HALAZ} Maximum specification to $+15$ from $+10$.
16. Changed T_{HALBZ} Maximum specification to $+20$ from $+15$.
17. Added T_{HAHBV} Maximum specification.
18. Changed T_{SAM} for 10-bit mode to 1 μs from 3 μs.
19. Changed T_{SAM} for 8-bit mode to 1 μs from 2 μs.
20. Changed I_{IH1} test condition to $V_{IN} = 2.4V$ from 5.5V.
21. Changed I_{IH1} maximum specification to $+200$ μA from $+100$ μA.
22. Removed NMI from list of standard inputs.
23. Updated I_{CC} and I_{IDLE} vs frequency graph.
24. Updated note under DC EPROM Programming Characteristics.
25. Changed I_{LI1} maximum specification to -12 mA from -6 mA.