



PRELIMINARY

# 8XC196KB ADVANCED 16-BIT CHMOS MICROCONTROLLER ROMless OR ROM

Automotive

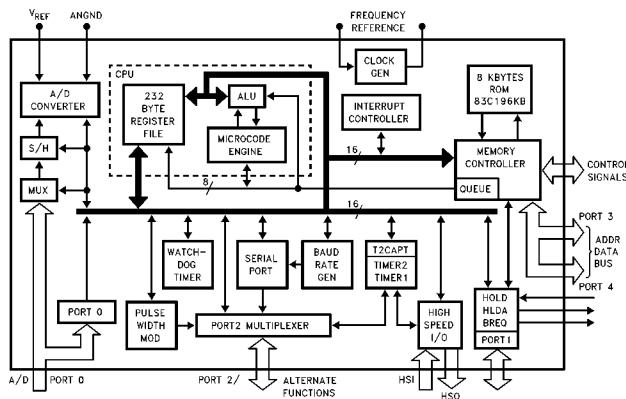
- -40°C to +125°C Ambient
- 232 Bytes of On-Chip Register RAM
- 8 Kbytes of On-Chip ROM (Optional)
- High-Performance CHMOS Process
- Register-to-Register Architecture
- 10-Bit A/D Converter with S/H
- Five 8-Bit I/O Ports
- 28 Interrupt Sources
- Pulse Width Modulated Output
- Powerdown and Idle Modes
- High Speed I/O Subsystem
- Dynamically Configurable 8/16-Bit Buswidth
- Full Duplex Serial Port
- Dedicated Baud Rate Generator
- 1.725  $\mu$ s 16 x 16 Multiply
- 3  $\mu$ s 32/16 Divide
- 16-Bit Watchdog Timer
- 16-Bit Timer
- 16-Bit Up/Down Counter w/Capture
- Four 16-Bit Software Timers
- HOLD/HOLDA Bus Protocol

The 8XC196KB 16-bit microcontroller comes with 8 Kbytes of on-chip mask programmable ROM or in ROMless versions. All devices are high performance members of the 8096 microcontroller family. The 8XC196KB is pin-to-pin compatible and uses a true superset of the 8096 instructions. Intel's CHMOS process provides a high performance processor along with low power consumption. To further reduce power requirements, the processor can be placed into Idle or Powerdown Mode.

Bit, byte, word and some 32-bit operations are available on the 8XC196KB. With a 16 MHz oscillator, a 16-bit addition takes 0.495  $\mu$ s, and the instruction times average 0.375  $\mu$ s to 1.125  $\mu$ s in typical applications.

Four high-speed capture inputs are provided to record times when events occur. 4 + 2 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 16-bit timer or a 16-bit up/down counter.

Also provided on-chip are an 8 channel, 10-bit A/D converter with Sample and Hold, a serial port with synchronous/asynchronous modes and on-chip baud rate generator, a 16-bit watchdog timer, pulse width modulated output with prescaler and an on-chip clock failure detect circuitry.



270679-1

Figure 1. 8XC196KB Block Diagram

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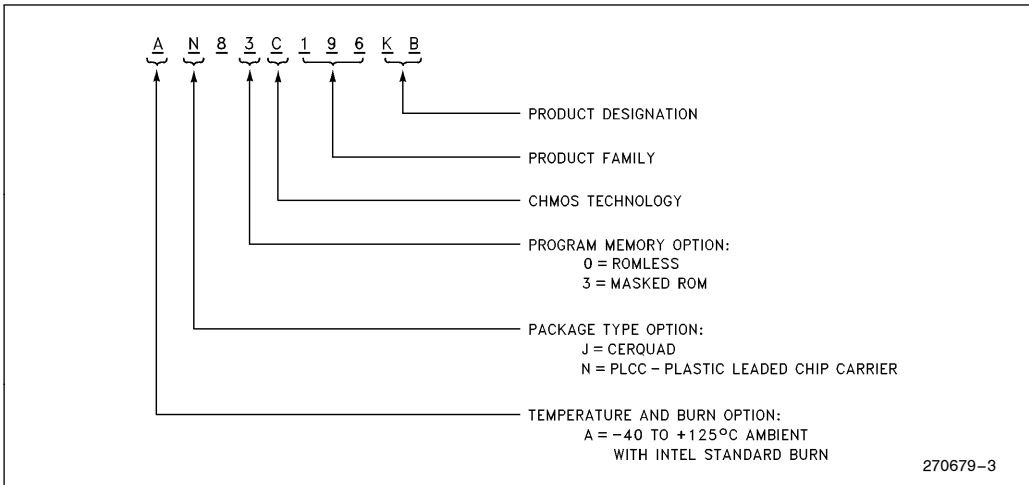


Figure 2. The 8XC196KB Family Nomenclature

**ARCHITECTURE**

The 8XC196KB is a member of the 8096 family, as such has the same architecture and uses the same instruction set as the 8096. Many new features have been added on the 8CX196KB including:

**CPU FEATURES**

Divide by 2 instead of divide by 3 clock for a 1.5x performance improvement

Faster instructions, especially indexed/indirect data operations

1.725 μs 16 x 16 multiply with 16 MHz clock (is 6.25 μs on the 8096)

Faster interrupt response (almost twice as fast)

Powerdown and Idle Modes

6 new instructions

8 new interrupt vectors/6 new interrupt sources

**PERIPHERAL FEATURES**

SFR window switching allows read-only SFRs to be written and vice-versa

Timer 2 can count up and down by external selection

Timer 2 has an independent capture register on rising edges of (P2.7)

HSD line events are stored in a register

HSD has CAM lock and CAM clear commands

New baud rate values are needed for serial port, which enables higher speeds in all modes.

Double buffered serial port transmit register (before, only receive was double buffered)

Serial port receive overrun and framing error detection

PWM has a divide by 2 prescaler

HOLD/HLDA bus protocol

**THERMAL CHARACTERISTICS**

	PLCC
$\theta_{JA}$	35°C/W
$\theta_{JC}$	12°C/W
Max Case Temperature	135°C

**NEW INSTRUCTIONS**

**PUSHA** PUSHes the PSW, IMASK, IMASK1 and WSR (used instead of PUSHF when using the new interrupts and registers)

**POPA** POPs the PSW, IMASK, IMASK1 and WSR (used instead of POPF when using the new interrupts and registers)

- IDLPD** Sets the device into Idle or Powerdown Mode. The instruction has the following format: IDLPD #key (where key = 1 for Idle and key = 2 for Powerdown. Illegal keys are processed, but no action is taken.
- CMPL** Compare 2 long direct values. Only the direct addressing mode is supported for this instruction and the format follows the CMP format.
- BMOV** Block move using 2 auto-incrementing pointers and a counter. The instruction has the following format: BMOV IPTR.wCNT. The IPTR is a long word, with the low word being the address of the source and the upper word being the address of the destination. wCNT is the number of words to be transferred.

**DJNZW\*** Decrement Jump Not Zero using a word counter. The instruction format follows the DJNZ instruction.

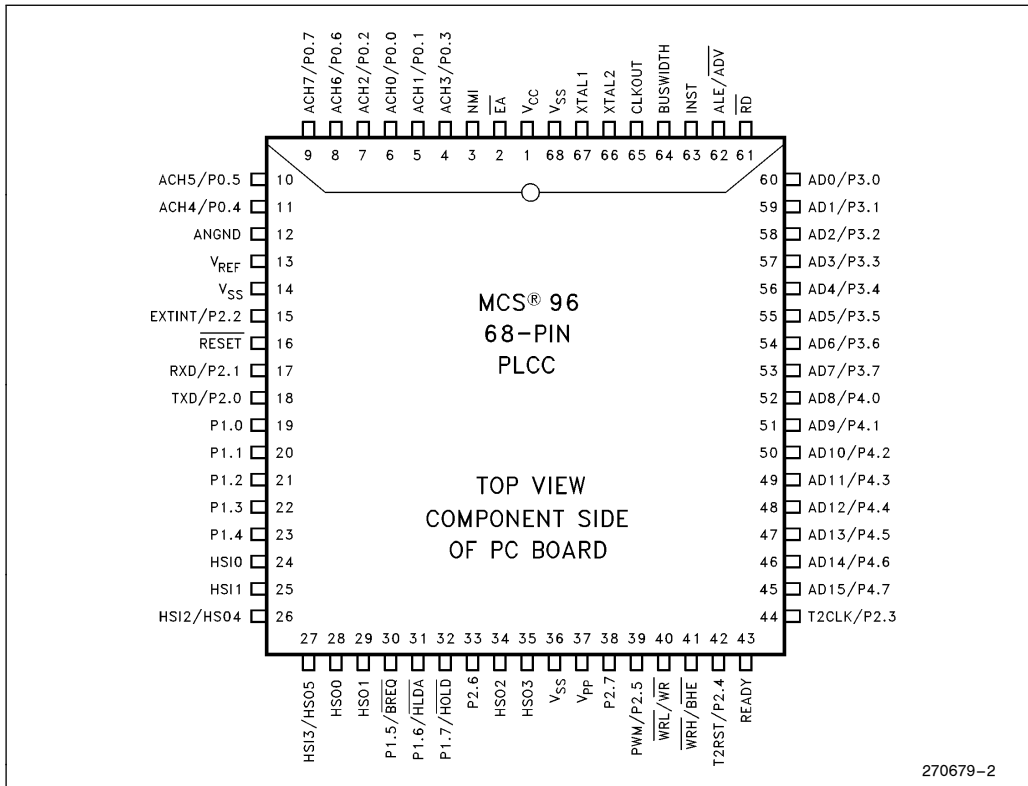
\*See the Functional Deviations section for details.

**SFR OPERATION**

All of the registers that were present on the 8096 work the same way as they did, except that the baud rate value will be different on the 8XC196KB. The new registers shown in the memory map control new functions. The most important register is the Window Select Register (WSR) which allows the reading of the formerly write-only registers, and vice-versa.

**PACKAGING**

The 8XC196KB is available in 68-pin plastic leaded chip carrier (PLCC) and 68-pin CERQUAD packages. Contact your local sales office to determine the exact ordering code for the part desired.



**Figure 3. 68-Pin PLCC Package**



PLCC	Description	PLCC	Description
9	ACH7/P0.7/PMD3	43	READY
8	ACH6/P0.6/PMD2	42	T2RST/P2.4/ $\overline{\text{AINC}}$
7	ACH2/P0.2	41	$\overline{\text{BHE}}$ /WRH
6	ACH0/P0.0	40	WR/WRL
5	ACH1/P0.1	39	PWM/P2.5
4	ACH3/P0.3	38	P2.7/T2CAPTURE/ $\overline{\text{PACT}}$
3	NMI	37	V <sub>PP</sub>
2	$\overline{\text{EA}}$	36	V <sub>SS</sub>
1	V <sub>CC</sub>	35	HSO.3
68	V <sub>SS</sub>	34	HSO.2
67	XTAL1	33	P2.6
66	XTAL2	32	P1.7/ $\overline{\text{HOLD}}$
65	CLKOUT	31	P1.6/ $\overline{\text{HLDA}}$
64	BUSWIDTH	30	P1.5/ $\overline{\text{BREQ}}$
63	INST	29	HSO.1
62	ALE/ $\overline{\text{ADV}}$	28	HSO.0
61	$\overline{\text{RD}}$	27	HSO.5/HSI.3/SID3
60	AD0/P3.0	26	HSO.4/HSI.2/SID2
59	AD1/P3.1	25	HSI.1/SID1
58	AD2/P3.2	24	HSI.0/SID0
57	AD3/P3.3	23	P1.4
56	AD4/P3.4	22	P1.3
55	AD5/P3.5	21	P1.2
54	AD6/P3.6	20	P1.1
53	AD7/P3.7	19	P1.0
52	AD8/P4.0	18	TXD/P2.0/PVER
51	AD9/P4.1	17	RXD/P2.1/ $\overline{\text{PALE}}$
50	AD10/P4.2	16	RESET
49	AD11/P4.3	15	EXTINT/P2.2/ $\overline{\text{PROG}}$
48	AD12/P4.4	14	V <sub>SS</sub>
47	AD13/P4.5	13	V <sub>REF</sub>
46	AD14/P4.6	12	ANGND
45	AD15/P4.7	11	ACH4/P0.4/PMD0
44	T2CLK/P2.3	10	ACH4/P0.5/PMD1

Figure 4. PLCC Functional Pinouts

**PIN DESCRIPTIONS**

Symbol	Name and Function
V <sub>CC</sub>	Main Supply Voltage (+ 5V)
V <sub>SS</sub>	Digital Circuit Ground (0V). There are three V <sub>SS</sub> pins, all of which MUST be connected.
V <sub>REF</sub>	Reference for the A/D Converter (+ 5V). V <sub>REF</sub> 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 <sub>SS</sub> .
V <sub>PP</sub>	Programming Voltage for the EPROM Parts. It should be + 12.75V for programming. This pin was V <sub>BB</sub> on 8X9X-90 parts. It is also the timing pin for the return from powerdown circuit. Connect this pin with a 1 μF capacitor to V <sub>SS</sub> and a 1 MΩ resistor to V <sub>CC</sub> . If this function is not used, V <sub>PP</sub> may be tied to V <sub>CC</sub> .
XTAL1	Input of the Oscillator Inverter and 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. It has a 50% duty cycle.
RESET	Reset Input to the Chip. Input low for at least 4 state times will reset the chip. The subsequent low to high transition resynchronizes CLKOUT and commences a 10-state time sequence in which the PSW is cleared, a byte is read from 2018H loading the CCB, and a jump to location 2080H is executed. Input high for normal operation. RESET has an internal pullup.
BUSWIDTH	Input for Bus Width Selection. If CCR bit 1 is a one, this pin selects the buswidth for the bus cycle in progress. If BUSWIDTH is low, an 8-bit cycle occurs. If BUSWIDTH is high, a 16-bit cycle occurs. If CCR bit 1 is a 0, the bus is always an 8-bit bus. This pin is the TEST pin on the 8X9X-90 parts. Systems with TEST tied to V <sub>CC</sub> need NOT change.
NMI	A positive transition causes an interrupt vector through external memory location 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 active only during external memory fetches, during internal EPROM/ROM fetches INST is held low.
$\overline{EA}$	Input for Memory Select (External Access). $\overline{EA}$ equal to a TTL-high causes memory accesses to locations 2000H through 3FFFH to be directed to on-chip EPROM/ROM. $\overline{EA}$ equal to a TTL-low causes accesses to these locations to be directed to off-chip memory. $\overline{EA} = + 12.75V$ causes execution to begin in the Programming Mode. $\overline{EA}$ has an internal pulldown, so it defaults to execute from external memory, unless otherwise driven. $\overline{EA}$ is latched at reset.
ALE/ $\overline{ADV}$	Address Latch Enable or Address Valid Output, as Selected by CCR. Both pin options provide a latch to demultiplex the address from the address/data bus. When the pin is $\overline{ADV}$ , it goes inactive (high) at the end of the bus cycle. $\overline{ADV}$ can be used as a chip select for external memory. ALE/ $\overline{ADV}$ is active only during external memory accesses.

## PIN DESCRIPTIONS (Continued)

Symbol	Name and Function
$\overline{RD}$	Read Signal Output to External Memory. $\overline{RD}$ is active only during external memory reads.
$\overline{WR}/\overline{WRL}$	Write and Write Low Output to External Memory, as Selected by the CCR. $\overline{WR}$ will go low for every external write, while $\overline{WRL}$ will go low only for external writes where an even byte is being written. $\overline{WR}/\overline{WRL}$ is active during external memory writes.
$\overline{BHE}/\overline{WRH}$	Byte High Enable or Write High Output as Selected by the CCR. $\overline{BHE} = 0$ selects the bank of memory that is connected to the high byte of the data bus. $A0 = 0$ selects that bank of memory that is connected to the low byte. Thus accesses to a 16-bit wide memory can be to the low byte only ( $A0 = 0, \overline{BHE} = 1$ ), to the high byte only ( $A0 = 1, \overline{BHE} = 0$ ) or both bytes ( $A0 = 0, \overline{BHE} = 0$ ). If the $\overline{WRH}$ function is selected, the pin will go low if the bus cycle is writing to an odd memory location. $\overline{BHE}/\overline{WRH}$ is only valid during 16-bit external memory write cycles.
READY	Ready Input to lengthen external memory cycles, for interfacing with slow or dynamic memory, or for bus sharing. If the pin is high, CPU operation continues in a normal manner. If the pin is low prior to the falling edge of CLKOUT, the memory controller goes into a wait state mode until the next positive transition in CLKOUT occurs with READY high. When external memory is not used, READY has no effect. The number of wait states inserted into the bus cycle is controlled by the CCR.
HSI	Inputs to High Speed Input Unit. Four HSI pins are available: HSI.0, HSI.1, HSI.2, HSI.3. Two of which are shared with the HSO Unit (HSI.2 and HSI.3). The HSI pins are also used as the SID in Slave Programming Mode.
HSO	Outputs from High Speed Output Unit. Six HSO pins are available (HSO.0 through HSO.5). HSO.4 and HSO.5 are shared with HSI.
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. These pins are also used as inputs to EPROM parts to select the Programming Mode.
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.
PORT 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.
$\overline{HOLD}$	Bus Hold Input Requesting Control of the Bus. Enabled by Setting WSR.7
$\overline{HLDA}$	Bus Hold Acknowledge Output Indicating Release of the Bus. Enabled by setting WSR.7.
$\overline{BREQ}$	Bus Request Output. Activated when the bus controller has a pending external memory cycle. Enabled by setting WSR.7.



**ELECTRICAL CHARACTERISTICS**

**Absolute Maximum Ratings\***

Storage Temperature ..... -60°C to +150°C  
 Voltage from V<sub>PP</sub> or  $\overline{EA}$   
 to V<sub>SS</sub> or ANGND ..... -0.5V to +13.0V  
 Voltage on Any Pin  
 to V<sub>SS</sub> or ANGND ..... -0.5V to +7.0V  
 This includes V<sub>PP</sub> on ROM and CPU devices.  
 Power Dissipation ..... 1.5W

NOTICE: This data sheet contains preliminary 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 data sheet before finalizing a design.

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

**OPERATING CONDITIONS**

Symbol	Parameter	Min	Max	Units
T <sub>A</sub>	Ambient Temperature under Bias	-40	+125	°C
V <sub>CC</sub>	Digital Supply Voltage	4.50	5.50	V
V <sub>REF</sub>	Analog Supply Voltage	4.50	5.50	V
F <sub>OSC</sub>	Oscillator Frequency	3.5	16	MHz

**NOTE:**  
 ANGND and V<sub>SS</sub> should be nominally at the same potential.

**DC CHARACTERISTICS** (Under Listed Operating Conditions)

Symbol	Parameter	Min	Typ	Max	Units	Test Conditions
I <sub>CC</sub>	V <sub>CC</sub> Supply Current (-40°C to +125°C Ambient)		50	70	mA	XTAL1 = 16 MHz, V <sub>CC</sub> = V <sub>PP</sub> = V <sub>REF</sub> = 5.5V
I <sub>PD</sub>	Powerdown Mode Current		5		μA	V <sub>CC</sub> = V <sub>PP</sub> = V <sub>REF</sub> = 5.5V
I <sub>REF</sub>	A/D Reference Supply Current		2	5	mA	XTAL1 = 16 MHz, V <sub>CC</sub> = V <sub>PP</sub> = V <sub>REF</sub> = 5.5V
I <sub>IDLE</sub>	Idle Mode Current		10	35	mA	XTAL1 = 16 MHz, V <sub>CC</sub> = V <sub>PP</sub> = V <sub>REF</sub> = 5.5V
V <sub>IL</sub>	Input Low Voltage	-0.5V		+0.8	V	
V <sub>IH</sub>	Input High Voltage <sup>(1)</sup>	0.2 V <sub>CC</sub> + 1.1		V <sub>CC</sub> + 0.5	V	
V <sub>IH1</sub>	Input High Voltage on XTAL1	0.7 V <sub>CC</sub>		V <sub>CC</sub> + 0.5	V	
V <sub>IH2</sub>	Input on High Voltage on RESET	2.6		V <sub>CC</sub> + 0.5	V	
V <sub>OL</sub>	Output Low Voltage			0.3 0.45 1.5	V	I <sub>OL</sub> = 200 μA I <sub>OL</sub> = 3.2 mA I <sub>OL</sub> = 7.0 mA
V <sub>OH</sub>	Output High Voltage (Standard Outputs)	V <sub>CC</sub> - 0.3 V <sub>CC</sub> - 0.7 V <sub>CC</sub> - 1.5			V	I <sub>OH</sub> = -200 μA I <sub>OH</sub> = -3.2 mA I <sub>OH</sub> = -7.0 mA
V <sub>OH1</sub>	Output High Voltage (Quasi-Bidirectional Outputs)	V <sub>CC</sub> - 0.3 V <sub>CC</sub> - 0.7 V <sub>CC</sub> - 1.5			V	I <sub>OH</sub> = -15 μA I <sub>OH</sub> = -30 μA I <sub>OH</sub> = -60 μA



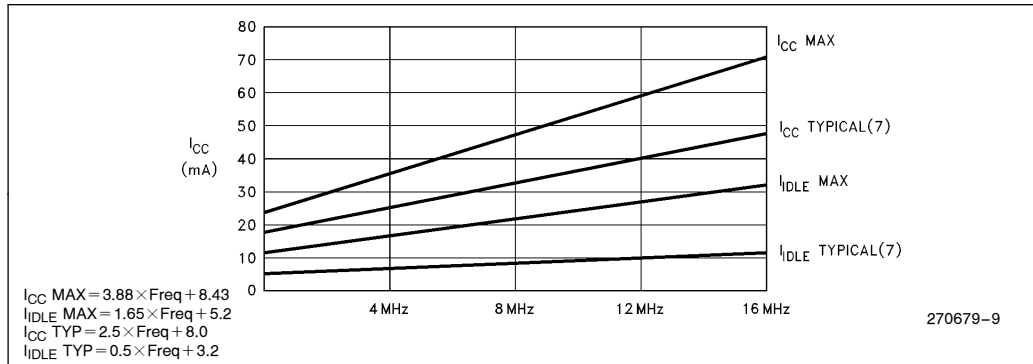
**DC CHARACTERISTICS** (Under Listed Operating Conditions) (Continued)

Symbol	Parameter	Min	Typ	Max	Units	Test Conditions
I <sub>LI</sub>	Input Leakage Current (Std. Inputs)			± 10	μA	0 < V <sub>IN</sub> < V <sub>CC</sub> - 0.3V
I <sub>LI1</sub>	Input Leakage Current (Port 0)			± 3	μA	0 < V <sub>IN</sub> < V <sub>REF</sub>
I <sub>TL</sub>	1 to 0 Transition Current (QBD Pins)			-800	μA	V <sub>IN</sub> = 2.0V
I <sub>IL</sub>	Logical 0 Input Current (QBD Pins)			-50	μA	V <sub>IN</sub> = 0.45V
I <sub>IL1</sub>	Logical 0 Input Current in Reset (ALE, RD, INST)			-9	mA	V <sub>IN</sub> = 0.45V
I <sub>IL2</sub>	Logical 0 Input Current in Reset (WR, P2.0, BHE)			-700	μA	V <sub>IN</sub> = 0.45V
HYST	Hysteresis on RESET Pin	250			mV	
R <sub>RST</sub>	Reset Pullup Resistor	6K		50	Ω	
C <sub>S</sub>	Pin Capacitance (Any Pin to V <sub>SS</sub> )			10	pF	F <sub>TEST</sub> = 1.0 MHz

**NOTES:** (Notes apply to all specifications)

- All pins except RESET and XTAL1. QBC (Quasi-bidirectional) pins include Port 1, P2.6, P2.7.
- Standard Outputs include AD0-15, RD, WR, ALE, BHE, INST, HSO pins, PWM/P2.5, CLKOUT, RESET, Port 3 and 4, TXD/P2.0 and RXD (in serial mode 0). The V<sub>OH</sub> specification is not valid for RESET. Ports 3 and 4 are open drain outputs.
- Standard Inputs include HSI pins, CDE, EA, READY, BUSWIDTH, NMI, RXD/P2.1, EXTINT/P2.2, T2CLK/P2.3 and T2RST/P2.4
- Maximum current per pin must be externally limited to the following values if V<sub>OL</sub> is held above 0.45V or V<sub>OH</sub> is held below V<sub>CC</sub> - 0.7V:
  - I<sub>OL</sub> on Output pins: 10 mA
  - I<sub>OL</sub> on QBD pins: self limiting
  - I<sub>OL</sub> on Standard Output pins: 10 mA
- Maximum current per bus pin (data and control) during normal operation is ±3.2 mA.
- During normal (non-transient) conditions the following total current limits apply:
 

Port 1, P2.6	I <sub>OL</sub> : 29 mA	I <sub>OH</sub> : is Self Limiting
HSO, P2.0, RXD, RESET	I <sub>OL</sub> : 29 mA	I <sub>OH</sub> : 26 mA
P2.5, P2.7, WR, BHE	I <sub>OL</sub> : 13 mA	I <sub>OH</sub> : 11 mA
AD0-AD15	I <sub>OL</sub> : 52 mA	I <sub>OH</sub> : 52 mA
RD, ALE, INST, CLKOUT	I <sub>OL</sub> : 13 mA	I <sub>OH</sub> : 13 mA
- Typicals are based on limited number of samples and are not guaranteed. The values listed are at room temperature and V<sub>REF</sub> = V<sub>CC</sub> = 5V.



**Figure 5. I<sub>CC</sub> vs Frequency**





**AC CHARACTERISTICS** Over Specified Operating Conditions

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

**The system must meet these specifications to work with the 8XC196KB**

Symbol	Parameter	Min	Max	Units
$T_{AVYV}$	Address Valid to READY Setup		$2 T_{OSC} - 75$	ns
$T_{LLYV}$	ALE Low to READY Setup		$T_{OSC} - 60$	ns
$T_{YLYH}$	Non READY Time	No Upper Limit		ns
$T_{CLYX}$	READY Hold after CLKOUT Low	0	$T_{OSC} - 30$	ns <sup>(1)</sup>
$T_{LLYX}$	READY Hold after ALE Low	$T_{OSC} - 15$	$2 T_{OSC} - 40$	ns <sup>(1)</sup>
$T_{AVGV}$	Address Valid to Buswidth Setup		$2 T_{OSC} - 75$	ns
$T_{LLGV}$	ALE Low to Buswidth Setup		$T_{OSC} - 60$	ns
$T_{CLGX}$	Buswidth Hold after CLKOUT Low	0		ns
$T_{AVDV}$	Address Valid to Input Data Valid		$3 T_{OSC} - 55$	ns
$T_{RLDV}$	$\overline{RD}$ Active to Input Data Valid		$T_{OSC} - 23$	ns
$T_{CLDV}$	CLKOUT Low to Input Data Valid		$T_{OSC} - 50$	ns
$T_{RHDZ}$	End of $\overline{RD}$ to Input Data Float		$T_{OSC} - 20$	ns
$T_{RXDX}$	Data hold after $\overline{RD}$ Inactive	0		ns
$F_{XTAL}$	Oscillator Frequency	3.5	16	MHz
$T_{OSC}$	Oscillator Period ( $1/f_{XTAL}$ )	62.5	286	ns
$T_{XHCH}$	XTAL1 High to CLKOUT High or LOW <sup>(1)</sup>	20	110	ns
$T_{CLCL}$	CLKOUT Period	$2 T_{OSC}$		ns
$T_{CHCL}$	CLKOUT High Period	$T_{OSC} - 10$	$T_{OSC} + 10$	ns
$T_{CLLH}$	CLKOUT Falling Edge to ALE Rising	-10	10	ns
$T_{LLCH}$	ALE/ $\overline{ADV}$ Falling Edge to CLKOUT Rising	-15	15	ns
$T_{LHLH}$	ALE/ $\overline{ADV}$ Cycle Time	$4 T_{OSC}$		ns
$T_{LHLL}$	ALE/ $\overline{ADV}$ High Period	$T_{OSC} - 10$	$T_{OSC} + 10$	ns
$T_{AVLL}$	Address Setup to ALE/ $\overline{ADV}$ Falling Edge	$T_{OSC} - 30$		ns
$T_{LLAX}$	Address Hold after ALE/ $\overline{ADV}$ Falling Edge	$T_{OSC} - 40$		ns
$T_{LLRL}$	ALE/ $\overline{ADV}$ Falling Edge to $\overline{RD}$ Falling Edge	$T_{OSC} - 35$		ns
$T_{RLCL}$	$\overline{RD}$ Low to CLKOUT Falling Edge	4	25	ns
$T_{RLRH}$	$\overline{RD}$ Low Period	$T_{OSC} - 10$	$T_{OSC} + 25$	ns
$T_{RHLH}$	$\overline{RD}$ Rising Edge to ALE/ $\overline{ADV}$ Rising Edge <sup>(3)</sup>	$T_{OSC}$	$T_{OSC} + 25$	ns
$T_{RLAZ}$	$\overline{RD}$ Low to Address Float		5	ns
$T_{LLWL}$	ALE/ $\overline{ADV}$ 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	$T_{OSC} - 23$		ns
$T_{CHWH}$	CLKOUT High to $\overline{WR}$ Rising Edge	-5	15	ns
$T_{WLWH}$	$\overline{WR}$ Low Period	$T_{OSC} - 15$	$T_{OSC} + 5$	ns



**AC CHARACTERISTICS** Over Specified Operating Conditions (Continued)

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

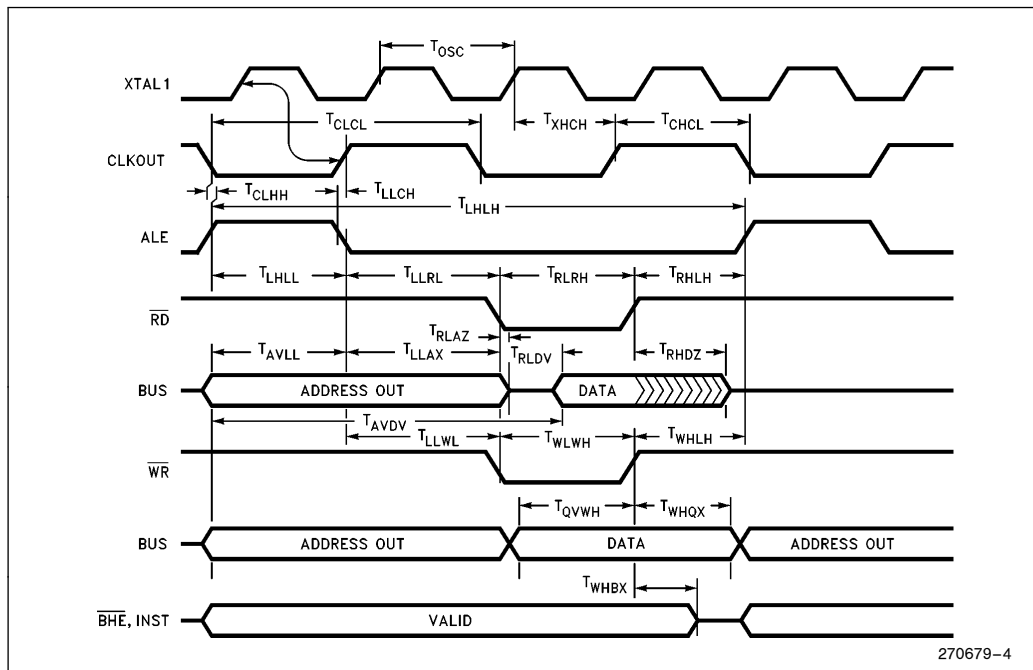
**The system must meet these specifications to work with the 8XC196KB**

Symbol	Parameter	Min	Max	Units
$T_{WHQX}$	Data Hold after $\overline{WR}$ Rising Edge	$T_{OSC} - 15$		ns
$T_{WHLH}$	$\overline{WR}$ Rising Edge to ALE/ $\overline{ADV}$ Rising Edge <sup>(3)</sup>	$T_{OSC} - 20$	$T_{OSC} + 10$	ns
$T_{WHBX}$	$\overline{BHE}$ , INST, HOLD after $\overline{WR}$ , $\overline{RD}$ Rising Edge	$T_{OSC} - 15$		ns
$T_{WHAX}$	AD8-15 Hold after $\overline{WR}$ / $\overline{RD}$ Rising Edge	$T_{OSC} - 30$		ns
$T_{RHBX}$	$\overline{BHE}$ , INST HOLD after $\overline{RD}$ Rising	$T_{OSC} - 10$		ns
$T_{RHAX}$	AD8-15 HOLD after $\overline{RD}$ Rising	$T_{OSC} - 25$		ns

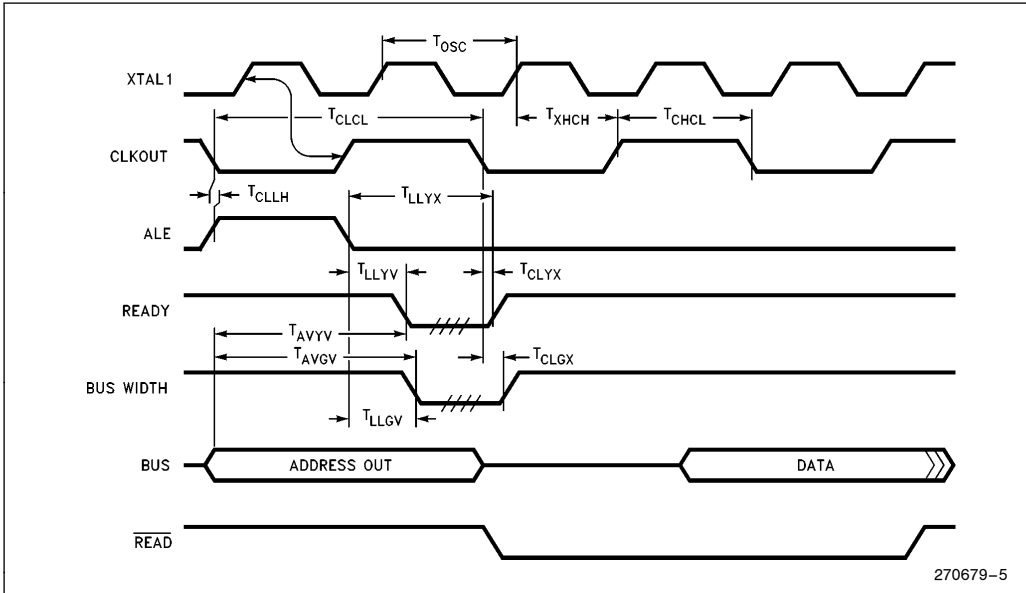
**NOTES:**

1. Typical specification, not guaranteed.
  2. Assuming back-to-back bus cycles.
- $T_{OSC} = 62.5$  ns at 16 MHz;  $T_{OSC} = 100$  ns at 10 MHz;  $T_{OSC} = 125$  ns at 8 MHz.

**System Bus Timing**



**Ready/Buswidth Timing**

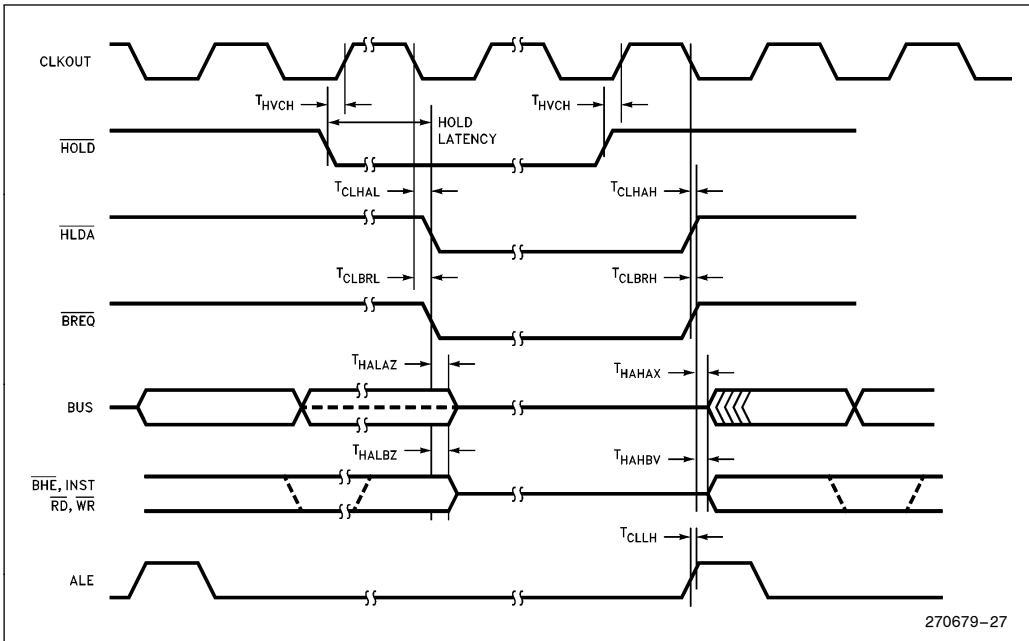


**HOLD/HLDA Timings**

Symbol	Description	Min	Max	Units	Notes
$T_{HVCH}$	HOLD Setup 80C196KB 83C196KB	75 85		ns	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 80C196KB 83C196KB		15 20	ns	
$T_{HALBZ}$	$\overline{HLDA}$ Low to BHE, INST, RD, WR Float			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	-5		ns	
$T_{HAHBV}$	$\overline{HLDA}$ High to $\overline{BHE}$ , INST, $\overline{RD}$ , $\overline{WR}$ Valid	-20		ns	
$T_{CLLH}$	CLKOUT Low to ALE High	-5	15	ns	

**NOTE:**

1. To guarantee recognition at next clock.

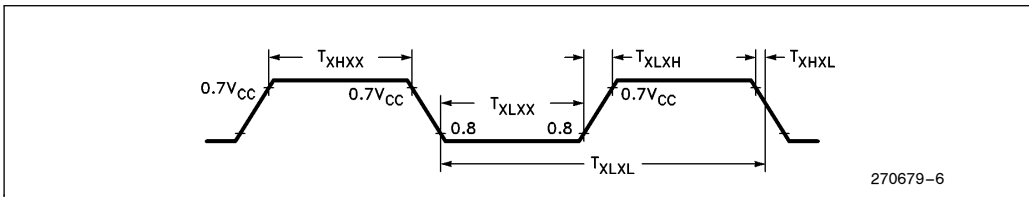


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**External Clock Drive**

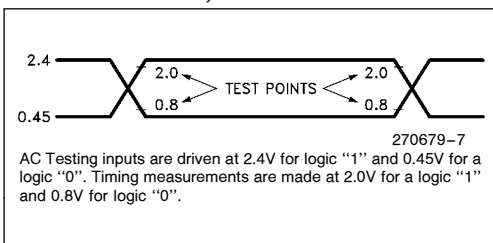
Symbol	Parameter	Min	Max	Units
$1/T_{XLXL}$	Oscillator Frequency	3.5	16	MHz
$T_{XLXL}$	Oscillator Period ( $T_{OSC}$ )	62.5	286	ns
$T_{XHXX}$	High Time	$T_{OSC} - 51$		ns
$T_{XLXX}$	Low Time	$T_{OSC} - 51$		ns
$T_{XLXH}$	Rise Time		$T_{OSC} - 73$	ns
$T_{XHXL}$	Fall Time		$T_{OSC} - 73$	ns

**EXTERNAL CLOCK DRIVE WAVEFORMS**

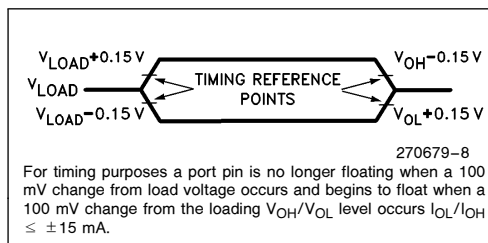


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**AC TESTING INPUT, OUTPUT WAVEFORMS**



**FLOAT WAVEFORMS**



**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— BHE
- C— CLKOUT
- D— Data
- G— Buswidth
- L— ALE/ $\overline{ADV}$
- R— RD
- W—  $\overline{WR}/\overline{WRH}/\overline{WRI}$
- X— XTAL1
- Y— Ready

**AC CHARACTERISTICS—SERIAL PORT—SHIFT REGISTER MODE**

**SERIAL PORT TIMING—SHIFT REGISTER MODE**

Test Conditions:  $T_C = -40^\circ\text{C}$  to  $+125^\circ\text{C}$ ;  $V_{CC} = 5.0\text{V} \pm 10\%$ ;  $V_{SS} = 0.0\text{V}$ ; Load Capacitance = 80 pF

Symbol	Parameter	Min	Max	Unit
$T_{XLXL}$	Serial Port Clock Period <sup>(9)</sup>	$6 T_{OSC}/4 T_{OSC}$		ns
$T_{XLXH}$	Serial Port Clock Falling Edge to Rising Edge <sup>(9)</sup>	$4 T_{OSC} - 50/2 T_{OSC} - 50$	$4 T_{OSC} + 50/2 T_{OSC} - 50$	ns
$T_{QVXH}$	Output Data Setup 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
$T_{XHDX}^{(8)}$	Input Data Hold after Clock Rising Edge	0		ns
$T_{XHQZ}^{(8)}$	Last Clock Rising to Output Float		$T_{OSC}$	ns

**NOTES:**

- 8. Parameter not tested.
- 9. Baud Rate Register  $\geq 8002\text{H}$ /Baud Rate Register = 8001H.



**A to D CHARACTERISTICS**

There are two modes of A/D operation: with and without clock prescaler. The modes are shown in the table below. In mode 2, with the clock prescaler disabled, the maximum XTAL1 frequency is 8.0 MHz. Accuracy will degrade at higher frequencies in this mode. The frequency divider option is provided to obtain higher accuracy outside of the currently specified operating conditions.

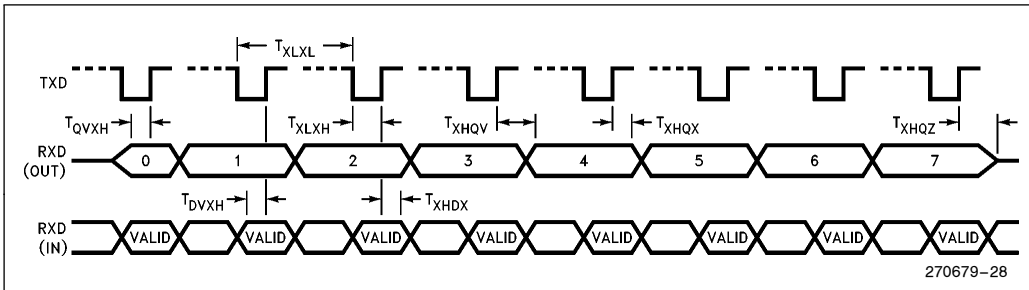
The converter is ratiometric, so the absolute accuracy is directly dependent on the accuracy and stability of VREF. VREF must be close to VCC since it supplies both the resistor ladder and the digital section of the converter.

**A/D Converter Specifications**

The specifications given below assume adherence to the operating conditions section of this data sheet. Testing is performed in mode 2 with VREF = 5.12V and 8 MHz operating clock frequency.

**WAVEFORM—SERIAL PORT—SHIFT REGISTER MODE**

**SERIAL PORT WAVEFORM—SHIFT REGISTER MODE**



Clock Prescaler ON IOC2.4 = 0	Clock Prescaler OFF IOC2.4 = 1
Mode 1— 158 States for Execution 26.33 μs @ 12 MHz	Mode 2— 91 States for Execution 22.75 μs @ 8 MHz (Maximum)

**NOTE:**  
IOC2.3 = 0, The No Sample and Hold feature is not available on the 8XC196KB device.

Parameter	Typical*(1)	Minimum	Maximum	Units**
Resolution		512 9	1024 10	Level Bits
Absolute Error		0	±6	LSBs
Full Scale Error	0.25 ± 0.5			LSBs
Zero Offset Error	-0.25 ± 0.5			LSBs
Non-Linearity	1.5 ± 2.5	0	±4	LSBs
Differential Non-Linearity		> -1	+2	LSBs
Channel-to-Channel Matching	±0.1	0	±1	LSBs
Repeatability	±0.25			LSBs(1)
Temperature Coefficients:				
Offset	0.009			LSB/C(1)
Full Scale	0.009			LSB/C(1)
Differential Non-Linearity	0.009			LSB/C(1)
Off Isolation		-60		dB(1, 2, 4)
Feedthrough	-60			dB(1, 2)
V <sub>CC</sub> Power Supply Rejection	-60			dB(1, 2)
Input Resistance		1K	5K	Ω(1)
DC Input Leakage		0	3	μA
Sample Time (Prescaler on/off)	15/8			States (3)
Input Capacitance	3			pF

**NOTES:**

\*These values are expected for most parts at 25°C but are not tested or guaranteed.

\*\*An “LSB”, as used here, has a value of approximately 5 mV. (See Automotive Handbook, for A/D glossary of terms.)

1. These values are not tested in production and are based on theoretical estimates and/or laboratory test.

2. DC to 100 KHz.

3. One state = 125 ns @ 16 MHz; 333 ns @ 6 MHz.

4. Multiplexer Break-Before-Make Guaranteed.

**80C196KB FUNCTIONAL DEVIATIONS**

The 80C196KB has the following problems.

1. The HSI unit has two errata: one dealing with resolution and the other with first entries into the FIFO.

The HSI resolution is 9 states instead of 8 states. Events on the same line may be lost if they occur faster than once every 9 state times.

There is a mismatch between the 9 state time HSI resolution and the 8 state time timer. This causes one time value to be unused every 9 timer counts. Events may receive a time-tag one count later than expected because of this “skipped” time value.

If the first two events into an empty FIFO (not including the Holding Register) occur in the same internal phase, both are recorded with one time-tag. Otherwise, if the second event occurs within 9 states after the first, its time-tag is one count later than the first's. If this is the “skipped” time value, the second event's time-tag is 2 counts later than the first's.

If the FIFO and Holding Register are empty, the first event will transfer into the Holding Register after 8 state times, leaving the FIFO empty again. If the second event occurs after this time, it will act as a new first event into an empty FIFO.

2. If an A/D conversion in progress is aborted by starting a new A/D conversion, results of the second conversion may be inaccurate.

The work-around is to wait for the conversion in progress to finish before starting the second conversion. Polling or an interrupt will detect the conversion completion.

3. If the unsigned divide instruction (word or byte) is in the queue as HOLD or READY is asserted, the result may be incorrect. TechBit (MC1791). (B-step only.)

### DIFFERENCES BETWEEN THE 80C196KA AND THE 80C196KB

The 8XC196KB is identical to 8XC196KA except for the following differences.

1. ALE is high after reset on the 80C196KB instead of low as on the 80C196KA.
2. The DJNZW instruction is not guaranteed to work on the 80C196KB. (A-step only.)
3. The  $\overline{\text{HOLD}}/\overline{\text{HLDA}}$  bus protocol is available on the 80C196KB.

### CONVERTING FROM OTHER 8096BH FAMILY PRODUCTS TO THE 80C196KB

The following list of suggestions for designing an 809XBH system will yield a design that is easily converted to the 80C196KB.

1. Do not base critical timing loops on instruction or peripheral execution times.
2. Use equate statements to set all timing parameters, including the baud rate.
3. Do not base hardware timings on CLKOUT or XTAL1. The timings of the 80C196KB are different than those of the 8X9XBH, but they will function with standard ROM/EPROM/Peripheral type memory systems.

4. Make sure all inputs are tied high or low and not left floating.
5. Indexed and indirect operations relative to the stack pointer (SP) work differently on the 80C196KB than on the 8096BH. On the 8096BH, the address is calculated based on the un-updated version of the stack pointer. The 80C196KB uses the updated version. The offset for POP[SP] and POP nn[SP] instructions may need to be changed by a count of 2.
6. The  $V_{PD}$  pin on the 8096BH has changed to a  $V_{SS}$  pin on the 80C196KB.

### OTHER DESIGN CONSIDERATIONS (KB B-0 to KB C-1)

1. The NMI pin on the KB ROM (C-1) has a weak pulldown.  $I_{IH1}$  max is 100  $\mu\text{A}$ . The KB ROM (B-0) did not have a pulldown on NMI. If KB ROM (B-0) designs have NMI tied to  $V_{CC}$ , the NMI pin must be tied to  $V_{SS}$ . If NMI is tied to  $V_{SS}$  or is floating, it is okay.
2. The ALE, RD, and INST pins on the KB ROM (C-1) have stronger pullups during RESET than on the KB ROM (B-0).  $I_{IL1}$  is  $-7$  mA on the KB ROM (C-1) compared to  $-1.2$  mA on the KB ROM (B-0). Designs which pull these pins low to enter ONCE mode must have strong enough pull-downs to overcome the pullups.
3. Pin on the PLCC package on the KB ROM (B-0) was the CDE pin. That function did not work so the pin was assigned to  $V_{SS}$ . On the KB ROM (C-1) this pin is tied directly to  $V_{SS}$  on the device and MUST be tied to  $V_{SS}$  externally.
4. Several AC/DC specifications have changed. (See Data Sheet Revision History; review them carefully.)



**DATA SHEET REVISION HISTORY**

This is the -005 revision of the 8XC196KB data sheet and is valid for devices marked with a “F” or “G” at the end of the topside tracking number. The following differences exist between the -004 revision and the -005 revision:

1. All performance related data is now quoted at 16 MHz. The maximum clock rate has changed from 12 MHz to 16 MHz.
2. Max power dissipation changes from 0.43W to 1.5W.
3.  $I_{CC}$  max has changed from 60 mA to 70 mA.
4.  $I_{CC}$  typical has changed from 40 mA to 50 mA.
5.  $I_{REF}$  typical has changed from 1 mA to 2 mA.
6.  $I_{IDLE}$  has changed from 25 mA to 35 mA.
7.  $V_{IH2}$  min has changed from 2.4V to 2.5V.
8.  $V_{OH1}$  test condition for  $V_{CC} - 0.3V$  has changed from  $-7 \mu A$  to  $-15 \mu A$ .
9.  $I_{TL}$  has changed from  $-650 \mu A$  to  $-800 \mu A$ .
10.  $I_{IL1}$  has changed from  $-1.2$  mA to  $-9$  mA.
11.  $I_{IL1}$  now only applies to ALE,  $\overline{RD}$  and INST.
12.  $R_{RST}$  max has changed from 100 K $\Omega$  to 50 K $\Omega$ .
13. Added spec for RESET pin hysteresis and  $I_{IL2}$  for WR, P2.0, and BHE.
14.  $T_{AVYV}$  has changed from  $2 T_{OSC} - 85$  ns to  $2 T_{OSC} - 75$  ns.
15.  $T_{LLYV}$  has changed from  $T_{OSC} - 72$  ns to  $T_{OSC} - 60$  ns.
16.  $T_{AVGV}$  has changed from  $2 T_{OSC} - 85$  ns to  $2 T_{OSC} - 75$  ns.
17.  $T_{AVDV}$  has changed from  $3 T_{OSC} - 65$  ns to  $3 T_{OSC} - 55$  ns.
18.  $F_{XTAL}$  max has changed from 12 MHz to 16 MHz.
19.  $T_{OSC}$  min has changed from 83 ns to 62.5 ns.
20.  $T_{XHCH}$  min has changed from 40 ns to 20 ns.
21.  $T_{CLLH}$  min/max has changed from  $-5$  ns/15 ns to  $-10$  ns/10 ns.
22.  $T_{LHLL}$  min/max has changed from  $T_{OSC} \pm 12$  ns to  $T_{OSC} \pm 10$  ns.
23.  $T_{AVLL}$  has changed from  $T_{OSC} - 20$  ns to  $T_{OSC} - 30$  ns.
24.  $T_{LLRL}$  has changed from  $T_{OSC} - 40$  ns to  $T_{OSC} - 35$  ns.
25.  $T_{RLCL}$  min/max has changed from 5 ns/30 ns to 4 ns/25 ns.
26.  $T_{RLRH}$  has changed from  $T_{OSC} - 5$  ns to  $T_{OSC} - 10$  ns.
27.  $T_{RLAZ}$  has changed from 12 ns to 5 ns.
28.  $T_{CHWH}$  min/max has changed from  $-10$  ns/10 ns to  $-5$  ns/15 ns.
29.  $T_{WLWH}$  min/max has changed from  $T_{OSC} - 30$  ns to  $T_{OSC} - 15$  ns.
30.  $T_{WHQX}$  has changed from  $T_{OSC} - 10$  ns to  $T_{OSC} - 15$  ns.
31.  $T_{WHLH}$  min/max has changed from  $T_{OSC} - 10$  ns/ $T_{OSC} + 15$  ns to  $T_{OSC} - 20$  ns/ $T_{OSC} + 10$  ns.
32.  $T_{WHBX}$  has changed from  $T_{OSC} - 10$  ns to  $T_{OSC} - 15$  ns.
33.  $T_{WHAX}$  has changed from  $T_{OSC} - 50$  ns to  $T_{OSC} - 30$  ns.
34.  $T_{RHAX}$  has changed from  $T_{OSC} - 50$  ns to  $T_{OSC} - 25$  ns.
35. Functional deviation number 1 has been removed (DJWZ is now functional).
36. Functional deviation number 3 has been removed (SIO framing flag now works correctly).
37. Functional deviation number 5 has been removed (SIO RI now correctly generated).
38. Functional deviation number 6 has been corrected. The divide during HOLD bug has been fixed.
39. The section “Other Design Considerations KB B-0 to KB C-1” has been added.