HARRIS SEMICONDUCTOR

CDP68HC05P1B, CDP68HCL05P1B, CDP68HSC05P1B

November 1997

8-Bit Enhanced Microcontroller Series

Features

HARDWARE

- **HCMOS Technology**
- **8-Bit Architecture**
- **Power-Saving STOP, WAIT, and Data Retention Modes**
  - **STOP Instruction can be Disabled via Mask Option**
- **Fully Static Operation**
- **On-Chip Memory**
  - **2,320 Bytes of ROM**
  - **128 Bytes of RAM**
- **ROM Security Feature**
- **20 Bidirectional I/O Lines, 1 Input-Only Line**
  - **2 High Current Outputs (PC0 and PC1)**
  - **8 Interruptible Inputs (with Pull-Up Resistors) - Port A**
  - **Schmitt Trigger Inputs on Port A**
- **Watchdog Timer (COP)**
- **Low Power Wake Up Timer**
- **Internal 16-Bit Timer**
  - **1 Timer Capture**
  - **1 Timer Compare**
- **Interrupts - External, Port A, Software, and Timer**
- **Master Reset and Power-On Reset**
- **On-Chip Oscillator with RC or Crystal Mask Options**
- **CDP68HC05P1B**
  - **4.2MHz Operating Frequency (2.1MHz Internal Bus Frequency) at 5V; 2MHz at 3.0V**
  - **Single 3.0V to 6.0V Supply (1.5V Data Retention)**
- **CDP68HCL05P1B**
  - **Lower Supply Current, I_{DD}, In RUN, WAIT and STOP Modes at 5.5V, 3.3V and 2.4V**
  - **Single 2.4V to 6.0V Supply (1.5V Data Retention)**
- **CDP68HSC05P1B**
  - **8.0MHz Operating Frequency (4.0MHz Internal Bus Frequency) at 5.0V; 4.2MHz at 3.3V**
  - **Single 3.0V to 6.0V Supply (1.5V Data Retention)**

SOFTWARE

- **Supports Full CDP68HC05 Instruction Set**
- **8 x 8 Unsigned Multiply Instruction**
- **True Bit-Manipulation**
- **Two Power Saving Standby Modes**
- **Memory Mapped I/O**

Description

The CDP68HC05P1B HCMOS Microcomputer is a member of the CDP68HC05 family of single chip microcomputers. This 8-bit microcomputer unit (MCU) contains a CPU, 128 bytes of RAM, 2,320 bytes of masked ROM, a flexible 16-bit timer with one input capture and one output compare, 20 bidirectional I/O lines and one input only line (two high current outputs and eight mask programmable as interruptible inputs), keypad scanning logic, a watchdog timer, a maskable STOP instruction, and an on-chip oscillator. The fully static design allows operation at frequencies down to DC, further reducing the already low power consumption.

The CDP68HCL05P1B MCU device is a version of the CDP68HC05P1B with low power consumption in the RUN, WAIT, and STOP modes; and operation down to 2.4V. The CDP68HSC05P1B MCU device is a high-speed version of the CDP68HC05P1B with up to 8.0MHz operation.

The CDP68HC05P1B family supports the full CDP68HC05 instruction set. Development can be performed with tools supplied by Harris or offered by numerous third party vendors. Available tools include assemblers and C compilers.

NOTE: Unless otherwise stated, *CDP68HC05P1B* refers to the entire family of P1B microcontrollers (HC, HCL, and HSC).

Table of Contents

CAUTION: These devices are sensitive to electrostatic discharge. Users should follow proper IC Handling Procedures.

File Number **4408.1**

Ordering Information

PART NUMBER	TEMP. RANGE (^{o}C)	PACKAGE	PKG. NO.
CDP68HC05P1BM20	-40 to 85	20 Ld SOIC	M20.3
CDP68HC05P1BE28	-40 to 85	28 Ld PDIP	E28.6
CDP68HC05P1BM28	-40 to 85	28 Ld SOIC	M28.3
CDP68HCL05P1BM20	0 to 70	20 Ld SOIC	M20.3
CDP68HCL05P1BE28	0 to 70	28 Ld PDIP	E28.6
CDP68HCL05P1BM28	0 to 70	28 Ld SOIC	M28.3
CDP68HSC05P1BM20	0 to 85	20 Ld SOIC	M20.3
CDP68HSC05P1BE28	0 to 85	28 Ld PDIP	E28.6
CDP68HSC05P1BM28	0 to 85	28 Ld SOIC	M28.3

NOTE: Pin number references throughout this specification refer to the 28 lead DIP/SOIC. See pinouts for cross reference.

ROM Ordering Information

The CDP68HC05P1B family of microcontrollers contains a mask programmed ROM. The contents of this ROM is personalized to meet a customer's code requirements during manufacturing of the ICs. The code is programmed via photomasking techniques. Semiconductor manufacturing is a batch process, and all microcontrollers manufactured in a given lot (a batch) will contain identical ROM code.

Harris generates a customer's ROM mask from an ASCII representation of the desired ROM contents together with other specific information. The following pages contain sheets which can be used to provide the required information when ordering a masked ROM microcontroller.

Data Format Options

The ROM data can be submitted in various formats. The following list summarizes the principal formats which Harris will accept. The list is in order of preference, with S-Record formatted data files being the preferred format.

- **S-Record Formatted Hex Data File via Modem Upload**
- **S-Record Formatted Hex Data File on Floppy Disk**
- **S-Record Formatted Hex Data File via email**
- **6805 Assembly Language Source File on Floppy Disk**
- **Contents of a 27XX type EPROM/EEPROM**

Regardless of the medium used to transfer the data, contents of all of the User ROM regions of the memory map of the particular microcontroller should be specified. This includes any Page 0 User ROM and User Reset/Interrupt Vectors. Data should not be specified for the Self Check ROM space of a device. All unused locations should either not be specified (S-Record and source files) or specified as $00 (EPROM/EEPROM).

Procedure for Submitting Data

When submitting data via a physical medium such as a floppy disk or EPROM, the appropriate "Ordering Information Sheet" on the following pages must be completed and submitted with the data.

When utilizing the Harris Customer Pattern Retrieval System (modem upload) the customer will be prompted for the same information as that specified on the "Ordering Information Sheet".

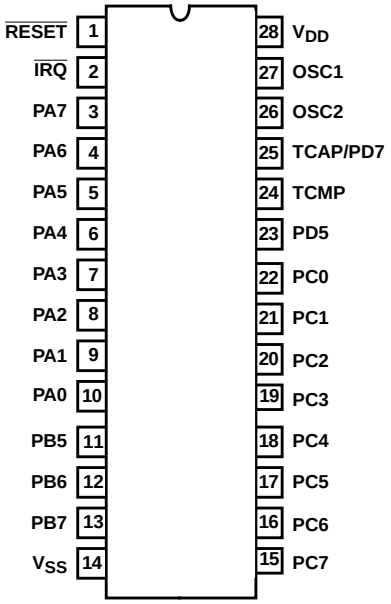
If the data is submitted via email, the message should include the same information as that specified on the "Ordering Information Sheet".

Harris Customer Pattern Retrieval System

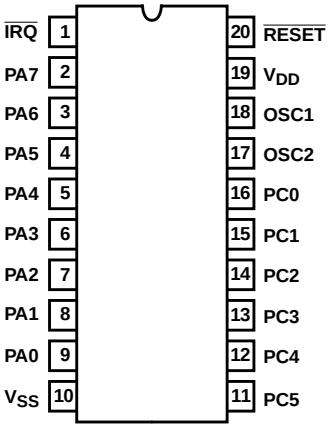
To access the Harris Customer Pattern Retrieval System, you must first obtain an account ID and password from your Harris sales representative. The system is accessed by dialing 1-908-685-6541. It is presently set to run with baud rates up to 2400 baud, with 8 data bits, 1 stop bit, and no parity bit. The data transfer is done using text mode Kermit transfers.

Pinouts

CDP68HC05P1B, CDP68HCL05P1B, CDP68HSC05P1B
28 LEAD (SOIC, PDIP)
TOP VIEW

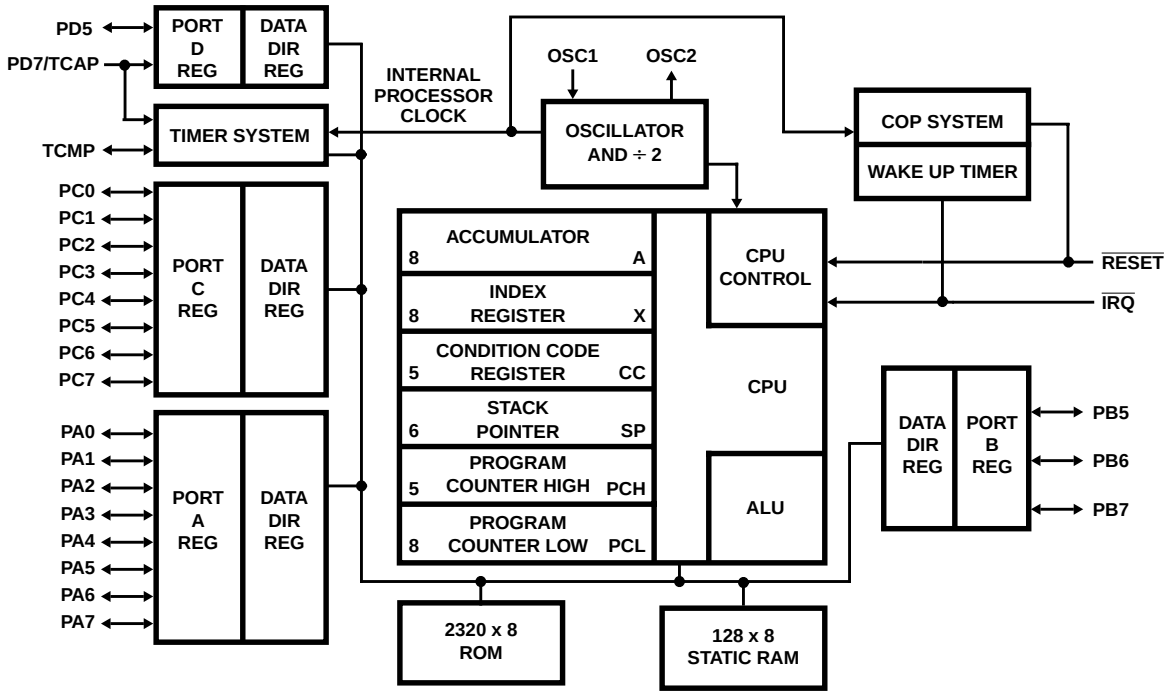


CDP68HC05P1B, CDP68HCL05P1B, CDP68HSC05P1B
20 LEAD (SOIC Only)
TOP VIEW



NOTE: Low EMI Pinouts available. See Harris Technical Brief TB354.

Block Diagram



Absolute Maximum Ratings

Supply Voltage, V_{DD} . . . . . -0.5V to +7V
Input Voltage, V_{IN} . . . . . V_{SS} - 0.3V to V_{DD} + 0.3V
Self-Check Mode (IRQ Pin Only), V_{IN} . . . V_{SS} - 0.3V to 2 x V_{DD} + 0.3V
Current Drain Per Pin Excluding V_{DD} and V_{SS}, I 40mA

Operating Conditions

Operating Voltage Range . . . . . +1.8V to +6.0V
Operating Temperature Range . . . . . -55^oC to 125^oC
CDP68HC05P1B . . . . . -40^oC to 85^oC
CDP68HCL05P1B . . . . . 0^oC to 70^oC
CDP68HSC05P1B . . . . . 0^oC to 85^oC
Input High Voltage . . . . . ($0.8 \times V_{DD}$) to V_{DD}

Thermal Information

Thermal Resistance (Typical, Note 1)	θ_{JA} ($^oC/W$)
28 Ld PDIP	60
20 Ld SOIC	110
28 Ld SOIC	75

Maximum Junction Temperature . . . . . 150^oC
Maximum Storage Temperature Range (T_{STG}) . . . . -65^oC to 150^oC
Maximum Lead Temperature (Soldering 10s) . . . . . 300^oC
(SOIC - Lead Tips Only)

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTE:

1. θ_{JA} is measured with the component mounted on an evaluation PC board in free air.

DC Electrical Specifications HC Product Type

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CDP68HC05P1B V_{DD} = 5V ±10%, V_{SS} = 0V, T_A = -40^oC to 85^oC (Note 2)						
Output Voltage	V_{OL}	I_{LOAD} < 10µA	-	-	0.1	V
	V_{OH}		V_{DD} - 0.1	-	-	V
Output High Voltage						
PA0-7. PB5-7, PC2-7, PD5	V_{OH}	I_{LOAD} = -0.8mA	V_{DD} - 0.8	-	-	V
PC0-1	V_{OH}	I_{LOAD} = -5.0mA	V_{DD} - 0.8	-	-	V
Output Low Voltage						
PA0-7. PB5-7, PC2-7, PD5	V_{OL}	I_{LOAD} = 1.6mA	-	-	0.4	V
PC0-1	V_{OL}	I_{LOAD} = 15.0mA	-	-	0.4	V
Input High Voltage PA0-7, PB5-7, PC0-7, PD5, PD7/TCAP, $\overline{RESET}$, $\overline{IRQ}$, OSC1	V_{IH}		0.7•V_{DD}	-	V_{DD}	V
Input Low Voltage PA0-7, PB5-7, PC0-7, PD5, PD7/TCAP, $\overline{RESET}$, $\overline{IRQ}$, OSC1	V_{IL}		V_{SS}	-	0.2•V_{DD}	V
Data Retention Mode	V_{RM}	T_A = 0^oC to 70^oC	1.5	-	-	V
Supply Current						
RUN (Note 9)	I_{DD}	f_{OSC} = 4.0MHz External Square Wave	-	TBD	TBD	mA
WAIT (Notes 10, 12)	I_{DD}		-	TBD	TBD	mA
STOP (Note 11)	I_{DD}	T_A = 25^oC	-	1	8	µA
STOP with Wake Up Timer Enabled	I_{DD}	T_A = 25^oC	-	10	-	µA
Wake Up Timer RC Oscillator Frequency	f_{RCO}	T_A = 25^oC	-	13	-	kHz
I/O Ports Hi-Z Leakage Current: PA0-7. PB5-7, PC0-7, PD5	I_{IL}		-	-	±10	µA
Input Current: $\overline{RESET}$, $\overline{IRQ}$, OSC1, TCAP/PD7	I_{IN}		-	-	±1	µA
Capacitance Ports (As Input or Output, Note 3) $\overline{RESET}$, $\overline{IRQ}$, OSC1	C_{OUT}		-	-	12	pF
	C_{IN}		-	-	8	pF

DC Electrical Specifications HC Product Type (Continued)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Source Current: PA0-7 Interrupts	I_{IH}	$V_{IN} \le V_{IL}$ (Port A)	TBD	-	TBD	µA
		$V_{IN} \ge V_{IH}$ (Port A)	TBD	-	TBD	µA
Input Hysteresis Voltage: PA0-7	V_{HYS}		-	0.5	-	V
Input Hysteresis Voltage: $\overline{RESET}$, $\overline{IRQ}$, OSC1, TCAP	V_{HYS}		$0.1 \bullet V_{DD}$	1.0	$0.5 \bullet V_{DD}$	V
CDP68HC05P1B V_{DD} = 3.3V ±10%, V_{SS} = 0V, T_A = 0°C to 70°C (Note 2)						
Output Voltage	V_{OL}	I_{LOAD} < 10µA	-	-	0.1	V
	V_{OH}		V_{DD} - 0.1	-	-	V
Output High Voltage						
PA0-7. PB5-7, PC2-7, PD5	V_{OH}	I_{LOAD} = -0.2mA	V_{DD} - 0.3	-	-	V
PC0-1	V_{OH}	I_{LOAD} = -6.0mA	V_{DD} - 0.3	-	-	V
Output Low Voltage						
PA0-7. PB5-7, PC2-7, PD5	V_{OL}	I_{LOAD} = 0.4mA	-	-	0.3	V
PC0-1	V_{OL}	I_{LOAD} = 6.0mA	-	-	0.3	V
Input High Voltage PA0-7, PB5-7, PC0-7, PD5, PD7/TCAP, $\overline{RESET}$, $\overline{IRQ}$, OSC1	V_{IH}		$0.7 \bullet V_{DD}$	-	V_{DD}	V
Input Low Voltage PA0-7, PB5-7, PC0-7, PD5, PD7/TCAP, $\overline{RESET}$, $\overline{IRQ}$, OSC1	V_{IL}		V_{SS}	-	$0.2 \bullet V_{DD}$	V
Data Retention Mode	V_{RM}	T_A = 0°C to 70°C	1.5	-	-	V
Supply Current						
RUN (Note 9)	I_{DD}	f_{OSC} = 4.0MHz External Square Wave	-	TBD	TBD	mA
WAIT (Notes 10, 12)	I_{DD}		-	TBD	TBD	mA
STOP (Note 11)	I_{DD}	T_A = 25°C	-	1	8	µA
STOP with Wake Up Timer Enabled	I_{DD}	T_A = 25°C	-	10	-	µA
Wake Up Timer RC Oscillator Frequency	f_{RCO}	T_A = 25°C	-	13	-	kHz
I/O Ports Hi-Z Leakage Current: PA0-7. PB5-7, PC0-7, PD5	I_{IL}		-	-	±10	µA
Input Current: $\overline{RESET}$, $\overline{IRQ}$, OSC1, TCAP/PD7	I_{IN}		-	-	±1	µA
Capacitance Ports (As Input or Output, Note 3) $\overline{RESET}$, $\overline{IRQ}$, OSC1	C_{OUT}		-	-	12	pF
	C_{IN}		-	-	8	pF
Input Source Current: PA0-7 Interrupts	I_{IH}	$V_{IN} \le V_{IL}$ (Port A)	TBD	-	TBD	µA
		$V_{IN} \ge V_{IH}$ (Port A)	TBD	-	TBD	µA
Input Hysteresis Voltage: PA0-7	V_{HYS}		-	0.5	-	V
Input Hysteresis Voltage: $\overline{RESET}$, $\overline{IRQ}$, OSC1, TCAP	V_{HYS}		$0.1 \bullet V_{DD}$	1.0	$0.5 \bullet V_{DD}$	V

NOTES:

2. This device contains circuitry to protect the inputs against damage due to high static voltages of electric fields; however, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high impedance circuit. For proper operation it is recommended that V_{IN} and V_{OUT} be constrained to the range $V_{SS} < (V_{IN}$ or $V_{OUT}) < V_{DD}$. Reliability of operation is enhanced if unused inputs except OSC2 are connected to an appropriate logic voltage level (e.g., either V_{SS} or V_{DD}).
3. Includes ports used as input/output pins; Ports used as input only pins, Ports used as output only pins.

Control Timing HC Product Type

PARAMETER	SYMBOL	MIN	MAX	UNITS
CDP68HC05P1B V_{DD} = 5V ±10%, V_{SS} = 0V, T_A = -40°C to 85°C				
Frequency Of Operation				
Crystal Option	f_{OSC}	-	4.2	MHz
External Clock Option	f_{OSC}	DC	4.2	MHz
Internal Operating Frequency				
Crystal (f_{OSC} ÷ 2)	f_{OP}	-	2.1	MHz
External Clock (f_{OSC} ÷ 2)	f_{OP}	DC	2.1	MHz
Cycle Time (See Figure 15)	t_{CYC}	480	-	ns
Crystal Oscillator Start-up Time for AT-cut Crystal (See Figure 15)	t_{OXOV}	-	100	ms
Stop Recovery Start-up Time (AT-cut Crystal Oscillator) (See Figure 1)	t_{ILCH}	-	100	ms
$\overline{\text{RESET}}$ Pulse Width (See Figure 15)	t_{RL}	1.5	-	t_{CYC}
Timer				
Resolution (Note 5)	t_{RES}	4	-	t_{CYC}
Input Capture Pulse Width (See Figures 2, 23)	t_{TH}, t_{TL}	125	-	ns
Input Capture Pulse Period (See Figures 2, 23)	t_{TLTL}	(Note 6)	-	t_{CYC}
Interrupt Pulse Width Low (Edge-Triggered) (See Figure 16B)	t_{ILIH}	125	-	ns
Interrupt Pulse Period (See Figure 16B)	t_{ILIH}	(Note 4)	-	t_{CYC}
OSC1 Pulse Width	t_{OH}, t_{OL}	90	-	ns
CDP68HC05P1B V_{DD} = 3.3V ±10%, V_{SS} = 0V, T_A = 0°C to 70°C				
Frequency Of Operation				
Crystal Option	f_{OSC}	-	2.0	MHz
External Clock Option	f_{OSC}	DC	2.0	MHz
Internal Operating Frequency				
Crystal (f_{OSC} ÷ 2)	f_{OP}	-	1.0	MHz
External Clock (f_{OSC} ÷ 2)	f_{OP}	DC	1.0	MHz
Cycle Time (See Figure 15)	t_{CYC}	1000	-	ns
Crystal Oscillator Start-up Time for AT-cut Crystal (See Figure 15)	t_{OXOV}	-	100	ms
Stop Recovery Start-up Time (AT-cut Crystal Oscillator) (See Figure 1)	t_{ILCH}	-	100	ms
$\overline{\text{RESET}}$ Pulse Width (See Figure 15)	t_{RL}	1.5	-	t_{CYC}
Timer				
Resolution (Note 5)	t_{RES}	4.0	-	t_{CYC}
Input Capture Pulse Width (See Figures 2, 23)	t_{TH}, t_{TL}	250	-	ns
Input Capture Pulse Period (See Figures 2, 23)	t_{TLTL}	(Note 6)	-	t_{CYC}
Interrupt Pulse Width Low (Edge-Triggered) (See Figure 16B)	t_{ILIH}	250	-	ns
Interrupt Pulse Period (See Figure 16B)	t_{ILIH}	(Note 4)	-	t_{CYC}
OSC1 Pulse Width	t_{OH}, t_{OL}	200	-	ns

NOTES:

4. The minimum period t_{ILIH} should not be less than the number of cycle times it takes to execute the interrupt service routine plus 21 t_{CYC}.
5. Since a 2-bit prescaler in the timer must count four internal cycles (t_{CYC}), this is the limiting minimum factor in determining the timer resolution.
6. The minimum period t_{TLTL} should not be less than the number of cycle times it takes to execute the capture interrupt service routine plus 24 t_{CYC}.

DC Electrical Specifications HCL Product Type

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CDP68HCL05P1B V_{DD} = 5V ±10%, V_{SS} = 0V, T_A = 0°C to 70°C (Note 2)						
Output Voltage	V_{OL}	I_{LOAD} < 10µA	-	-	0.1	V
	V_{OH}		V_{DD} - 0.1	-	-	V
Output High Voltage						
PA0-7. PB5-7, PC2-7, PD5	V_{OH}	I_{LOAD} = -0.8mA	V_{DD} - 0.8	-	-	V
PC0-1	V_{OH}	I_{LOAD} = -5.0mA	V_{DD} - 0.8	-	-	V
Output Low Voltage						
PA0-7. PB5-7, PC2-7, PD5	V_{OL}	I_{LOAD} = 1.6mA	-	-	0.4	V
PC0-1	V_{OL}	I_{LOAD} = 15.0mA	-	-	0.4	V
Input High Voltage PA0-7, PB5-7, PC0-7, PD5, PD7/TCAP, $\overline{RESET}$, $\overline{IRQ}$, OSC1	V_{IH}		0.7•V_{DD}	-	V_{DD}	V
Input Low Voltage PA0-7, PB5-7, PC0-7, PD5, PD7/TCAP, $\overline{RESET}$, $\overline{IRQ}$, OSC1	V_{IL}		V_{SS}	-	0.2•V_{DD}	V
Data Retention Mode	V_{RM}	T_A = 0°C to 70°C	1.5	-	-	V
Supply Current						
RUN (Note 9)	I_{DD}	f_{OSC} = 4.0MHz External Square Wave	-	TBD	TBD	mA
WAIT (Notes 10, 12)	I_{DD}		-	TBD	TBD	mA
STOP (Note 11)	I_{DD}	T_A = 25°C	-	1	8	µA
STOP with Wake Up Timer Enabled	I_{DD}	T_A = 25°C	-	10	-	µA
Wake Up Timer RC Oscillator Frequency	f_{RCO}	T_A = 25°C	-	13	-	kHz
I/O Ports Hi-Z Leakage Current: PA0-7. PB5-7, PC0-7, PD5	I_{IL}		-	-	±10	µA
Input Current: $\overline{RESET}$, $\overline{IRQ}$, OSC1, TCAP/PD7	I_{IN}		-	-	±1	µA
Capacitance Ports (As Input or Output, Note 3) $\overline{RESET}$, $\overline{IRQ}$, OSC1	C_{OUT}		-	-	12	pF
	C_{IN}		-	-	8	pF
Input Source Current: PA0-7 Interrupts	I_{IH}	$V_{IN} \leq V_{IL}$ (Port A)	TBD	-	TBD	µA
		$V_{IN} \geq V_{IH}$ (Port A)	TBD	-	TBD	µA
Input Hysteresis Voltage: PA0-7	V_{HYS}		-	0.5	-	V
Input Hysteresis Voltage: $\overline{RESET}$, $\overline{IRQ}$, OSC1, TCAP	V_{HYS}		0.1•V_{DD}	1.0	0.5•V_{DD}	V
CDP68HCL05P1B V_{DD} = 2.5V - 3.6V ±10%, V_{SS} = 0V, T_A = 0°C to 70°C (Note 2)						
Output Voltage	V_{OL}	I_{LOAD} < 10µA	-	-	0.1	V
	V_{OH}		V_{DD} - 0.1	-	-	V
Output High Voltage						
PA0-7. PB5-7, PC2-7, PD5	V_{OH}	I_{LOAD} = -0.2mA	V_{DD} - 0.3	-	-	V
PC0-1	V_{OH}	I_{LOAD} = -6.0mA	V_{DD} - 0.3	-	-	V
Output Low Voltage						
PA0-7. PB5-7, PC2-7, PD5	V_{OL}	I_{LOAD} = 0.4mA	-	-	0.3	V
PC0-1	V_{OL}	I_{LOAD} = 6.0mA	-	-	0.3	V

DC Electrical Specifications HCL Product Type (Continued)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input High Voltage PA0-7, PB5-7, PC0-7, PD5, PD7/TCAP, $\overline{RESET}$, $\overline{IRQ}$, OSC1	V_{IH}		$0.7 \bullet V_{DD}$	-	V_{DD}	V
Input Low Voltage PA0-7, PB5-7, PC0-7, PD5, PD7/TCAP, $\overline{RESET}$, $\overline{IRQ}$, OSC1	V_{IL}		V_{SS}	-	$0.2 \bullet V_{DD}$	V
Data Retention Mode	V_{RM}	$T_A = 0^oC$ to 70^oC	1.5	-	-	V
Supply Current RUN (Note 9)	I_{DD}	f_{OSC} = 4.0MHz External Square Wave	-	TBD	TBD	mA
WAIT (Notes 10, 12)	I_{DD}		-	TBD	TBD	mA
STOP (Note 11)	I_{DD}	$T_A = 25^oC$	-	1	8	µA
STOP with Wake Up Timer Enabled	I_{DD}	$T_A = 25^oC$	-	10	-	µA
Wake Up Timer RC Oscillator Frequency	f_{RCO}	$T_A = 25^oC$	-	13	-	kHz
I/O Ports Hi-Z Leakage Current: PA0-7. PB5-7, PC0-7, PD5	I_{IL}		-	-	±10	µA
Input Current: $\overline{RESET}$, $\overline{IRQ}$, OSC1, TCAP/PD7	I_{IN}		-	-	±1	µA
Capacitance Ports (As Input or Output, Note 3) $\overline{RESET}$, $\overline{IRQ}$, OSC1	C_{OUT}		-	-	12	pF
	C_{IN}		-	-	8	pF
Input Source Current: PA0-7 Interrupts	I_{IH}	$V_{IN} \le V_{IL}$ (Port A)	TBD	-	TBD	µA
		$V_{IN} \ge V_{IH}$ (Port A)	TBD	-	TBD	µA
Input Hysteresis Voltage: PA0-7	V_{HYS}		-	0.5	-	V
Input Hysteresis Voltage: $\overline{RESET}$, $\overline{IRQ}$, OSC1, TCAP	V_{HYS}		$0.1 \bullet V_{DD}$	1.0	$0.5 \bullet V_{DD}$	V
CDP68HCL05P1B V_{DD} = 1.8V - 2.4V, V_{SS} = 0V, $T_A = 0^oC$ to 70^oC, Unless Otherwise Specified						
Output Voltage	V_{OL}	$I_{LOAD} < 10\mu A$	-	-	0.1	V
	V_{OH}		V_{DD} - 0.1	-	-	V
Output High Voltage PA0-7. PB5-7, PC2-7, PD5	V_{OH}	I_{LOAD} = -0.2mA	V_{DD} - 0.3	-	-	V
PC0-1	V_{OH}	I_{LOAD} = -6.0mA	V_{DD} - 0.3	-	-	V
Output Low Voltage PA0-7. PB5-7, PC2-7, PD5	V_{OL}	I_{LOAD} = 0.4mA	-	-	0.3	V
PC0-1	V_{OL}	I_{LOAD} = 6.0mA	-	-	0.3	V
Input High Voltage PA0-7, PB5-7, PC0-7, PD5, PD7/TCAP, $\overline{RESET}$, $\overline{IRQ}$, OSC1	V_{IH}		$0.7 \bullet V_{DD}$	-	V_{DD}	V
Input Low Voltage PA0-7, PB5-7, PC0-7, PD5, PD7/TCAP, $\overline{RESET}$, $\overline{IRQ}$, OSC1	V_{IL}		V_{SS}	-	$0.2 \bullet V_{DD}$	V
Data Retention Mode	V_{RM}	$T_A = 0^oC$ to 70^oC	1.5	-	-	V
Supply Current RUN (Note 9)	I_{DD}	f_{OSC} = 4.0MHz External Square Wave	-	TBD	TBD	mA
WAIT (Notes 10, 12)	I_{DD}		-	TBD	TBD	mA

DC Electrical Specifications HCL Product Type (Continued)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
STOP (Note 11)	I_{DD}	$T_A = 25^oC$	-	1	8	µA
STOP with Wake Up Timer Enabled	I_{DD}	$T_A = 25^oC$	-	10	-	µA
Wake Up Timer RC Oscillator Frequency	f_{RCO}	$T_A = 25^oC$	-	13	-	kHz
I/O Ports Hi-Z Leakage Current: PA0-7. PB5-7, PC0-7, PD5	I_{IL}		-	-	±10	µA
Input Current: $\overline{RESET}$, $\overline{IRQ}$, OSC1, TCAP/PD7	I_{IN}		-	-	±1	µA
Capacitance Ports (As Input or Output, Note 3) $\overline{RESET}$, $\overline{IRQ}$, OSC1	C_{OUT}		-	-	12	pF
	C_{IN}		-	-	8	pF
Input Source Current: PA0-7 Interrupts	I_{IH}	$V_{IN} \le V_{IL}$ (Port A)	TBD	-	TBD	µA
		$V_{IN} \ge V_{IH}$ (Port A)	TBD	-	TBD	µA
Input Hysteresis Voltage: PA0-7	V_{HYS}		-	0.5	-	V
Input Hysteresis Voltage: $\overline{RESET}$, $\overline{IRQ}$, OSC1, TCAP	V_{HYS}		$0.1 \bullet V_{DD}$	1.0	$0.5 \bullet V_{DD}$	V

NOTES:

7. All values shown reflect average measurement.
8. Typical values at midpoint of voltage range, 25^oC only.
9. Run (Operating) I_{DD}, Wait I_{DD}: Measured using external square-wave clock source, all inputs 0.2V from rail, no DC loads, less than 50pF on all outputs, C_L = 20pF on OSC2.
10. Wait, Stop I_{DD}: All ports configured as inputs, V_{IL} = 0.2V, $V_{IH} = V_{DD}$ - 0.2V.
11. Stop I_{DD} measured with OSC1 = V_{SS}.
12. Wait I_{DD} is affected linearly by the OSC2 capacitance.
13. Input pullup current measured with V_{IL} = 0.2V.

Control Timing HCL Product Type

PARAMETER	SYMBOL	MIN	MAX	UNITS
CDP68HCL05P1B V_{DD} = 5V 10%, V_{SS} = 0V, $T_A = 0^oC$ to 70^oC				
Frequency Of Operation				
Crystal Option	f_{OSC}	-	4.2	MHz
External Clock Option	f_{OSC}	DC	4.2	MHz
Internal Operating Frequency				
Crystal ($f_{OSC} \div 2$)	f_{OP}	-	2.1	MHz
External Clock ($f_{OSC} \div 2$)	f_{OP}	DC	2.1	MHz
Cycle Time (See Figure 15)	t_{CYC}	480	-	ns
Crystal Oscillator Start-up Time for AT-cut Crystal (See Figure 15)	t_{OXOV}	-	100	ms
Stop Recovery Start-up Time (AT-cut Crystal Oscillator) (See Figure 1)	t_{ILCH}	-	100	ms
$\overline{RESET}$ Pulse Width (See Figure 15)	t_{RL}	1.5	-	t_{CYC}
Timer				
Resolution (Note 15)	t_{RES}	4	-	t_{CYC}
Input Capture Pulse Width (See Figures 2, 23)	t_{TH}, t_{TL}	125	-	ns
Input Capture Pulse Period (See Figures 2, 23)	t_{TLTL}	(Note 16)	-	t_{CYC}
Interrupt Pulse Width Low (Edge-Triggered) (See Figure 16B)	t_{ILIH}	125	-	ns
Interrupt Pulse Period (See Figure 16B)	t_{ILIH}	(Note 14)	-	t_{CYC}
OSC1 Pulse Width	t_{OH}, t_{OL}	90	-	ns

Control Timing HCL Product Type (Continued)

PARAMETER	SYMBOL	MIN	MAX	UNITS
CDP68HCL05P1B V_{DD} = 2.4V to 3.6V, V_{SS} = 0V, T_A = 0^oC to 70^oC (V_{DC} = 3.6)				
Frequency Of Operation				
Crystal Option	f_{OSC}	-	2.0	MHz
External Clock Option	f_{OSC}	DC	2.0	MHz
Internal Operating Frequency				
Crystal ($f_{OSC} \div 2$)	f_{OP}	-	1.0	MHz
External Clock ($f_{OSC} \div 2$)	f_{OP}	DC	1.0	MHz
Cycle Time (See Figure 15)	t_{CYC}	1000	-	ns
Crystal Oscillator Start-up Time for AT-cut Crystal (See Figure 15)	t_{OXOV}	-	100	ms
Stop Recovery Start-up Time (AT-cut Crystal Oscillator) (See Figure 1)	t_{ILCH}	-	100	ms
$\overline{\text{RESET}}$ Pulse Width (See Figure 15)	t_{RL}	1.5	-	t_{CYC}
Timer				
Resolution (Note 15)	t_{RES}	4.0	-	t_{CYC}
Input Capture Pulse Width (See Figures 2, 23)	t_{TH}, t_{TL}	250	-	ns
Input Capture Pulse Period (See Figures 2, 23)	t_{TLTL}	(Note 16)	-	t_{CYC}
Interrupt Pulse Width Low (Edge-Triggered) (See Figure 16B)	t_{ILIH}	250	-	ns
Interrupt Pulse Period (See Figure 16B)	t_{ILIH}	(Note 14)	-	t_{CYC}
OSC1 Pulse Width	t_{OH}, t_{OL}	200	-	ns
CDP68HCL05P1B V_{DD} = 2.4V to 3.6V, V_{SS} = 0V, T_A = 0^oC to 70^oC (V_{DC} = 2.4)				
Frequency Of Operation				
Crystal Option	f_{OSC}	-	2.0	MHz
External Clock Option	f_{OSC}	DC	2.0	MHz
Internal Operating Frequency				
Crystal ($f_{OSC} \div 2$)	f_{OP}	-	1.0	MHz
External Clock ($f_{OSC} \div 2$)	f_{OP}	DC	1.0	MHz
Cycle Time (See Figure 15)	t_{CYC}	1000	-	ns
Crystal Oscillator Start-up Time for AT-cut Crystal (See Figure 15)	t_{OXOV}	-	100	ms
Stop Recovery Start-up Time (AT-cut Crystal Oscillator) (See Figure 1)	t_{ILCH}	-	100	ms
$\overline{\text{RESET}}$ Pulse Width (See Figure 15)	t_{RL}	1.5	-	t_{CYC}
Timer				
Resolution (Note 15)	t_{RES}	4.0	-	t_{CYC}
Input Capture Pulse Width (See Figures 2, 23)	t_{TH}, t_{TL}	250	-	ns
Input Capture Pulse Period (See Figures 2, 23)	t_{TLTL}	(Note 16)	-	t_{CYC}
Interrupt Pulse Width Low (Edge-Triggered) (See Figure 16B)	t_{ILIH}	250	-	ns
Interrupt Pulse Period (See Figure 16B)	t_{ILIH}	(Note 14)	-	t_{CYC}
OSC1 Pulse Width	t_{OH}, t_{OL}	200	-	ns

NOTES:

14. The minimum period t_{ILIH} should not be less than the number of cycle times it takes to execute the interrupt service routine plus 21 t_{CYC}.
15. Since a 2-bit prescaler in the timer must count four internal cycles (t_{CYC}), this is the limiting minimum factor in determining the timer resolution.
16. The minimum period t_{TLTL} should not be less than the number of cycle times it takes to execute the capture interrupt service routine plus 24 t_{CYC}.

DC Electrical Specifications HSC Product Type

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CDP68HSC05P1B V_{DD} = 5V ±10%, V_{SS} = 0V, T_A = 0°C to 85°C, Unless Otherwise Specified						
Output Voltage	V_{OL}	I_{LOAD} < 10µA	-	-	0.1	V
	V_{OH}		V_{DD} - 0.1	-	-	V
Output High Voltage PA0-7. PB5-7, PC2-7, PD5	V_{OH}	I_{LOAD} = -0.8mA	V_{DD} - 0.8	-	-	V
PC0-1	V_{OH}	I_{LOAD} = -5.0mA	V_{DD} - 0.8	-	-	V
Output Low Voltage PA0-7. PB5-7, PC2-7, PD5	V_{OL}	I_{LOAD} = 1.6mA	-	-	0.4	V
PC0-1	V_{OL}	I_{LOAD} = 15.0mA	-	-	0.4	V
Input High Voltage PA0-7, PB5-7, PC0-7, PD5, PD7/TCAP, $\overline{RESET}$, $\overline{IRQ}$, OSC1	V_{IH}		0.7•V_{DD}	-	V_{DD}	V
Input Low Voltage PA0-7, PB5-7, PC0-7, PD5, PD7/TCAP, $\overline{RESET}$, $\overline{IRQ}$, OSC1	V_{IL}		V_{SS}	-	0.2•V_{DD}	V
Data Retention Mode	V_{RM}	T_A = 0°C to 70°C	1.5	-	-	V
Supply Current RUN (Note 19)	I_{DD}	f_{OSC} = 4.0MHz External Square Wave	-	TBD	TBD	mA
WAIT (Notes 20, 22)	I_{DD}		-	TBD	TBD	mA
STOP (Note 21)	I_{DD}	T_A = 25°C	-	1	8	µA
STOP with Wake Up Timer Enabled	I_{DD}	T_A = 25°C	-	10	-	µA
Wake Up Timer RC Oscillator Frequency	f_{RCO}	T_A = 25°C	-	13	-	kHz
I/O Ports Hi-Z Leakage Current: PA0-7. PB5-7, PC0-7, PD5	I_{IL}		-	-	±10	µA
Input Current: $\overline{RESET}$, $\overline{IRQ}$, OSC1, TCAP/PD7	I_{IN}		-	-	±1	µA
Capacitance Ports (As Input or Output, Note 3) $\overline{RESET}$, $\overline{IRQ}$, OSC1	C_{OUT}		-	-	12	pF
	C_{IN}		-	-	8	pF
Input Source Current: PA0-7 Interrupts	I_{IH}	$V_{IN} \leq V_{IL}$ (Port A)	TBD	-	TBD	µA
		$V_{IN} \geq V_{IH}$ (Port A)	TBD	-	TBD	µA
Input Hysteresis Voltage: PA0-7	V_{HYS}		-	0.5	-	V
Input Hysteresis Voltage: $\overline{RESET}$, $\overline{IRQ}$, OSC1, TCAP	V_{HYS}		0.1•V_{DD}	1.0	0.5•V_{DD}	V
CDP68HSC05P1B V_{DD} = 2.4V - 3.6V, V_{SS} = 0V, T_A = 0°C to 85°C, Unless Otherwise Specified						
Output Voltage	V_{OL}	$I_{LOAD} \leq$10µA	-	-	0.1	V
	V_{OH}		V_{DD} - 0.1	-	-	V
Output High Voltage PA0-7. PB5-7, PC2-7, PD5	V_{OH}	I_{LOAD} = -0.8mA	V_{DD} - 0.8	-	-	V
PC0-1	V_{OH}	I_{LOAD} = -5.0mA	V_{DD} - 0.8	-	-	V
Output Low Voltage PA0-7. PB5-7, PC2-7, PD5	V_{OL}	I_{LOAD} = 0.4mA	-	-	0.3	V
PC0-1	V_{OL}	I_{LOAD} = 6.0mA	-	-	0.3	V

DC Electrical Specifications HSC Product Type (Continued)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input High Voltage PA0-7, PB5-7, PC0-7, PD5, PD7/TCAP, $\overline{RESET}$, $\overline{IRQ}$, OSC1	V_{IH}		0.7•V_{DD}	-	V_{DD}	V
Input Low Voltage PA0-7, PC0-7, $\overline{RESET}$, $\overline{IRQ}$, OSC1	V_{IH}		V_{SS}	-	0.2•V_{DD}	V
Data Retention Mode	V_{RM}	T_A = 0°C to 70°C	1.5	-	-	V
Supply Current (f_{OSC} = 4.0MHz) Run (Note 19)	I_{DD}		-	2.5	4	mA
WAIT (Note 20, 22)	I_{DD}		-	1	2	mA
STOP (Note 21)	I_{DD}	T_A = 25°C	-	1	8	µA
		T_A = 0°C to 70°C	-	-	16	µA
		T_A = -40°C to 85°C	-	-	20	µA
STOP with Wake Up Timer Enabled	I_{DD}	T_A = 25°C	-	10	-	µA
Wake Up Timer RC Oscillator Frequency	f_{RCO}	T_A = 25°C	-	13	-	kHz
I/O Ports Hi-Z Leakage Current: PA0-7, PC0-7	I_{IL}		-10	-	+10	µA
Input Source Current: PA0-7 Interrupts	I_{IH}	$V_{IN} \le V_{IL}$ (Port A)	TBD	-	TBD	µA
		$V_{IN} \ge V_{IH}$ (Port A)	TBD	-	TBD	µA
Input Hysteresis Voltage: PA0-7	V_{HYS}		-	0.5	-	V
Input Hysteresis Voltage: $\overline{RESET}$, $\overline{IRQ}$, OSC1, TCAP	V_{HYS}		0.1•V_{DD}	1.0	0.5•V_{DD}	V
Input Current: $\overline{RESET}$, $\overline{IRQ}$, OSC1, TCAP	I_{IN}		-1	-	+1	µA
Capacitance Ports (As Input or Output) $\overline{RESET}$, $\overline{IRQ}$, TCAP, OSC1	C_{OUT}		-	-	12	pF
	C_{IN}		-	-	8	pF

NOTES:

17. All values shown reflect average measurement.
18. Typical values at midpoint of voltage range, 25°C only.
19. Run (Operating) I_{DD}, Wait I_{DD}: Measured using external square-wave clock source, all inputs 0.2V from rail, no DC loads, less than 50pF on all outputs, C_L = 20pF on OSC2.
20. Wait, Stop I_{DD}: All ports configured as inputs, V_{IL} = 0.2V, V_{IH} = V_{DD} - 0.2V.
21. Stop I_{DD} measured with OSC1 = V_{SS}.
22. Wait I_{DD} is affected linearly by the OSC2 capacitance.

Control Timing HSC Product Type

PARAMETER	SYMBOL	MIN	MAX	UNITS
CDP68HSC05P1B V_{DD} = 5V ±10%, V_{SS} = 0V, T_A = 0°C to 85°C, Unless Otherwise Specified				
Frequency Of Operation Crystal Option	f_{OSC}	-	4.2	MHz
External Clock Option	f_{OSC}	DC	4.2	MHz
Internal Operating Frequency Crystal (f_{OSC} ÷ 2)	f_{OP}	-	2.1	MHz
External Clock (f_{OSC} ÷ 2)	f_{OP}	DC	2.1	MHz
Cycle Time (See Figure 15)	t_{CYC}	480	-	ns
Crystal Oscillator Start-up Time for AT-cut Crystal (See Figure 15)	t_{OXOV}	-	100	ms

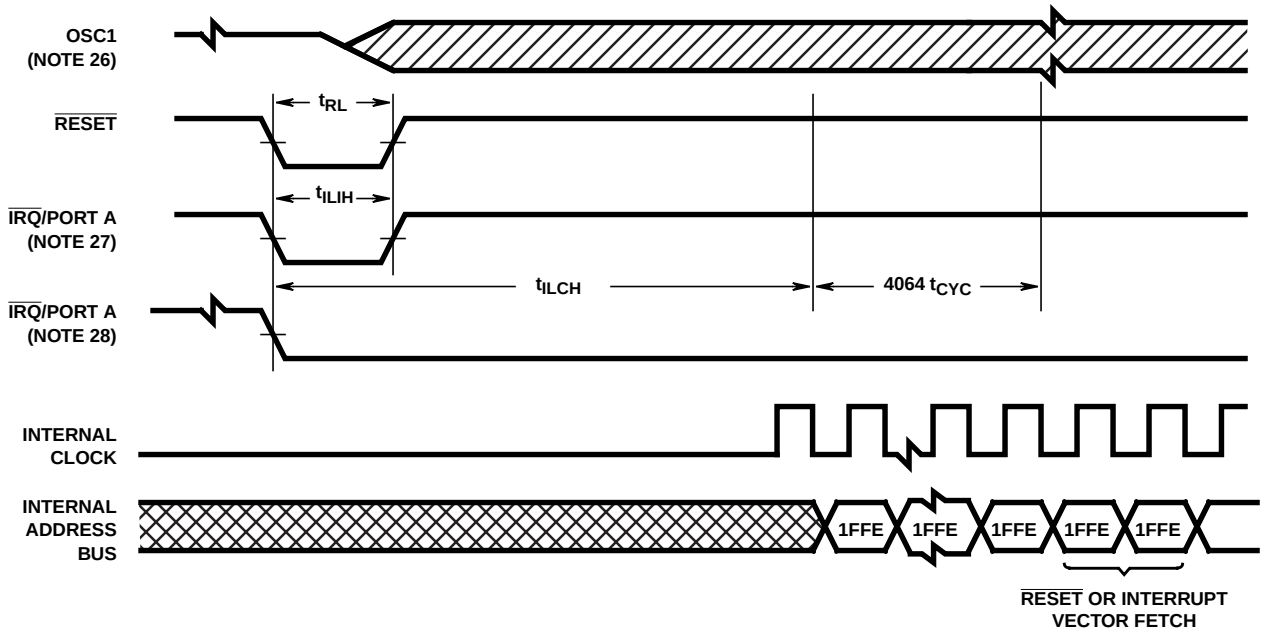
Control Timing HSC Product Type (Continued)

PARAMETER	SYMBOL	MIN	MAX	UNITS
Stop Recovery Start-up Time (AT-cut Crystal Oscillator) (See Figure 1)	t_{ILCH}	-	100	ms
$\overline{\text{RESET}}$ Pulse Width (See Figure 15)	t_{RL}	1.5	-	t_{CYC}
Timer				
Resolution (Note 24)	t_{RES}	4	-	t_{CYC}
Input Capture Pulse Width (See Figures 2, 23)	t_{TH}, t_{TL}	125	-	ns
Input Capture Pulse Period (See Figures 2, 23)	t_{TLTL}	(Note 23)	-	t_{CYC}
Interrupt Pulse Width Low (Edge-Triggered) (See Figure 16B)	t_{ILIH}	125	-	ns
Interrupt Pulse Period (See Figure 16B)	t_{ILIH}	(Note 25)	-	t_{CYC}
OSC1 Pulse Width	t_{OH}, t_{OL}	90	-	ns
CDP68HSC05P1B V_{DD} = 2.4V - 3.6V, V_{SS} = 0V, T_A = 0°C to 85°C, Unless Otherwise Specified				
Frequency Of Operation				
Crystal Option	f_{OSC}	-	2.0	MHz
External Clock Option	f_{OSC}	DC	2.0	MHz
Internal Operating Frequency				
Crystal (f_{OSC} ÷ 2)	f_{OP}	-	1.0	MHz
External Clock (f_{OSC} ÷ 2)	f_{OP}	DC	1.0	MHz
Cycle Time (See Figure 15)	t_{CYC}	1000	-	ns
Crystal Oscillator Start-up Time for AT-cut Crystal (See Figure 15)	t_{OXOV}	-	100	ms
Stop Recovery Start-up Time (AT-cut Crystal Oscillator) (See Figure 1)	t_{ILCH}	-	100	ms
$\overline{\text{RESET}}$ Pulse Width (See Figure 15)	t_{RL}	1.5	-	t_{CYC}
Timer				
Resolution (Note 24)	t_{RES}	4.0	-	t_{CYC}
Input Capture Pulse Width (See Figures 2, 23)	t_{TH}, t_{TL}	250	-	ns
Input Capture Pulse Period (See Figures 2, 23)	t_{TLTL}	(Note 23)	-	t_{CYC}
Interrupt Pulse Width Low (Edge-Triggered) (See Figure 16B)	t_{ILIH}	250	-	ns
Interrupt Pulse Period (See Figure 16B)	t_{ILIH}	(Note 25)	-	t_{CYC}
OSC1 Pulse Width	t_{OH}, t_{OL}	200	-	ns

NOTES:

23. The minimum period t_{ILIH} should not be less than the number of cycle times it takes to execute the interrupt service routine plus 21 t_{CYC}.
24. Since a 2-bit prescaler in the timer must count four internal cycles (t_{CYC}), this is the limiting minimum factor in determining the timer resolution.
25. The minimum period t_{TLTL} should not be less than the number of cycle times it takes to execute the capture interrupt service routine plus 24 t_{CYC}.

Control Timing Diagrams



NOTES:

26. Represents the internal gating of the OSC1 pin.
27. $\overline{IRQ}$/PORT A pin edge-sensitive mask option.
28. $\overline{IRQ}$/PORT A pin level and edge-sensitive mask option.

FIGURE 1. STOP RECOVERY TIMING DIAGRAM

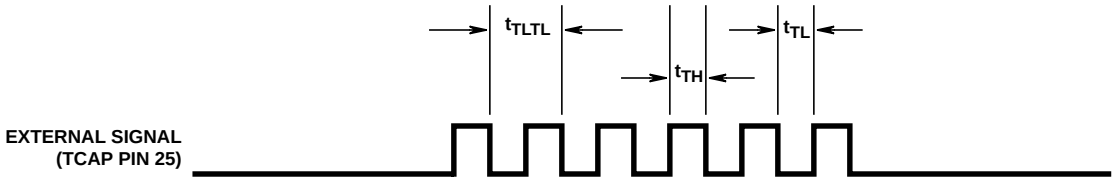


FIGURE 2. TIMER RELATIONSHIPS

Typical Performance Curves

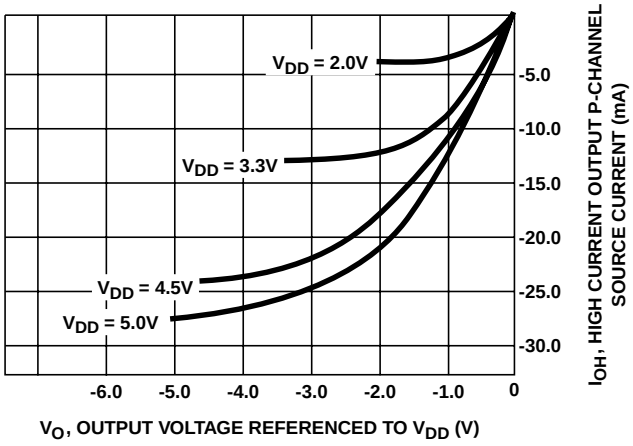


FIGURE 3. TYPICAL PC0/PC1 PORT OUTPUT P-CHANNEL SOURCE CURRENT FOR V_{DD} = 2V, 3.3V, 4.5V AND 5V AT 25°C

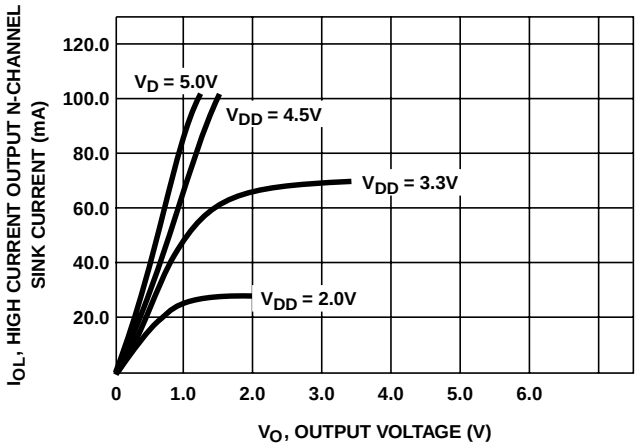


FIGURE 4. TYPICAL PC0/PC1 PORT OUTPUT N-CHANNEL SINK CURRENT FOR V_{DD} = 2V, 3.3V, 4.5V AND 5V AT 25°C

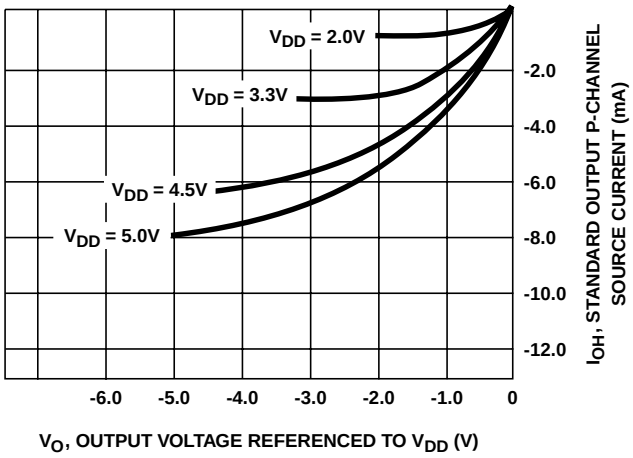


FIGURE 5. TYPICAL PORT OUTPUT P-CHANNEL SOURCE CURRENT FOR V_{DD} = 2V, 3.3V, 4.5V AND 5V AT 25°C

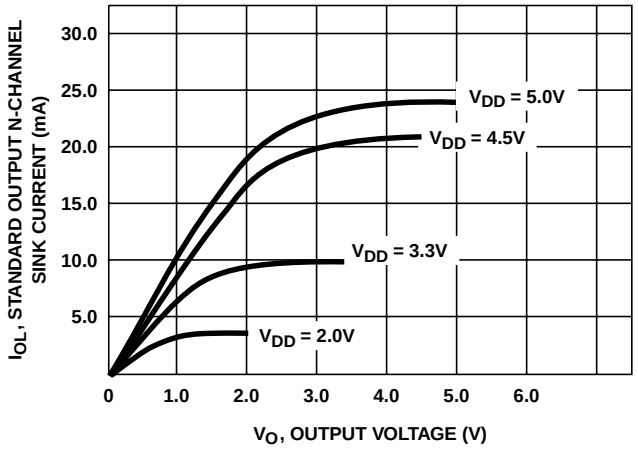


FIGURE 6. TYPICAL PORT OUTPUT N-CHANNEL SINK CURRENT FOR V_{DD} = 2V, 3.3V, 4.5V AND 5V AT 25°C

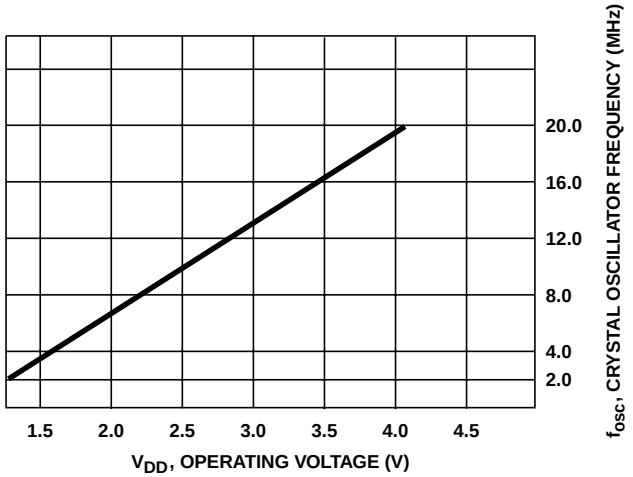


FIGURE 7. TYPICAL CRYSTAL OSCILLATOR OPERATING FREQUENCIES vs OPERATING VOLTAGE, V_{DD} AT 25°C

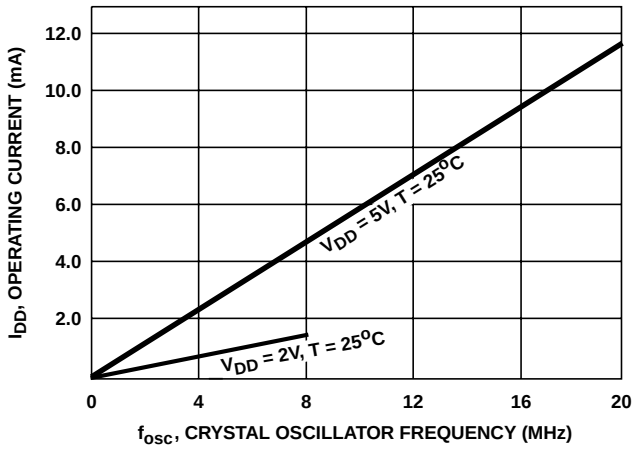


FIGURE 8. TYPICAL SUPPLY CURRENT vs OPERATING FREQUENCY AT 25°C

Functional Pin Description, Input/Output Programming, Memory, and CPU Registers

This section provides a description of the functional pins, input/output programming, memory, CPU registers, and self-check features of the CDP68HC05P1B.

Functional Pin Description

V_{DD} and V_{SS}

Power is supplied to the MCU using these two pins. V_{DD} is a positive voltage with respect to V_{SS} (ground).

$\overline{IRQ}$ / Port A (Maskable Interrupt Request)

As a mask programmable option two different choices of interrupt triggering sensitivity are available. These options are:

1. Negative edge-sensitive triggering only, or
2. Both negative edge-sensitive and level-sensitive triggering.

In the latter case, either type of input to the $\overline{IRQ}$ or Port A pin will produce an interrupt. The MCU completes the current instruction before it responds to the interrupt request. When the $\overline{IRQ}$ or Port A pin goes low for at least one t_{ILIH}, a logic one is latched internally to signify an interrupt has been requested. When the MCU completes its current instruction, the interrupt latch is tested. If the interrupt latch contains a logic one, and the interrupt mask bit (I-bit) in the condition code register is clear, the MCU then begins the interrupt sequence.

Schmitt trigger action is provided on the $\overline{IRQ}$ and Port A inputs pins to improve noise immunity.

If the option is selected to include level-sensitive triggering, then the $\overline{IRQ}$ input can be connected to V_{DD} via an external resistor to permit “wire ORed” operation. See **INTERRUPTS** for more detail concerning external interrupts and ***Input/Output Programming*** for description of Port A functions in this mode.

$\overline{RESET}$

The $\overline{RESET}$ input is not required for start-up but can be used to reset the MCU internal state and provide an orderly software start-up procedure. Refer to **RESETS** for a detailed description.

TCAP

The TCAP input controls the input capture feature for the on-chip programmable timer system. Refer to **Input Capture Register** for additional information.

TCMP

The TCMP pin provides an output for the output compare feature of the on-chip timer system. Refer to **Output Compare Register** for additional information.

OSC1, OSC2

The CDP68HC05P1B family of MCUs can be configured, during device manufacturing, to accept either a crystal or an RC network to control the internal oscillator. The internal clocks are derived by a divide-by-two of the external oscillator frequency (f_{OSC}).

Crystal

The circuit shown in Figure 9C is recommended when using a crystal. The internal oscillator is designed to interface with an AT-Cut parallel resonant quartz crystal resonator in the frequency range specified for f_{OSC} in Control Timing. Use of an external CMOS oscillator is recommended when crystals outside the specified ranges are to be used. The crystal and components should be mounted as close as possible to the input pins to minimize output distortion and start-up stabilization time. Refer to **Electrical Specifications** for V_{DD} Specifications.

Ceramic Resonator

A ceramic resonator may be used in place of the crystal in cost sensitive applications. The circuit in Figure 9C is recommended when using a ceramic resonator. Figure 9B lists the recommended capacitance and feedback resistance values. The manufacturer of the ceramic resonator being considered should be consulted for specific information.

	2MHz	4MHz	UNITS
R_S (Max)	400	75	Ω
C_0	5	7	pF
C_1	0.008	0.012	pF
C_{OSC1}	15-40	15-30	pF
C_{OSC2}	15-30	15-25	pF
R_P	10	10	MΩ
Q	30	40	K

FIGURE 9A. CRYSTAL RESONATOR PARAMETERS

	2MHz - 4MHz	UNITS
R_S (Typical)	10	Ω
C_0	40	pF
C_1	4.3	pF
C_{OSC1}	30	pF
C_{OSC2}	30	pF
R_P	1-10	MΩ
Q	1250	-

FIGURE 9B. CERAMIC RESONATOR PARAMETERS

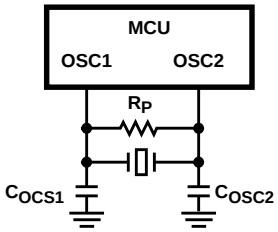


FIGURE 9C. CRYSTAL OSCILLATOR CONNECTIONS

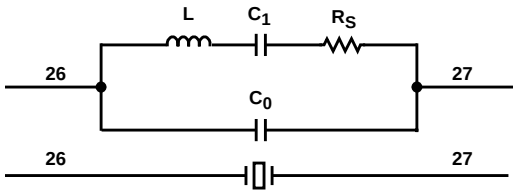


FIGURE 9D. EQUIVALENT CRYSTAL CIRCUIT

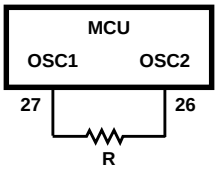


FIGURE 9E. RC OSCILLATOR CONNECTIONS

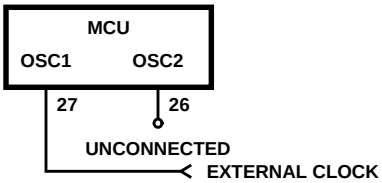


FIGURE 9F. EXTERNAL CLOCK SOURCE CONNECTIONS

FIGURE 9. OSCILLATOR CONNECTIONS

RC

If the RC oscillator option is selected, then a resistor is connected to the oscillator pins as shown in Figure 9E.

External Clock

An external clock should be applied to the OSC1 input with the OSC2 output not connected, as shown in Figure 10F. An external clock may be used with either the RC or crystal oscillator option. The t_{OXOV} or t_{ILCH} specifications do not apply when using an external clock input. The equivalent specification of the external clock source should be used in ***Input/Output Programming***.

Parallel Ports

The 20 I/O lines associated with ports A, B, C and D (bit 5 only) may be individually programmed as inputs or as outputs. Bit 7 of Port D is an input only pin. The direction of each I/O pin is determined by the state of the corresponding bit in the port data direction register (DDR). A port pin is configured as an output if its corresponding DDR bit is set to a logic one. A pin is configured as an input if its corresponding DDR bit is cleared to a logic zero. At power-on or RESET, all DDRs are cleared, which configures all port pins as inputs. The data direction registers are capable of being written to or read by the processor; refer to Table 1. During the programmed output state, a read of the data register actually reads the value of the output latch and not the I/O pin. As an example, if a port bit is set to be a high output and it is pulled low by an external load, reading the port will provide a high reading for that bit.

Input/Output Programming

The 20 bidirectional port pins of the CDP68HC05P1B can be programmed in software to be either inputs or outputs. The remaining port pin (PD7) can be used as an input only pin. The direction of the bidirectional pins is controlled by the state of the corresponding bit in the data direction register (DDR) for the port. Each I/O port has an associated DDR register. Each port pin is configured as an output if it's DDR bit is set. If the DDR bit is clear, the port pin is forced to the input mode.

During reset all of the data direction registers are reset, configuring all I/O ports to the input mode. All DDR locations are capable of being written to and read by the CPU. During the programmed output state, a read of the port data register read the register data, not the state of the port pin. For more information, see Table 1.

TABLE 1. BIDIRECTIONAL PORT TRUTH TABLE

(NOTE 29) R/$\overline{W}$	DDR	I/O PIN FUNCTION
0	0	The I/O pin is in input mode. Data is written into the output data latch
0	1	Data is written into the output data latch and output to the I/O pin.
1	0	The state of the I/O pin is read.
1	1	The I/O pin is in output mode. The output data latch is read.

NOTE:

29. R/$\overline{W}$ is an internal signal.

PA0-PA7

The Port A Data Register (PORTA) is located at $0000 and the Port A Data Direction Register (DDRA) is located at $0004. In addition to data direction control provided by DDRA, Port A I/O pins can be mask programmed, individually, to generate an $\overline{IRQ}$ interrupt if the input signal is in the low state. Refer to Figure 10 for an illustration of a typical Port A bit. See **INTERRUPTS** for more information on operation of Port A interrupts.

All bits in DDRA are cleared by power-on and RESET. Bits in PORTA are unaffected by power-on and RESET.

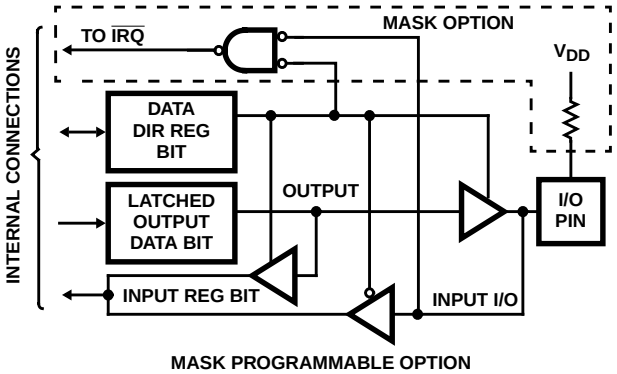


FIGURE 10. PORT A I/O CIRCUITRY

PB5-PB7

Port B is a three bit bidirectional I/O port. The Port B data register address is $0001 and the Port B DDR is addressed at $0005. Port B is a standard bidirectional I/O port, shown in Figure 11.

NOTE: None of the three port pins of Port B are not bonded out in the 20-lead SOIC version of the CDP68HC05P1B. If this option is selected, make sure that the software configures these I/O pins to the OUTPUT mode. If this in not done, the I/O pins will be left floating inside the device and could cause noise to be injected into the part.

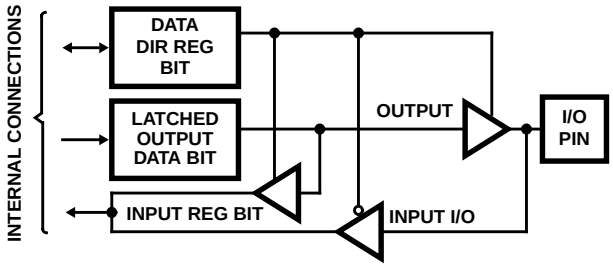


FIGURE 11. TYPICAL I/O PORT CIRCUITRY

Port C0-C7

Port C is an 8 bit bidirectional I/O port that does not share any of its pins with other subsystems. The Port C Data Register (PORTC) is located at $0002 and the Port C Data Direction Register (DDRC) is located at $0006. Like all standard I/O ports, reset does not affect the data in the Port C data register but does clear the contents of the Port C DDR, returning the port to the input state. Figure 11 shows the circuitry for each of the Port C I/O pins.

Two of the Port C pins, PC0 and PC1, have higher source/sink current capabilities than normal I/O pins. See the **DC Electrical Specifications** Tables and Figures 4 and 5 at the beginning of this document for more information.

NOTE: Two of the Port C pins, PC7 and PC6, are not bonded rout in the 20-pin SOIC version of the CDP68HC05P1B. Port C is a still a full 8 bit port, however, and the PC7 and PC6 lines exist inside the device. If this option is selected, make sure that the software configures these I/O pins to the OUTPUT mode. If this in not done, the I/O pins will be left floating inside the device and could cause noise to be injected into the part.

PD5 and TCAP/PD7

Port D is a two bit port with a data register located at address $0003. Bit 5 of this port is a fully bidirectional I/O pin with a DDR bit located in the Port D data direction register at $0007. Bit 7 is an input only pin that also functions as the input to the Timer Compare function of the on-chip Timer Subsystem. For more information on the TCAP function, see the ***Programmable Timer*** section. PD7 can be read at anytime and is not affected by the TCAP function.

None of the Port D pins are bonded out in the 20-pin SOIC version of the CDP68HC05P1B. If this option is selected, make sure that the software configures PD5 to the OUTPUT mode. If this in not done, PD5 will be left floating inside the device and could cause noise to be injected into the part. Since PD7 is an input only pin it is internally connected to V_{SS} when the 20-pin option is selected.

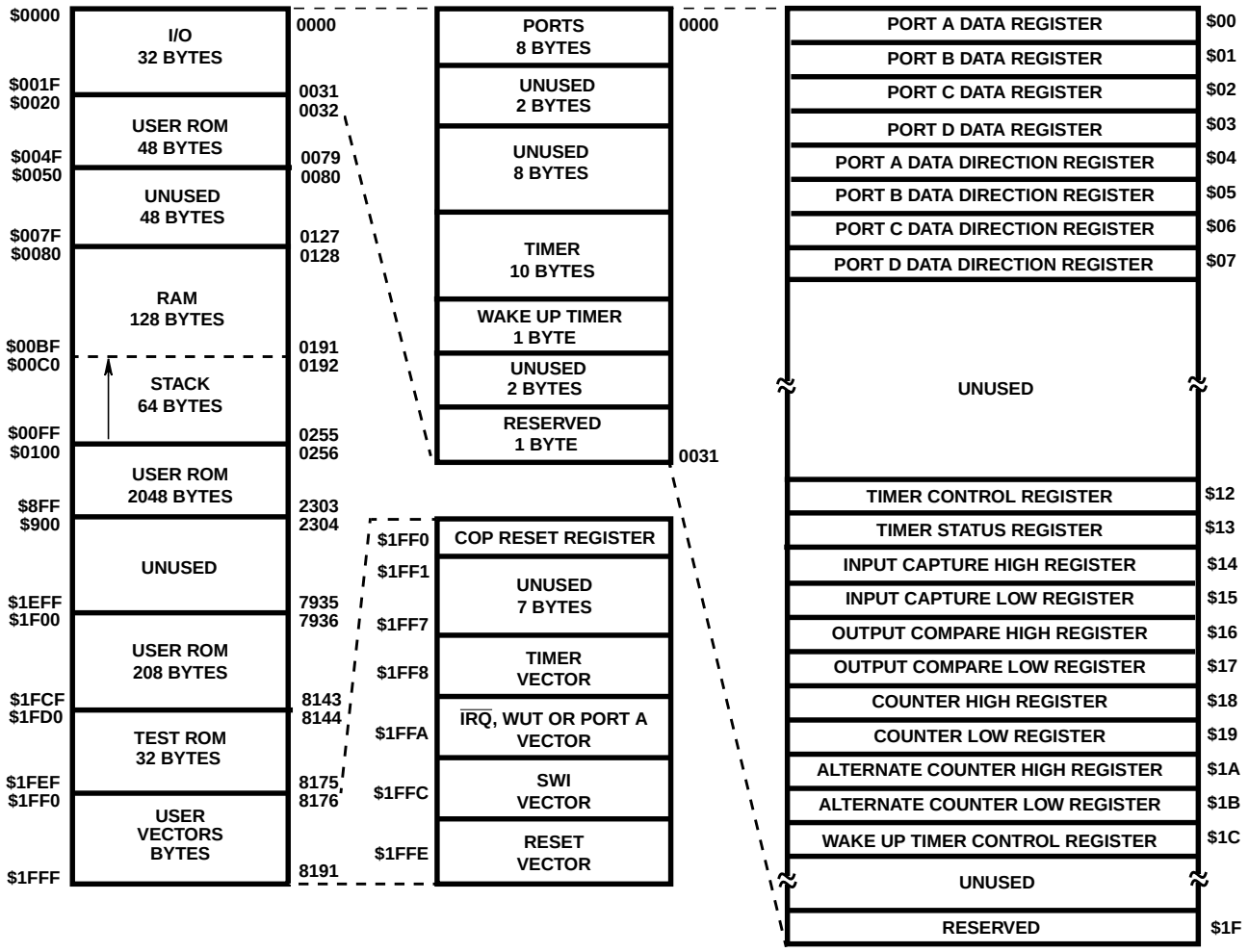


FIGURE 12. ADDRESS MAP

Memory

Figure 12 illustrates the address map of the CDP68HC05P1B. As shown, the memory consists of 128 bytes of RAM between $0080 and $00FF. The upper 64 bytes of RAM is used for a system stack which grows from higher addresses towards lower addresses. Locations $0100 through $08FF contain 2048 bytes of ROM for user ROM. Additionally, there is a 208 byte block of user ROM at locations $1F00 through $1FD0 and a 48 byte block of user ROM at locations $0020 through $004F. Locations $0050 through $0080 and $0900 through $1EFF are unused.

CPU REGISTER MODEL

The CPU contains five registers, as shown in the programing model of Figure 14. The interrupt stacking order is shown in Figure 13.

NOTE: Since the Stack Pointer decrements during pushes, the PCL is stacked first, followed by PCH, etc. Pulling from the stack is in the reverse order.

Accumulator (A)

The accumulator is an 8-bit general purpose register used to hold operands, results of the arithmetic calculations, and data manipulations.

Index Register (X)

The X register is an 8-bit register which is used during the indexed modes of addressing. It provides an 8-bit value which is used to create an effective address. The index register is also used for data manipulations with the read-modify-write type of instructions and as a temporary storage register when not performing addressing operations.

Program Counter (PC)

The program counter is a 13-bit register that contains the address of the next instruction to be executed by the processor.

Stack Pointer (SP)

The stack pointer is a 13-bit register containing the address of the next free location on the pushdown/popup stack. When accessing memory, the most significant bits are permanently configured to 0000011. These bits are appended to the six least significant register bits to produce an address within the range of $00FF to $00C0. The stack area of RAM is used to store the return address on subroutine calls and the machine state during interrupts. During external or power-on reset, and during a reset stack pointer (RSP) instruction, the stack pointer is set to its upper limit ($00FF).

Nested interrupt and/or subroutines may use up to 64 (decimal) locations. When the 64 locations are exceeded, the stack pointer wraps around and points to its upper limit ($00FF), thus, overwriting the previously stored information. A subroutine call occupies two RAM bytes on the stack, while an interrupt uses five RAM bytes.

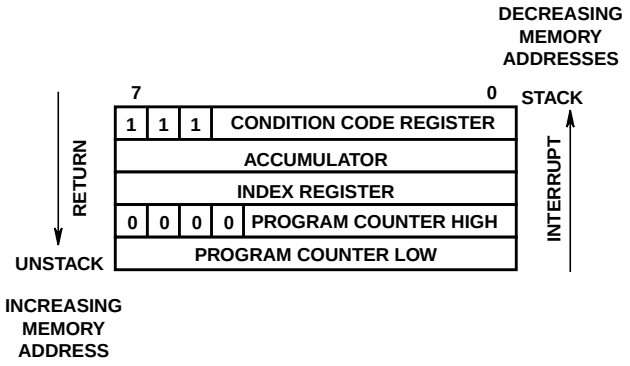


FIGURE 13. STACKING ORDER

Condition Code Register (CC)

The condition code register is a 5-bit register which indicates the results of the instruction just executed as well as the state of the processor. These bits can be individually tested by a program and specified action taken as a result of their state. Each bit is explained in the following paragraphs.

Half Carry Bit (H)

The H-bit is set to a one when a carry occurs between bits 3 and 4 of the ALU during an ADD or ADC instruction. The H-bit is useful in binary coded decimal subroutines.

Interrupt Mask Bit (I)

When the I-bit is set, all interrupts are disabled. Clearing this bit enables the interrupts. If an external ($\overline{IRQ}$ or Port A) interrupt occurs while the I-bit is set, the interrupt is latched and processed after the I-bit is next cleared; therefore, no interrupts are lost because of the I-bit being set. An internal interrupt can be lost if it is cleared while the I-bit is set (refer to Programmable Timer Section for more information).

Negative (N)

When set, this bit indicates that the result of the last arithmetic, logical, or data manipulation is negative (bit-7 in the result is a logic one).

Zero (Z)

When set, this bit indicates that the result of the last arithmetic, logical, or data manipulation is zero.

Carry/Borrow (C)

Indicates that a carry or borrow out of the arithmetic logic unit (ALU) occurred during the last arithmetic operation. This bit is also affected during bit test and branch instructions, shifts, and rotates.

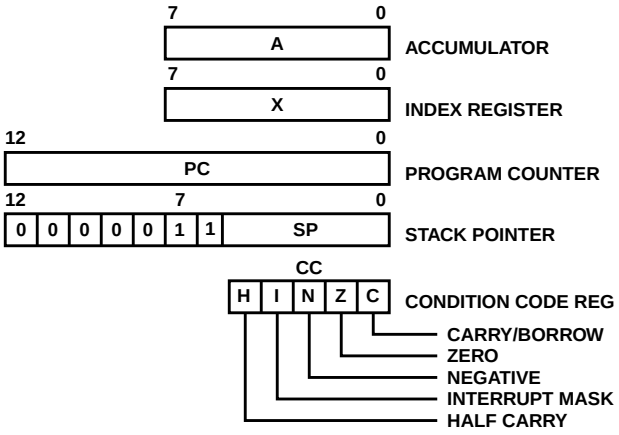
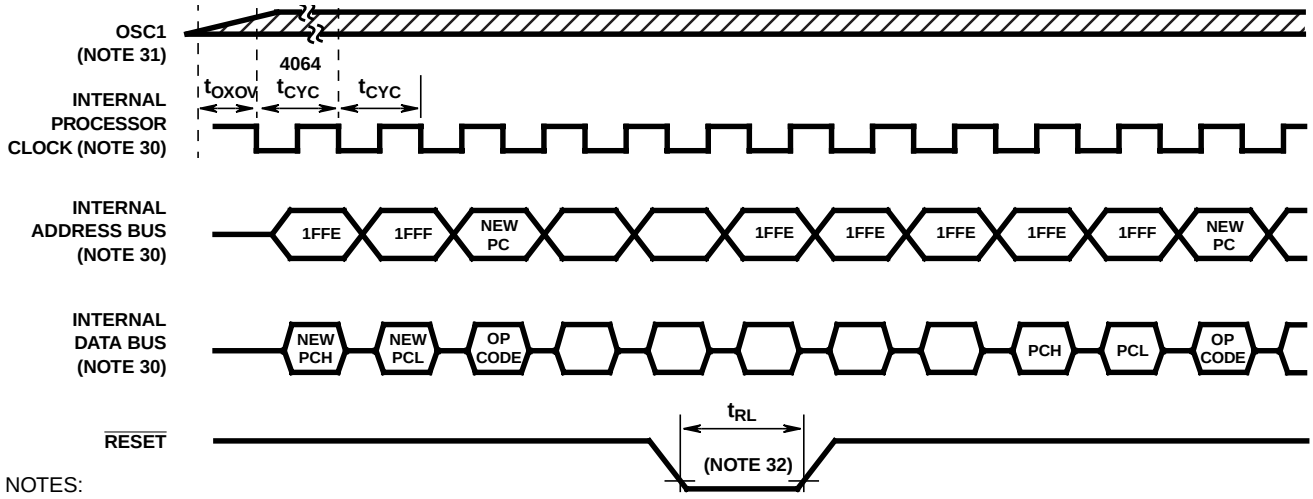


FIGURE 14. PROGRAMMING MODEL



NOTES:

30. Internal timing signal and bus information is not available externally.

31. OSC1 line is not meant to represent frequency. It is only meant to represent time.

32. The next rising edge of the internal processor clock following the rising edge of $\overline{\text{RESET}}$ initiates the reset sequence.

FIGURE 15. POWER-ON RESET AND $\overline{\text{RESET}}$

Resets, Interrupts, and Low Power Modes

RESETS

The MCU has two reset modes: an active low external reset pin ($\overline{\text{RESET}}$) and a power-on reset function; refer to Figure 15.

$\overline{\text{RESET}}$ Pin

The $\overline{\text{RESET}}$ input pin is used to reset the MCU to provide an orderly software start-up procedure. When using the external reset mode, the $\overline{\text{RESET}}$ pin must stay low for a minimum of one and one half t_{CYC}. The $\overline{\text{RESET}}$ pin contains an internal Schmitt Trigger as part of its input to improve noise immunity.

Power-On Reset

The power-on reset occurs when a positive transition is detected on V_{DD}. The power-on reset is used strictly for power turn-on conditions and should not be used to detect any drops in the power supply voltage. There is no provision for a power-down reset.

If the crystal oscillator option is chosen, the power-on circuitry provides for a 4064 t_{CYC} delay from the time that the oscillator becomes active. If the external $\overline{\text{RESET}}$ pin is low at the end of the 4064 t_{CYC} time out, the processor remains in the reset condition until $\overline{\text{RESET}}$ goes high.

If the RC oscillator option is chosen, the power-on circuitry provides a 2 t_{CYC} delay from the time that the oscillator becomes active. If the external $\overline{\text{RESET}}$ pin is low at the end of the 2 t_{CYC} time out, the processor remains in the reset condition until $\overline{\text{RESET}}$ goes high. Table 2 shows the actions of the two resets on internal circuits, but not necessarily in order of occurrence (X indicates that the condition occurs for the particular reset).

Computer Operating Properly (COP) Reset

The CDP68HC05P1B contains a watchdog timer (COP) as a mask option. The COP is an 18 stage counter which is driven by the oscillator. The result is a 65.5ms ($2^{18}/f_{osc}$) time out with a 4MHz crystal. Whenever the COP is allowed to time out, a system reset will occur, and the MCU will be re-initialized as if an external reset had occurred.

Resetting the COP is accomplished by writing a “0” to the COPC bit (bit 0) of the COP Reset Register (COPR) at location $1FF0. The COPR is a write-only register. Reading location $1FF0 will return the data stored there as part of the self-check code.

During WAIT mode the COP will continue to run. The system must periodically exit WAIT and clear the COPC bit.

During STOP mode the COP is held reset. If a hardware reset is used to exit the STOP mode, the COP will be reset following the 4064 cycle start up delay. If an interrupt is used to exit the STOP mode, the COP will begin running immediately and already be at a count of 4064 when the user program resumes. There is no way to turn the COP timer off in software, however it may disabled via a mask option.

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	COPC	$1FF0

INTERRUPTS

Systems often require that normal processing be interrupted so that some external event may be serviced. The CDP68HC05P1B may be interrupted in one of two different methods: either via any of the maskable hardware interrupts ($\overline{\text{IRQ}}$/Port A/WUT or Timer) or via the non-maskable software interrupt (SWI). The Timer interrupt has several flag and status bits which control the interrupt.

TABLE 2. RESET ACTION ON INTERNAL CIRCUIT

CONDITION	$\overline{\text{RESET}}$ PIN	POWER-ON RESET
Oscillator Start-Up Delay Set to 4064 t_{CYC} (8128 Oscillator Cycles)	Note 33	X
Timer Prescaler Reset to Zero State	X	X
Timer Counter Configured to $FFFC	X	X
Timer Output Compare (TCMP) Bit Reset to Zero	X	X
All Timer Interrupt Enable Bits Cleared (ICIE, OCIE, and TOIE) to Disable Timer Interrupts	X	X
Timer OLVL Bit is Cleared to Zero	X	X
Port A, B, C and D DDR'S Cleared to Zero Configuring All Port Pins as Inputs	X	X
Reset COP timer	X	X
Configure Stack Pointer to $00FF	X	X
Force Internal Address to the RESET Vector ($1FFE)	X	X
Set Bit in Condition Code Register to a Logic One to Disable All Interrupts Except SWI	X	X
Clear External Interrupt Latch	X	X
Clear WAIT Latch	X	X
Clear Stop Latch	X (Note 34)	X

NOTES:

33. A delay of 2 t_{CYC} (4 oscillator cycles) is introduced when restarting with RESET, except from STOP mode.
34. 4064 t_{CYC} oscillator start-up time-out occurs.

Generally, interrupt flags are located in read-only status register, whereas their equivalent enable bits are located in associated control registers. The interrupt flags and enable bits are never contained in the same register. If the enable bit is a logic zero it blocks the interrupt from occurring but does not inhibit the flag from being set. Reset clears all enable bits to preclude interrupts during the reset procedure.

The general sequence for clearing an interrupt is a software sequence of first accessing the status register while the interrupt flag is set, followed by a read or write of an associated register. When any of these interrupts occur, and if the enable bit is a logic 1, normal processing is suspended at the end of the current instruction execution. Interrupts cause the processor registers to be saved on the stack (see Figure 13) and the interrupt mask (I-bit) set to prevent additional interrupts. The appropriate interrupt vector then points to the starting address of the interrupt service routine (refer to Figure 12 for vector location). Upon completion of the interrupt service routine, the RTl instruction (which is normally a part of the service routine) causes the register contents to be recovered from the stack followed by a return to normal processing. The stack order is shown in Figure 13.

A discussion of interrupts, plus a table listing vector addresses for all interrupts, including RESET, of the MCU is provided in Table 3.

Hardware Controlled Interrupt Sequence

The following three functions (RESET, STOP, and WAIT) are not in the strictest sense an interrupt; however, they are acted upon in a similar manner. Flowcharts for hardware interrupts are shown in Figure 17, and for STOP and WAIT are provided in Figure 18. A discussion is provided below.

(a) RESET - A low input on the RESET input pin causes the program to vector to its starting address which is specified by the contents of memory locations $1FFE and $1FFF. The I-bit in the condition code register is also set. Much of the MCU is configured to a known state during this type of reset as previously described in RESETS paragraph.

(b) STOP - The STOP instruction causes the oscillator to be turned off and the processor to "sleep" until an external interrupt (lRQ or Port A interrupt) or a RESET. The STOP instruction may be disabled via mask option.

(c) WAIT - The WAIT instruction causes all processor clocks to stop, but leaves the Timer running. This "rest" state of the processor can be cleared by RESET, an external interrupt (lRQ or Port A) or Timer interrupt.

TABLE 3. INTERRUPT AND RESET VECTOR ADDRESSES

REGISTER	FLAG NAME	INTER-RUPTS	CPU INTERRUPT	VECTOR ADDRESS
N/A	N/A	Reset	$\overline{\text{RESET}}$	$1FFE - $1FFF
N/A	N/A	Software	SWI	$1FFC - $1FFD
Wake Up Timer	WUTF	Wake Up Timer	$\overline{\text{IRQ}}$	$1FFA - $1FFB
N/A	N/A	External Interrupt	$\overline{\text{IRQ}}$ or Port A	$1FFA - $1FFB
Timer Status (TCR)	ICF OCF TOF	Input Capture, Output Compare, Timer Overflow	TIMER	$1FF8 - $1FF9

There are no special “WAIT” or “STOP” vectors for the interrupts. When the processor is released from the WAIT or STOP state, the same RESET and interrupt vectors are used as at all other times. The processor provides no indication that a WAIT or STOP state has been exited.

Software Interrupt (SWI)

The software interrupt is an executable instruction. The action of the SWI instruction is similar to the hardware interrupts. The SWI is executed regardless of the state of the interrupt mask (I-bit) in the condition code register. The interrupt service routine address is specified by the contents of memory location $1FFC and $1FFD.

External Interrupt

There are two sources of external interrupts: the IRQ pin and the Port A pins. If the interrupt mask (I-bit) of the condition code register has been cleared and the external interrupt pin ($\overline{IRQ}$) or a Port A pin (if mask programmed for interrupt and software programmed as input) has gone low, then the external interrupt is recognized. When the interrupt is recognized, the current state of the CPU is pushed onto the stack and the I-bit is set. This masks further interrupts until the present one is serviced. The interrupt service routine address is specified by the contents of memory location $1FFA and $1FFB. Either a level-sensitive and negative edge-sensitive trigger, or a negative edge sensitive only trigger are available as a mask option for all external interrupts. Figure 16 shows both a functional and mode timing diagram for the interrupt line. The timing diagram shows two different treatments of the interrupt lines (IRQ/Port A) to the processor. The first method shows single pulses on the interrupt lines spaced far enough apart to be serviced. The minimum time between pulses is a function of the number of cycles required to execute the interrupt service routine plus 21 cycles. Once a pulse occurs, the next pulse should not occur until the MCU software has exited the routine (an RTI occurs). The second configuration shows several interrupt lines “wire-ORed” to form the interrupts at the processor. Thus, if after servicing one interrupt another interrupt line remains low, then the next interrupt is recognized.

NOTE: The internal interrupt latch is cleared in the first part of the service routine; therefore, one (and only one) external interrupt pulse could be latched during t_{ILIL} and serviced as soon as the I-bit is cleared.

Port A Interrupt Programming

The Port A interrupt mask option, allows the eight Port A pins to be individually programmed to cause an external interrupt. For an interrupt to occur, the port pin must also be programmed as an input by setting the associated bit low DDRA. These six lines are internally ORed with the $\overline{IRQ}$ pin and behave in every way like the $\overline{IRQ}$ pin. The level-only/edge-and-level interrupt mask option affects all Port A and $\overline{IRQ}$ pins equally. Similarly, the BIH and BIL instructions are sensitive to the logical OR of all interrupt enabled Port A pins and the $\overline{IRQ}$ pin. BIH will cause a branch if and only if all interrupt enabled Port A pins and the $\overline{IRQ}$ pin are high. BIL will cause a branch if any of the interrupt enabled Port A pins or the $\overline{IRQ}$ pin is low.

Timer Interrupt

There are three different timer interrupt flags that will cause a timer interrupt whenever they are set and enabled. These three interrupt flags are found in the three most significant bits of the Timer Status Register (TSR, location $13) and all three will vector to the same interrupt service routine ($1FF8 - $1FF9). All interrupt flags have corresponding enable bits (ICE, OCIE, and TOIE) in the Timer Control Register (TCR), location $0012). Reset clears all enable bits, thus, preventing an interrupt from occurring during the reset time period. The actual processor interrupt is generated only if the I-bit in the condition code register is also cleared. When the interrupt is recognized, the current machine state is pushed onto the stack and I-bit is set. This masks further interrupts until the present one is serviced.

The interrupt service routine address is specified by the contents of memory locations $1FF8 and $1FF9. The general sequence for clearing an interrupt is a software sequence of accessing the status register while the flag is set, followed by a read or write of an associated register. Refer to ***Programmable Timer*** for additional information about the timer circuity.

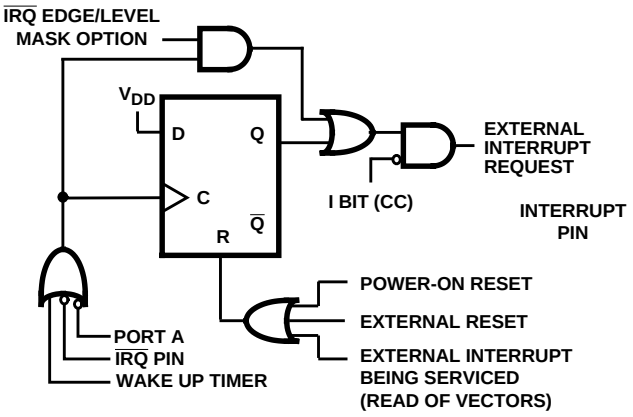
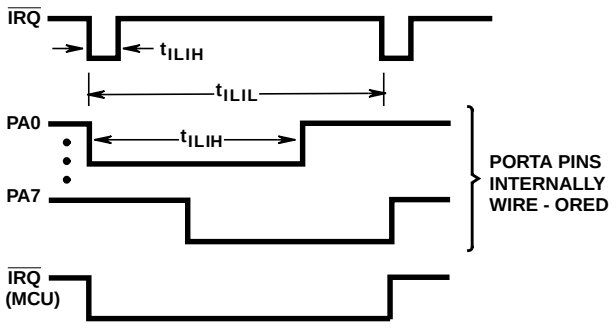


FIGURE 16A. EXTERNAL INTERRUPT FUNCTION DIAGRAM



NOTE: Edge-Sensitive Trigger Condition - The minimum pulse width (t_{ILIH}) is either 125ns (V_{DD} = 5V) or 250ns (V_{DD} = 3V). The period t_{ILIL} should be less than the number of t_{CYC} cycles it takes to execute the interrupt service routine plus 21 t_{CYC}.

NOTE: Level-Sensitive Trigger Condition - If after servicing an interrupt the $\overline{IRQ}$ remains low, then the next interrupt is recognized.

FIGURE 16B. EXTERNAL INTERRUPT MODE DIAGRAM

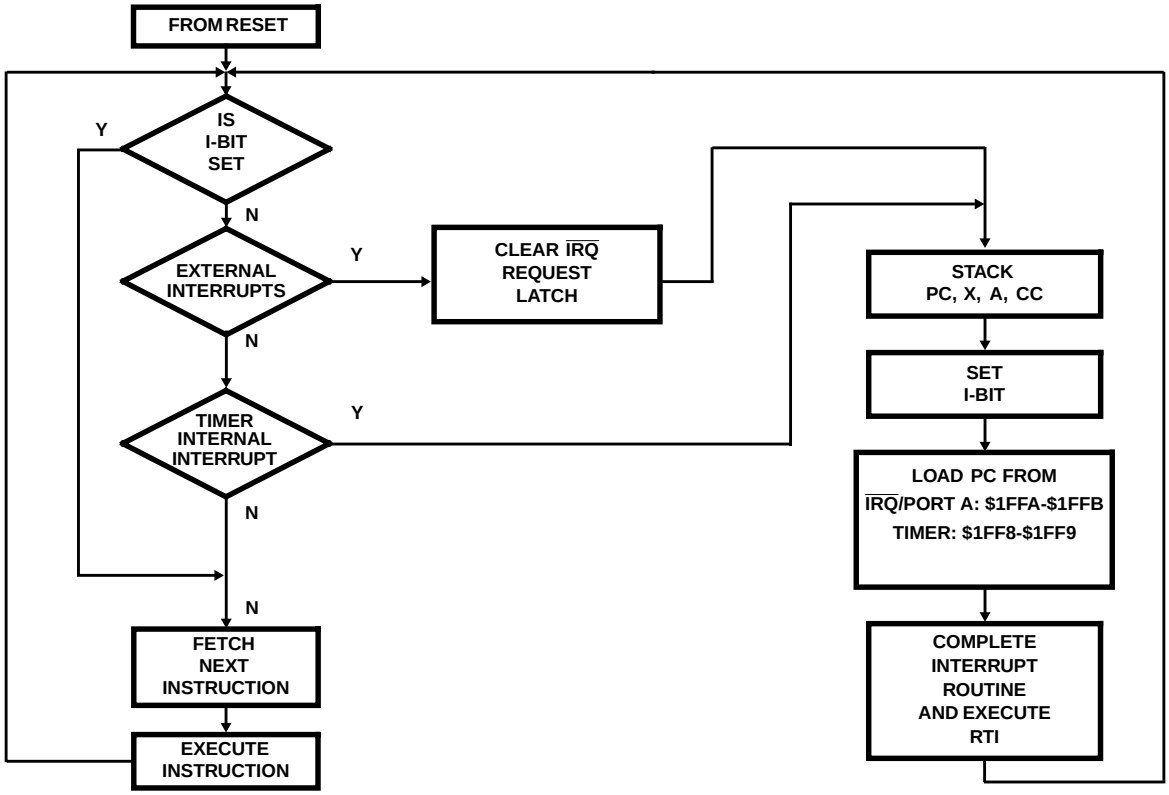


FIGURE 17. HARDWARE INTERRUPT FLOWCHART

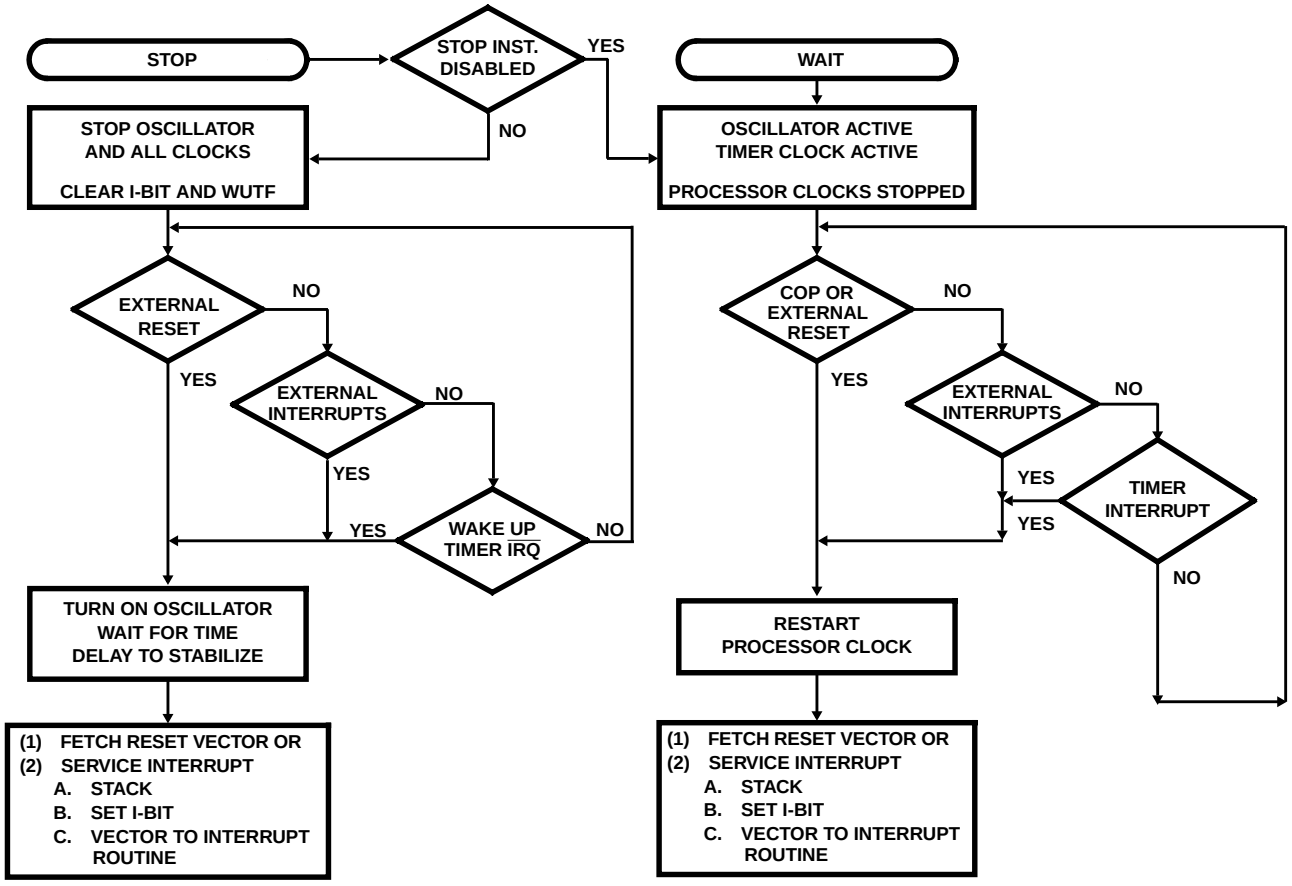


FIGURE 18. STOP/WAIT FLOWCHARTS

LOW POWER MODES

STOP Instruction

The STOP instruction places the MCU in its lowest power consumption mode. In the STOP mode the internal oscillator is turned off, causing all internal processing to be halted; refer to Figure 17. During the STOP mode, the I-bit in the condition code register is cleared to enable external interrupts. All other registers and memory remain unaltered and all input/output lines remain unchanged. This continues until an external interrupt ($\overline{IRQ}$ or Port A), a Wake Up Timer IRQ or a RESET is sensed, at which time the internal oscillator is turned on. The external interrupts and Wake up timer interrupts cause the program counter to load a vector from memory locations $1FFA-1FFB; RESET causes the program counter to load a vector from memory locations $1FFE-1FFF.

Execution of the STOP instruction may be disabled through a mask option. If this option is chosen, the CPU will execute the STOP instruction as a WAIT instruction. This will halt the CPU activity but will allow the internal clock to keep running and subsequently a COP time-out will occur (if the COP is enabled) and reset the part. This option should generally be used in conjunction with the COP to guard against code failure. If the COP is not enabled, the MCU will only come out of WAIT mode when it gets reset or an interrupt of any kind. See the **WAIT Instruction** section for more details about WAIT mode.

Wake Up Timer

The Wake Up Timer of the CDP68HC05CP1B is a 16 stage counter driven by a low power (10µA typical at 25^oC) RC oscillator that can be used to “wake up” the CPU from STOP mode at certain intervals. This oscillator for this circuit is completely independent from the main CPU oscillator and therefore is unaffected by STOP mode. The Wake Up Timer is a mask programmable option that, if selected, can be enabled and disabled at any time by the setting or clearing the WUTE bit in the Wake Up Timer Control Register (WUTCR, $1C). The flag bit for the system, WUTF, is also located in the WUTCR. Typical time out periods at 25^oC will be in the range of 2.2 to 2.9 seconds.

Wake Up Timer Control Register (WUTCR)

The Wake Up Timer Register, WUTCR, is located at $1C. It contains two bits that control the operation of the Wake Up Timer.

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	WUTF	WUTE	$1C

B7-B2 Not implemented, always read as 0.

B1, WUTF The Wake Up Timer Flag is a read only bit used to indicate that the Wake Up Timer circuitry has timed out and brought the MCU out of STOP mode. This bit is cleared by resetting the MCU, reading the WUTCR register or entering STOP mode.

B0, WUTE The Wake Up Timer Enable bit is used to control the on chip Wake Up Timer. If this bit is set (and the mask option is selected) the Wake Up Timer will be enabled when the MCU enters STOP mode. If this bit is clear the timer is disabled and the 16 stage counter is cleared. This bit is cleared by reset and may be read and written at any time.

When the Wake Up Timer mask option is selected and the WUTE bit in the WUTCR is set, the Wake Up Timer system will be enabled when the MCU enters STOP mode. When a STOP instruction is executed, the Wake Up Timer counter is cleared and the low power RC oscillator is powered on. The RC oscillator stabilizes within one cycle so no start up delay is necessary. When the counter overflows, the WUTF bit is set and an $\overline{IRQ}$ is generated, thus bringing the MCU out of STOP mode. The MCU will react to the Wake Up Timer $\overline{IRQ}$ in the same way as if an external interrupt was generated, i.e., the MCU will vector to $1FFA and $1FFB. Software can distinguish the Wake Up Timer $\overline{IRQ}$ from an external $\overline{IRQ}$ by checking the WUTF bit. If the Wake Up Timer option is selected, it is important that the $\overline{IRQ}$ service routine software read the WUTCR register to clear the WUTF bit. As long as the WUTF flag is set, the Wake Up Timer system will hold the internal $\overline{IRQ}$ signal low (Refer to Figure 16B). This will cause the MCU to either continuously generate $\overline{IRQ}$ interrupts (in the $\overline{IRQ}$ sensitivity is set to EDGE/LEVEL) or mask all $\overline{IRQ}$ requests (if $\overline{IRQ}$ sensitivity is set to EDGE only). If the Wake Up Timer mask option is not selected the WUTF will never affect the $\overline{IRQ}$ circuitry of the device. The WUTF bit is cleared when the WUTCR register is read, when the MCU enters STOP mode, or if the device is reset. The MCU can be brought out of STOP mode before the Wake Up Timer times out by RESET or an external $\overline{IRQ}$.

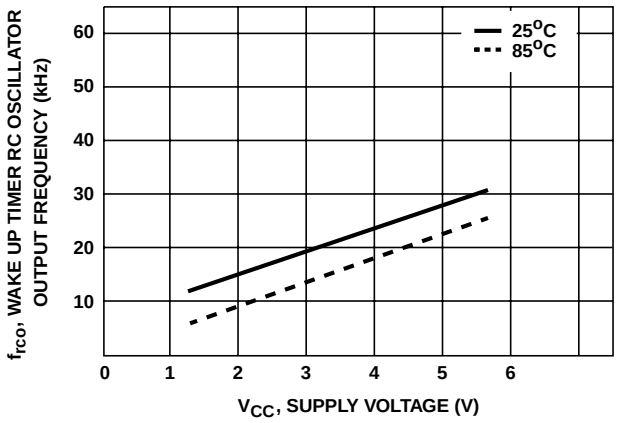


FIGURE 19. RC OSCILLATOR VOLTAGE/FREQUENCY CURVE

The time-out period of the Wake Up Timer is controlled by the frequency of the RC oscillator divided down through an 16 stage counter. Thus the time-out period of the Wake Up Timer is 65,536/(RC oscillator frequency, f_{rco}). The frequency of the RC oscillator is dependent on the supply voltage, V_{CC}, and the temperature of the device. Figure 19 shows the frequency output of the oscillator, f_{rco}, for different values of voltage and temperature. Keep in mind that these value are NOT exact; in addition to supply voltage and temperature, factors like the processing parameters of the device also affect the RC oscillator frequency.

WAIT Instruction

The WAIT instruction places the MCU in a low power consumption mode, but the WAIT mode consumes somewhat more power than the STOP mode. In the WAIT mode, the internal clock remains active, and all CPU processing is stopped; however, the programmable timer system remains active. Refer to Figure 18. During the WAIT mode, the I-bit in the condition code register is cleared to enable all interrupts (Timer interrupts must be enabled by setting the appropriate bits in the TCR prior to entering WAIT). All other registers and memory remain unaltered and all parallel input/output lines remain unchanged. This continues until any interrupt or RESET is sensed. At this time the program counter loads a vector from the appropriate memory location which contains the starting address of the interrupt or RESET service routine.

Data Retention Mode

The contents of RAM and CPU registers are retained at supply voltages as low as $1.5V_{DC}$. This is referred to as the Data Retention mode, where the data is held, but the device is not guaranteed to operate.

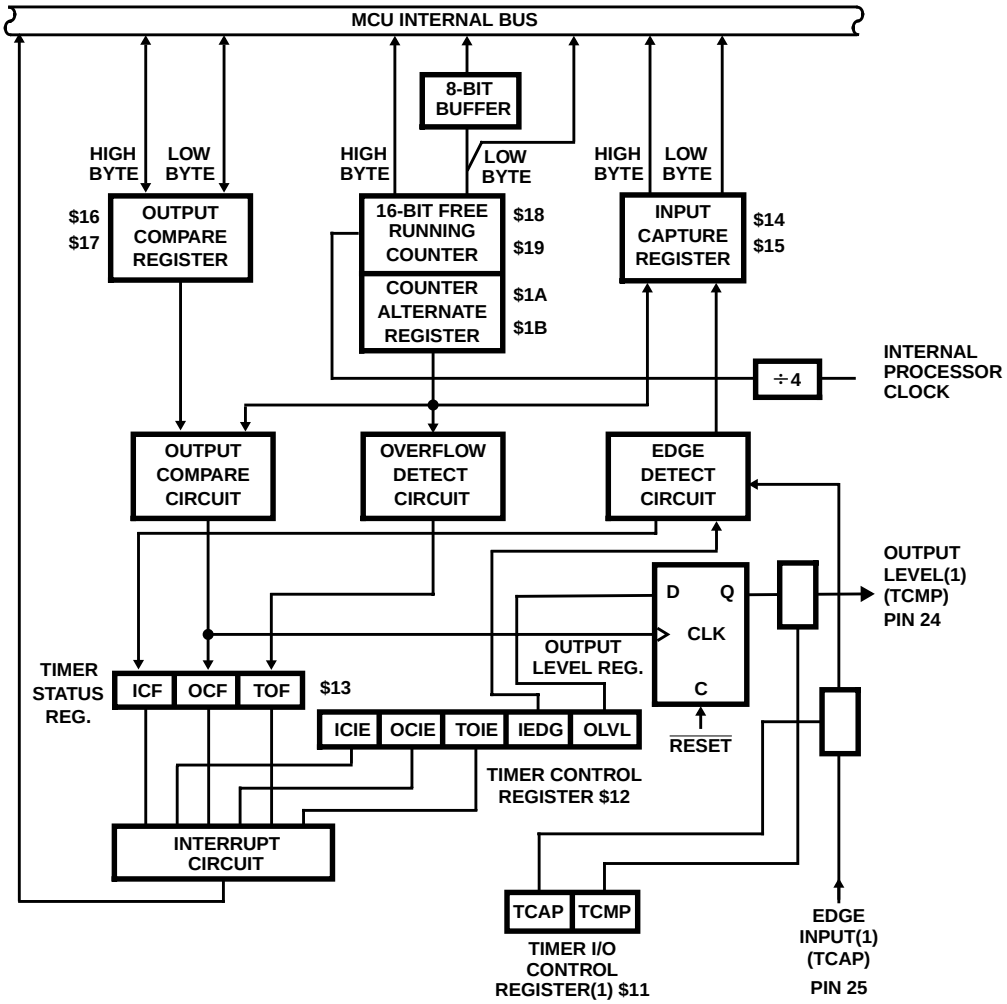


FIGURE 20. PROGRAMMABLE TIMER BLOCK DIAGRAM

Programmable Timer

INTRODUCTION

The programmable timer, which is preceded by a fixed divide-by-four prescaler, can be used for many purposes, including input waveform measurements while simultaneously generating an output waveform. Pulse widths can vary from several microseconds to many seconds. A block diagram of the timer is shown in Figure 20 and timing diagrams are shown in Figures 21 through 24.

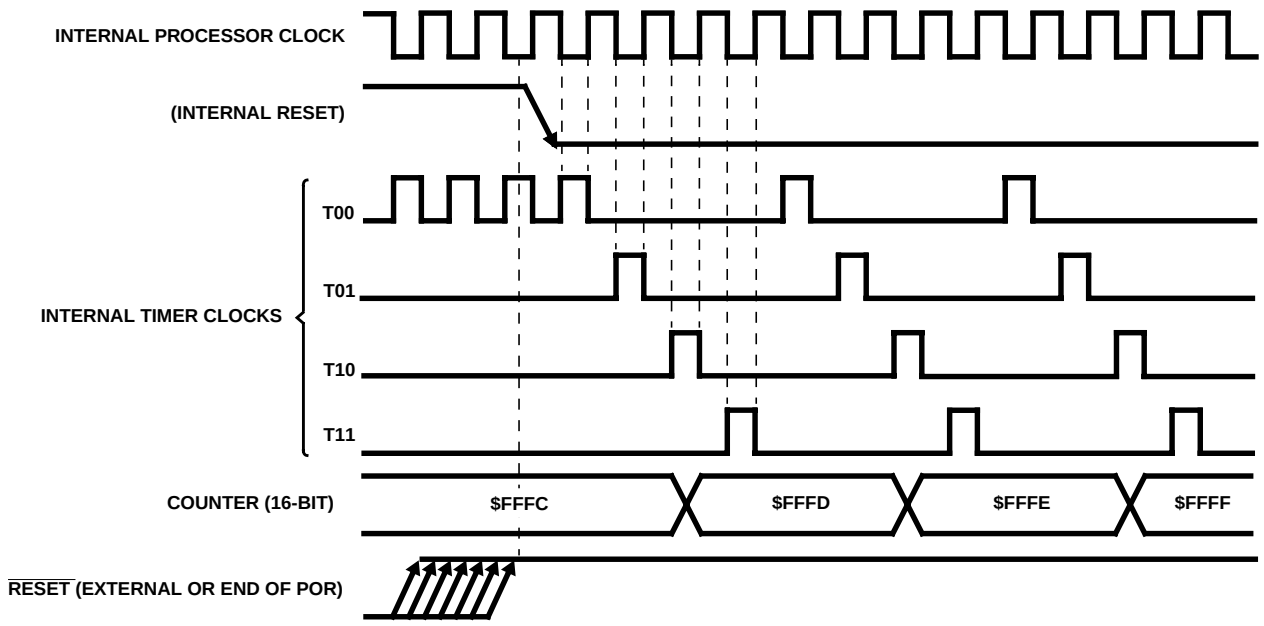
Because the timer has a 16-bit architecture, each specific functional segment (capability) is represented by two registers. These registers contain the high and low byte of that functional segment. Generally, accessing the low byte of a specific timer function allows full control of that function; however, an access of the high byte inhibits that specific timer function until the low byte is also accessed.

NOTE: The I-bit in the condition code register should be set while manipulating both the high and low byte register of a specific timer function to ensure that an interrupt does not occur. This prevents interrupts from occurring between the time that the high and low byte are accessed.

The programmable timer capabilities are provided by using the following ten addressable 8-bit registers (note the high and low represent the significance of the byte). A description of each register is provided below.

- Timer Control Register (TCR) location $12
- Timer Status Register (TSR) location $13
- Input Capture High Register location $14
- Input Capture Low Register location $15
- Output Compare High Register location $16
- Output Compare Low Register location $17
- Counter High Register location $18
- Counter Low Register location $19
- Alternate Counter High Register location $1A
- Alternate Counter Low Register location $1B

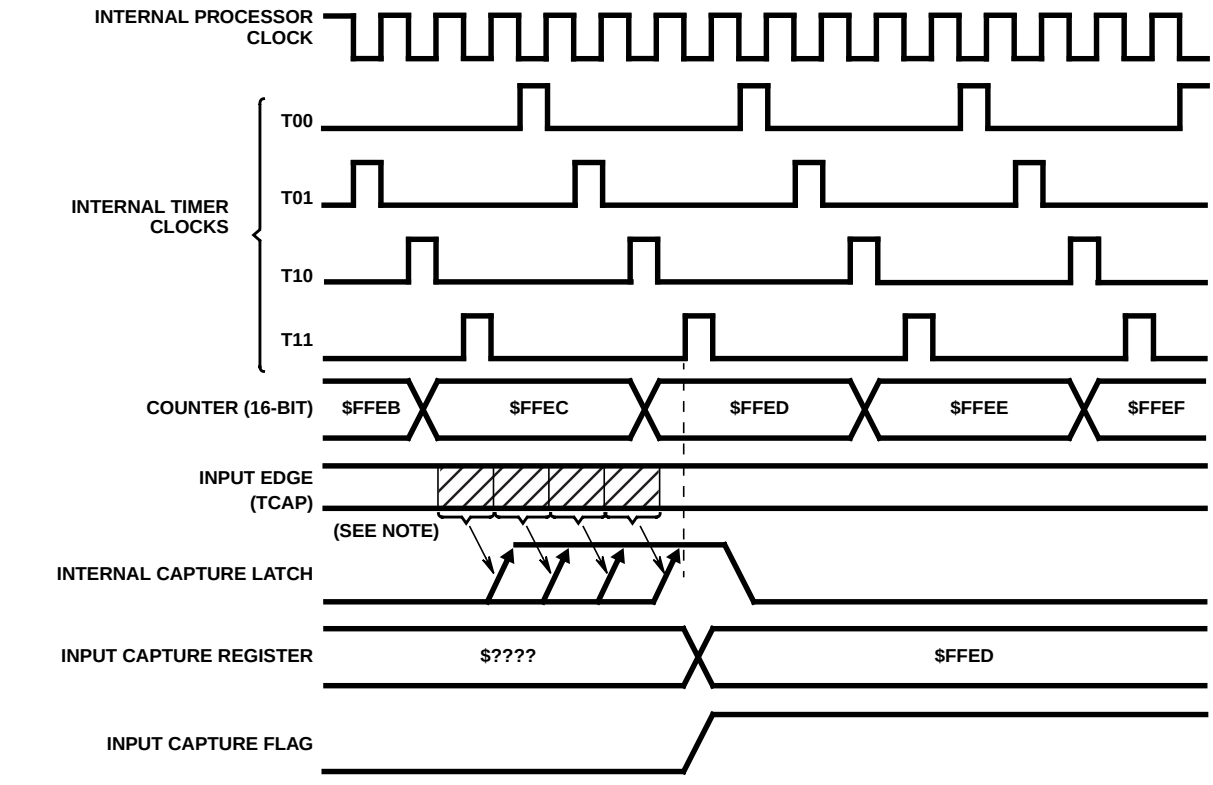
Timing Diagrams



NOTE:

35. The Counter Register and the Timer Control Register are the only ones affected by $\overline{\text{RESET}}$.

FIGURE 21. TIMER STATE DIAGRAM FOR RESET

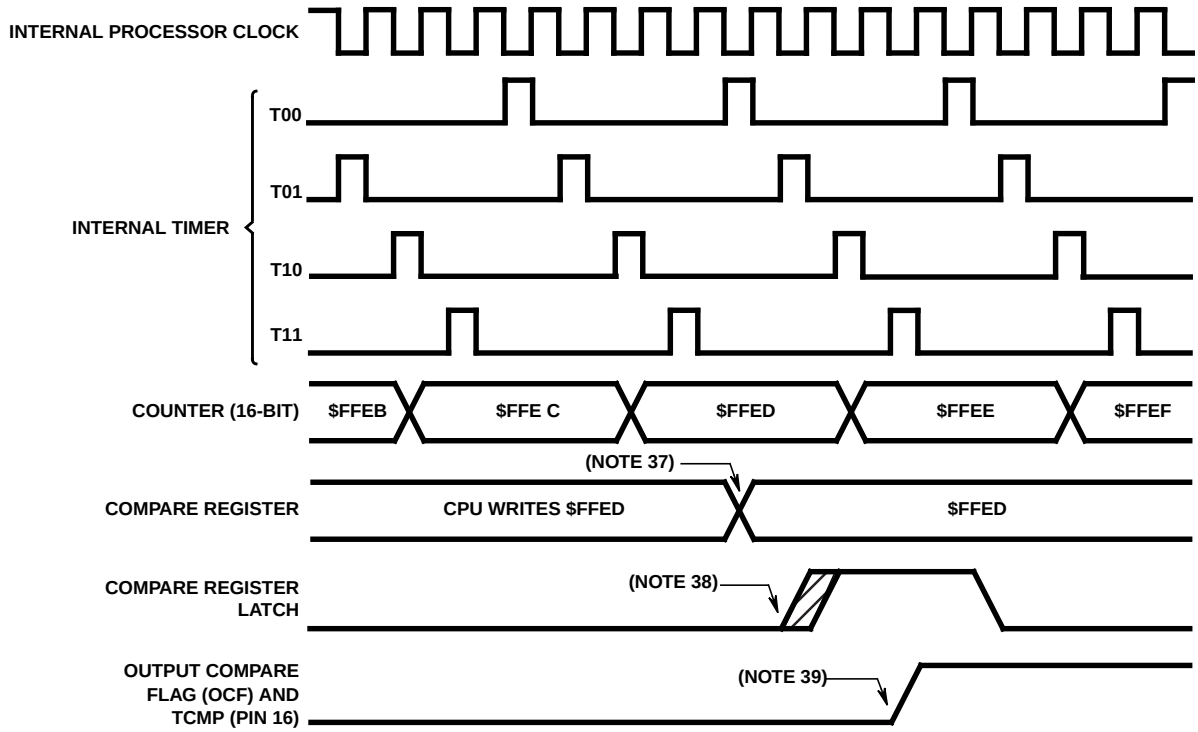


NOTES:

36. If the input edge occurs in the shaded area from one timer state T10 to the other timer state T10, the input capture flag is set during the next state T11.

FIGURE 22. TIMER STATE TIMING DIAGRAM FOR INPUT CAPTURE

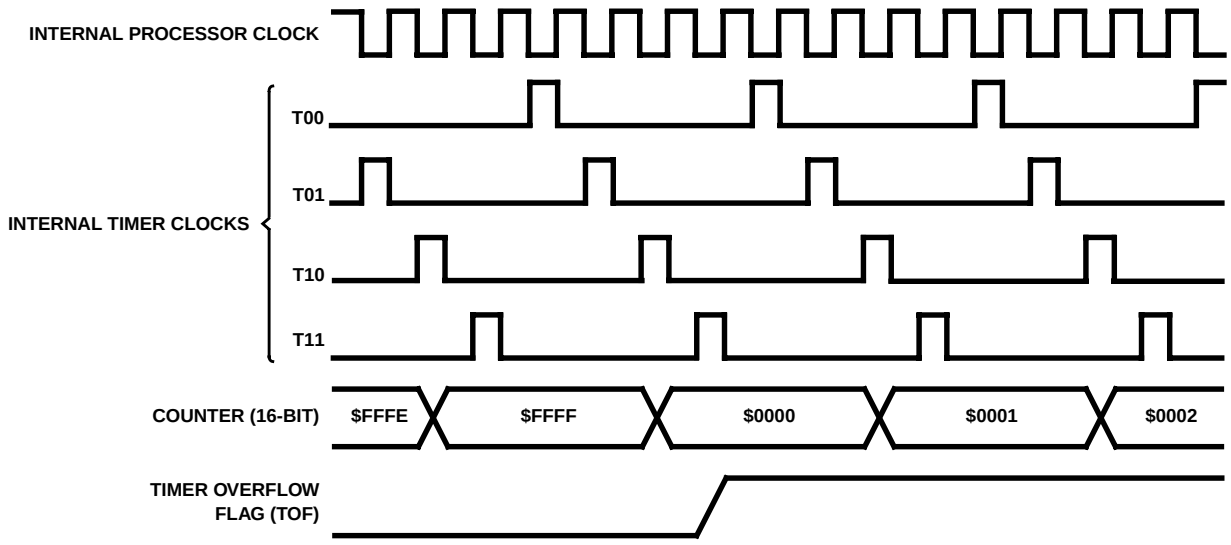
Timing Diagrams (Continued)



NOTES:

37. The CPU write to the Compare Register may take place at any time, but a compare only occurs at timer state T01. Thus, a 4 cycle difference may exist between the write to the Compare Register and the actual compare.
38. Internal compare takes place during timer state T01.
39. OCF is set at the timer state T11 which follows the comparison match ($FFED in this example).

FIGURE 23. TIMER STATE TIMING DIAGRAM FOR OUTPUT COMPARE



NOTES:

40. The TOF bit is set at timer state T11 (transition of the counter from $FFFF to $0000). It is cleared by a read of the Timer Status Register during the internal processor clock high time followed by a read of the Counter Low Register.

FIGURE 24. TIMER STATE DIAGRAM FOR TIMER OVERFLOW

COUNTER

The key element in the programmable timer is a 16-bit free running counter, or counter register, preceded by a prescaler which divides the internal processor clock by four. The prescaler gives the timer a resolution of 2.0µs if the internal processor clock is 2.0MHz. The counter is clocked to increasing values during the low portion of the internal processor clock. Software can read the counter at any time without affecting its value.

The double byte free running counter can be read from either of two locations $18 - $19 (called counter register at this location), or $1A - $1B (counter alternate register at this location). A read of only the least significant byte (LSB) of the free running counter ($19, $1B) retrieves the current count value. If a read of the free running counter first addresses the most significant byte ($18, $1A) the least significant byte is transferred to a buffer. This buffer value remains fixed after the first most significant byte “read” even if the user reads the most significant byte several times. This buffer is accessed when reading the LSB of the free running counter or counter alternate register ($19, $1B), if the most significant byte is read, the least significant byte must also be read in order to complete the sequence.

The free running counter is configured to $FFFC during reset and is always a read-only register. During a power-on-reset (POR), the counter is also configured to $FFFC and begins running after the oscillator start-up delay. Because the free running counter is 16 bits preceded by a fixed divide-by-four prescaler, the value in the free running counter repeats every 262,144 MPU internal processor clock cycles. When the counter rolls over from $FFFF to $0000, the timer overflow flag (TOF) bit is set. An interrupt can also be enabled when counter roll-over occurs by setting its interrupt enable bit (TOIE).

Output Compare Register

The output compare register is a 16-bit register, which is made up of two 8-bit registers at locations $16 (most significant byte) and $17 (least significant byte). The output compare register can be used for several purposes such as, controlling an output waveform or indicating when a period of time has elapsed. The output compare register is unique in that all bits are readable and writable and are not altered by the timer hardware. Reset does not affect the contents of this register and if the compare function is not utilized, the two bytes of the output compare register can be used as storage locations.

The contents of the output compare register are compared with the contents of the free running counter once during every four internal processor clocks. If a match is found, the corresponding output compare flag (OCF) bit is set and the corresponding output level (OLVL) bit is clocked (by the output compare circuit pulse) to an output level register. The values in the output compare register and the output level bit should be changed after each successful comparison in order to control an output waveform or establish a new elapsed time-out. An interrupt can also accompany a successful output compare provided the corresponding interrupt enable bit, OCIE, is set.

After a processor write cycle to the output compare register containing the most significant byte ($16), the output compare function is inhibited until the least significant byte ($17) is also written. The user must write both byte (locations) if the most significant byte is written first. A write made only to the least significant byte ($17) will not inhibit the compare function. The free running counter is updated every four internal processor clock cycles due to the internal prescaler. The minimum time required to update the output compare register is a function of the software program rather than the internal hardware. A processor write may be made to either byte of the output compare register without affecting the other byte. The output level (OLVL) bit is clocked to the output level register regardless of whether the output compare flag (OCF) is set or clear.

Because neither the output compare flag (OCF bit) nor the output compare register is affected by RESET, care must be exercised when initializing the output compare function with software. The following procedure is recommended:

1. Write the high byte of the output compare register to inhibit further compares until the low byte is written.
2. Read the timer status register to arm the OCF if it is already set.
3. Write the output compare register low byte to enable the output compare function with the flag clear.

The advantage of this procedure is that it prevents the OCF bit from being set between the time it is read and the write to the output compare register. A software example is shown below.

```
B716  STA  OCMPHI;   INHIBIT OUTPUT COMPARE
B613  LDA  TSTAT;    ARM OCF BIT IF SET
BF17  STX  OCMPLO;   READY FOR NEXT COMPARE
```

Input Capture Register

The two 8-bit registers which make up the 16-bit input capture register are read-only and are used to latch the value of the free running counter after a defined transition is sensed by the corresponding input capture edge detector. The level transition which triggers the counter transfer is defined by the corresponding input edge bit (IEDG). Reset does not affect the contents of the input capture register.

The result obtained by an input capture will be one more than the value of the free running counter on the rising edge of the internal processor clock preceding the external transition (refer to timing diagram shown in Figure 23). This delay is required for internal synchronization. Resolution is affected by the prescaler allowing the timer to only increment every four internal processor clock cycles.

After a read of the most significant byte of the input capture register ($14), counter transfer is inhibited until the least significant byte ($15) of the input capture register is also read. This characteristic forces the minimum pulse period attainable to be determined by the time used in the capture software routine and its interaction with the main program. The free running counter increments every four internal processor clock cycles due to the prescaler.

A read of the least significant byte ($15) of the input capture register does not inhibit the free running counter transfer. Again, minimum pulse periods are ones which allow software to read the least significant byte ($15) and perform needed operations. There is no conflict between the read of the input capture register and the free running counter transfer since they occur on opposite edges of the internal processor clock.

Timer Control Register (TCR)

The Timer Control Register (TCR, location $12) is an 8-bit read/write register which contains five control bits. Three of these bits control interrupts associated with each of the three flag bits found in the timer status register (discussed below). The other two bits control: 1. Which edge is significant to the capture edge detector (i.e., negative or positive), and 2. The next value to be clocked to the output level register in response to a successful output compare. The Timer Control Register and the free running counter are the only sections of the timer affected by RESET. The TCMP pin is forced low during external reset and stays low until a valid compare changes it to a high. The timer control register is illustrated below followed by a definition of each bit.

7	6	5	4	3	2	1	0	
ICIE	OCIE	TOIE	0	0	0	IEDG	OLVL	$12

B7, ICIE — If the input capture interrupt enable (ICIE) bit is set, a timer interrupt is enabled when the ICF status flag (in the Timer Status Register) is set. If the ICIE bit is clear, the interrupt is inhibited. The ICIE bit is cleared by reset.

B6, OCIE — If the output compare interrupt enable (OCIE) bit is set, a timer interrupt is enabled whenever the OCF status flag is set. If the OCIE bit is clear, the interrupt is inhibited. The OCIE bit is cleared by reset.

B5, TOIE — If the timer overflow interrupt enable (TOIE) bit is set, a timer interrupt is enabled whenever the TOF status flag (in the Timer Status Register) is set. If the TOIE bit is clear, the interrupt is inhibited. The TOIE bit is cleared by reset.

B4-B2 — Not implemented, always read as 0.

B1, IEDG — The value of the input edge (IEDG) bit determines which level transition on pin 24 will trigger a free running counter transfer to the input capture register. Reset does not affect the IEDG bit.
0 = negative edge
1 = positive edge

B0, OLVL — The value of the output level (OLVL) bit is clocked into the output level register by the next successful output compare and will appear at pin 24. This bit and the output level register are cleared by reset.
0 = low output
1 = high output

Timer Status Register (TSR)

The Timer Status Register (TSR) is an 8-bit register of which the three most significant bits contain read-only status information. These three bits indicate the following:

1. A proper transition has taken place at the TCAP pin with an accompanying transfer of the free running counter contents to the input capture register,
2. A match has been found between the free running counter and the output compare register, and,
3. A free running counter transition from $FFFF to $0000 has been sensed (timer overflow).

The Timer Status Register is illustrated below followed by a definition of each bit. Refer to timing diagrams shown in Figures 23, 24, and 25 for timing relationship to the timer status register bits.

7	6	5	4	3	2	1	0	
ICF	OCF	TOF	0	0	0	0	0	$13

B7, ICF — The Input Capture Flag (ICF) is set when a proper edge has been sensed by the input capture edge detector. It is cleared by a processor access of the Timer Status Register (with ICF set) followed by accessing the low byte ($15) of the Input Capture Register. Reset does not affect the Input Compare Flag.

B6, OCF — The Output Compare Flag (OCF) is set when the output compare register contents match the contents of the free running counter. The OCF is cleared by accessing the Timer Status Register (with OCF set) and then accessing the low byte ($17) of the Output Compare Register. Reset does not affect the output compare flag.

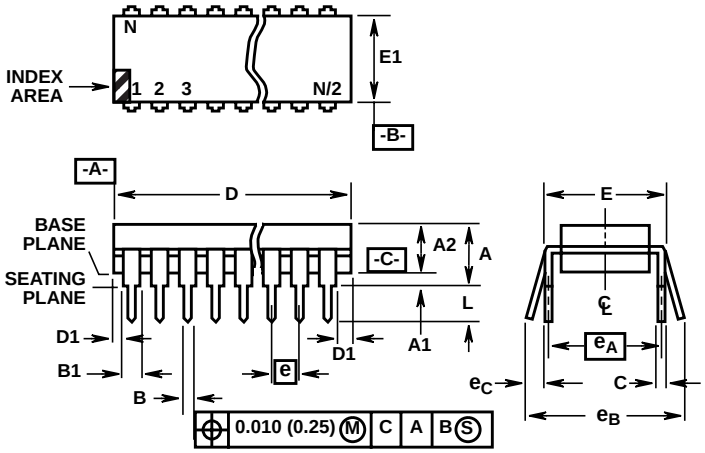
B5, TOF — The Timer Overflow Flag (TOF) bit is set by a transition of the free running counter from $FFFF to $0000. It is cleared by accessing the Timer Status Register (with TOF set) followed by an access of the free running counter least significant byte ($19). Reset does not affect the TOF bit.

B4-B0 — Not implemented, always read as 0.

Accessing the Timer Status Register satisfies the first condition required to clear any status bits which happen to be set during the access. The only remaining step is to provide an access of the register which is associated with the status bit. Typically, this presents no problem for the input capture and output compare functions.

A problem can occur when using the timer overflow function and reading the free running counter at random times to measure an elapsed time. Without incorporating the proper precautions into software, the Timer Overflow Flag could unintentionally be cleared if: 1) the Timer Status Register is read or written when TOF is set, and 2) the least significant byte of the free running counter is read but not for the purpose of servicing the flag. The Counter Alternate Register at address $1A and $1B contains the same value as the free running counter (at address $18 and $19); therefore, this alternate register can be read at any time without affecting the timer overflow flag in the timer status register.

Dual-In-Line Plastic Packages (PDIP)



NOTES:

1. Controlling Dimensions: INCH. In case of conflict between English and Metric dimensions, the inch dimensions control.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Symbols are defined in the “MO Series Symbol List” in Section 2.2 of Publication No. 95.
4. Dimensions A, A1 and L are measured with the package seated in JEDEC seating plane gauge GS-3.
5. D, D1, and E1 dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.010 inch (0.25mm).
6. E and e_A are measured with the leads constrained to be perpendicular to datum -C-.
7. e_B and e_C are measured at the lead tips with the leads unconstrained. e_C must be zero or greater.
8. B1 maximum dimensions do not include dambar protrusions. Dambar protrusions shall not exceed 0.010 inch (0.25mm).
9. N is the maximum number of terminal positions.
10. Corner leads (1, N, N/2 and N/2 + 1) for E8.3, E16.3, E18.3, E28.3, E42.6 will have a B1 dimension of 0.030 - 0.045 inch (0.76 - 1.14mm).

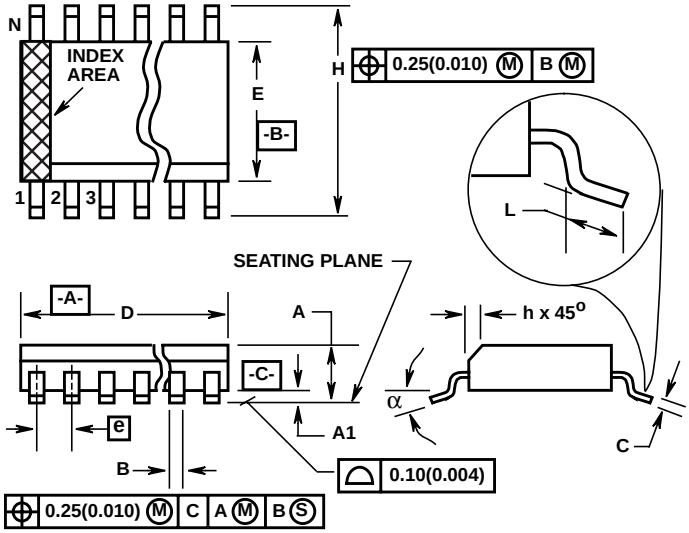
E28.6 (JEDEC MS-001-BF ISSUE D)

28 LEAD NARROW BODY DUAL-IN-LINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.250	-	6.35	4
A1	0.015	-	0.39	-	4
A2	0.125	0.195	3.18	4.95	-
B	0.014	0.022	0.356	0.558	-
B1	0.030	0.070	0.77	1.77	8
C	0.008	0.015	0.204	0.381	-
D	1.380	1.565	35.1	39.7	5
D1	0.005	-	0.13	-	5
E	0.600	0.625	15.24	15.87	6
E1	0.485	0.580	12.32	14.73	5
e	0.100 BSC		2.54 BSC		-
e_A	0.600 BSC		15.24 BSC		6
e_B	-	0.700	-	17.78	7
L	0.115	0.200	2.93	5.08	4
N	28		28		9

Rev. 0 12/93

Small Outline Plastic Packages (SOIC)



M20.3 (JEDEC MS-013-AC ISSUE C)
20 LEAD WIDE BODY SMALL OUTLINE PLASTIC PACKAGE

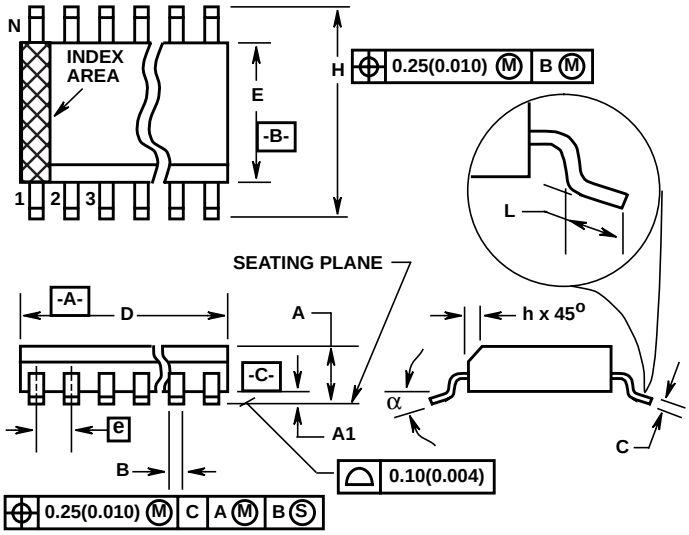
SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.0926	0.1043	2.35	2.65	-
A1	0.0040	0.0118	0.10	0.30	-
B	0.013	0.0200	0.33	0.51	9
C	0.0091	0.0125	0.23	0.32	-
D	0.4961	0.5118	12.60	13.00	3
E	0.2914	0.2992	7.40	7.60	4
e	0.050 BSC		1.27 BSC		-
H	0.394	0.419	10.00	10.65	-
h	0.010	0.029	0.25	0.75	5
L	0.016	0.050	0.40	1.27	6
N	20		20		7
α	0^o	8^o	0^o	8^o	-

Rev. 0 12/93

NOTES:

1. Symbols are defined in the “MO Series Symbol List” in Section 2.2 of Publication Number 95.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension “D” does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
4. Dimension “E” does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.25mm (0.010 inch) per side.
5. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
6. “L” is the length of terminal for soldering to a substrate.
7. “N” is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. The lead width “B”, as measured 0.36mm (0.014 inch) or greater above the seating plane, shall not exceed a maximum value of 0.61mm (0.024 inch)
10. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.

Small Outline Plastic Packages (SOIC)



M28.3 (JEDEC MS-013-AE ISSUE C)
28 LEAD WIDE BODY SMALL OUTLINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.0926	0.1043	2.35	2.65	-
A1	0.0040	0.0118	0.10	0.30	-
B	0.013	0.0200	0.33	0.51	9
C	0.0091	0.0125	0.23	0.32	-
D	0.6969	0.7125	17.70	18.10	3
E	0.2914	0.2992	7.40	7.60	4
e	0.05 BSC		1.27 BSC		-
H	0.394	0.419	10.00	10.65	-
h	0.01	0.029	0.25	0.75	5
L	0.016	0.050	0.40	1.27	6
N	28		28		7
α	0^o	8^o	0^o	8^o	-

Rev. 0 12/93

NOTES:

1. Symbols are defined in the “MO Series Symbol List” in Section 2.2 of Publication Number 95.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension “D” does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
4. Dimension “E” does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.25mm (0.010 inch) per side.
5. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
6. “L” is the length of terminal for soldering to a substrate.
7. “N” is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. The lead width “B”, as measured 0.36mm (0.014 inch) or greater above the seating plane, shall not exceed a maximum value of 0.61mm (0.024 inch)
10. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.

HARRIS CDP68HC05 FAMILY OF MICROCONTROLLERS

HARRIS PART NUMBER	ROM (BYTES)	RAM (BYTES)	TIMER	SERIAL PORTS	I/O	COP	HSC VERSION	HCL VERSION	COMMENTS	PACKAGE
CDP68HC05C4	4160	176	16 bit; 1IC, 1OC	SCI, SPI	24 i/o, 7 i	No	Yes	Yes	8x8 Unsigned Multiply, RC or Crystal Oscillator	40PDIP, 44PLCC, 44PQFP, 42SDIP
CDP68HC05C4B	4160	176	16 bit; 1IC, 1OC	SCI, SPI	24 i/o, 7 i	Yes	Yes	Yes	8x8 Unsigned Multiply, RC or Crystal Oscillator, Tone Generator, Keypad Scan Interface, 8 KBI, Mask Option Pull-Ups, STOP Disable, High Current Pin (20mA sink)	40PDIP, 44PLCC, 44PQFP, 42SDIP
CDP68HC05C8	7744	176	16 bit; 1IC, 1OC	SCI, SPI	24 i/o, 7 i	No	Yes	Yes	8x8 Unsigned Multiply, RC or Crystal Oscillator	40PDIP, 44PLCC, 44PQFP, 42SDIP
CDP68HC05C8B	7744	176	16 bit; 1IC, 1OC	SCI, SPI	24 i/o, 7 i	Yes	Yes	Yes	8x8 Unsigned Multiply, RC or Crystal Oscillator Tone Generator, Keypad Scan Interface, 8 KPI, Mask Option Pull-Ups, Wake Up Timer, High Current Pin (20mA sink)	40PDIP, 44PLCC, 44PQFP, 42SDIP
CDP68HC05C16B	15936	352	16 bit; 1IC, 1OC	SCI, SPI	31 i/o	Yes, CM	Yes	Yes	8x8 Unsigned Multiply, RC or Crystal Oscillator Tone Generator, Keypad Scan Interface, 8 KPI, Mask Option Pull-Ups, Wake Up Timer, High Current Pin (20mA sink)	40PDIP, 44PLCC, 44PQFP, 42SDIP
CDP68HC05J3	2352	128	16 bit; 1IC, 1OC	None	12 i/o	No	Yes	Yes	8x8 Unsigned Multiply, RC or Crystal Oscillator Keypad Scan Interface, 8 KPI, External Timer Oscillator, Oscillator Start Up Delay	20PDIP, 20SOIC
CDP68HC05J4B	4160	176	16 bit; 1IC, 1OC	None	14 i/o	Yes	Yes	Yes	8x8 Unsigned Multiply, RC or Crystal Oscillator, Keypad San Interface, STOP Disable, 2 High Current Pins (15mA)	20PDIP, 20SOIC, 28PDIP, 28SOIC
CDP68HC05JC2	4160	176	16 bit; 1IC, 1OC	SPI, J1850	13 i/o	Yes	No	No	8x8 Unsigned Multiply, RC or Crystal Oscillator, Analog Comparator, 10MHz Operation, Slow Clock Detect	28PDIP, 28SOIC
CDP68HC05P4B	4160	176	16 bit; 1IC, 1OC	SIOP	20 i/o, 1 i	Yes	Yes	Yes	8x8 Unsigned Multiply, RC or Crystal Oscillator, Keypad San Interface, 8 KPI, Wake Up Timer 2 High Current Pins (15mA)	28PDIP, 28SOIC, 20SOIC
CDP6805E2	None	112	8 bit, 7 bit prescaler	None	13 i/o	No	No	No	8k External Address Space 5MHz Operation	40PDIP, 44PLCC
CDP6805E3	None	112	8 bit, 7 bit prescaler	None	13 i/o	No	No	No	64k External Address Space 5MHz Operation	40PDIP, 44PLCC

CM=Clock Monitor
IC= Input Capture
i=Input Only Port

i/o=Bidirectional Port
KPI=Keypad Interrupt
OC=Output Compare

J1850=SAE J1850 Serial Communications Interface
SCI=Serial Communications Interface
SPI=Serial Peripheral Interface

SIOP=Simple Serial I/O Port
HSC Versions: High Speed Versions, Max f_{OSC} = 8MHz
HCL Versions: Low Power Versions, Typical Run Power = 1.2mW

INSTRUCTION SET OPCODE MAP

	BIT MANIPULATION		BRANCH	READ/MODIFY/WRITE					CONTROL		REGISTER/MEMORY						
	BTB	BSC	REL	DIR	INH	INH	IX1	IX	INH	INH	IMM	DIR	EXT	IX2	IX1	IX	
HI / LOW	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	HI / LOW
0	BRSET0 3 BTB	BSET0 2 BSC	BRA 2 REL	NEG 2 DIR	NEGA 1 INH	NEGX 1 INH	NEG 2 IX1	NEG 1 IX	RTI 1 INH		SUB 2 IMM	SUB 2 DIR	SUB 3 EXT	SUB 3 IX2	SUB 2 IX1	SUB 1 IX	0
1	BRCLR0 3 BTB	BCLR0 2 BSC	BRN 2 REL						RTS 1 INH		CMP 2 IMM	CMP 2 DIR	CMP 3 EXT	CMP 3 IX2	CMP 2 IX1	CMP 1 IX	1
2	BRSET1 3 BTB	BSET1 2 BSC	BHI 2 REL		MUL 1 INH						SBC 2 IMM	SBC 2 DIR	SBC 3 EXT	SBC 3 IX2	SBC 2 IX1	SBC 1 IX	2
3	BRCLR1 3 BTB	BCLR1 2 BSC	BLS 2 REL	COM 2 DIR	COMA 1 INH	COMX 1 INH	COM 2 IX1	COM 1 IX	SWI 1 INH		CPX 2 IMM	CPX 2 DIR	CPX 3 EXT	CPX 3 IX2	CPX 2 IX1	CPX 1 IX	3
4	BRSET2 3 BTB	BSET2 2 BSC	BCC 2 REL	LSR 2 DIR	LSRA 1 INH	LSRX 1 INH	LSR 2 IX1	LSR 1 IX			AND 2 IMM	AND 2 DIR	AND 3 EXT	AND 3 IX2	AND 2 IX1	AND 1 IX	4
5	BRCLR2 3 BTB	BCLR2 2 BSC	BCS 2 REL								BIT 2 IMM	BIT 2 DIR	BIT 3 EXT	BIT 3 IX2	BIT 2 IX1	BIT 1 IX	5
6	BRSET3 3 BTB	BSET3 2 BSC	BNE 2 REL	ROR 2 DIR	RORA 1 INH	RORX 1 INH	ROR 2 IX1	ROR 1 IX			LDA 2 IMM	LDA 2 DIR	LDA 3 EXT	LDA 3 IX2	LDA 2 IX1	LDA 1 IX	6
7	BRCLR3 3 BTB	BCLR3 2 BSC	BEQ 2 REL	ASR 2 DIR	ASRA 1 INH	ASRX 1 INH	ASR 2 IX1	ASR 1 IX		TAX 1 INH		STA 2 DIR	STA 3 EXT	STA 3 IX2	STA 2 IX1	STA 1 IX	7
8	BRSET4 3 BTB	BSET4 2 BSC	BHCC 2 REL	LSL 2 DIR	LSLA 1 INH	LSLX 1 INH	LSL 2 IX1	LSL 1 IX		CLC 1 INH	EOR 2 IMM	EOR 2 DIR	EOR 3 EXT	EOR 3 IX2	EOR 2 IX1	EOR 1 IX	8
9	BRCLR4 3 BTB	BCLR4 2 BSC	BHCS 2 REL	ROL 2 DIR	ROLA 1 INH	ROLX 1 INH	ROL 2 IX1	ROL 1 IX		SEC 1 INH	ADC 2 IMM	ADC 2 DIR	ADC 3 EXT	ADC 3 IX2	ADC 2 IX1	ADC 1 IX	9
A	BRSET5 3 BTB	BSET5 2 BSC	BPL 2 REL	DEC 2 DIR	DECA 1 INH	DECX 1 INH	DEC 2 IX1	DEC 1 IX		CLI 1 INH	ORA 2 IMM	ORA 2 DIR	ORA 3 EXT	ORA 3 IX2	ORA 2 IX1	ORA 1 IX	A
B	BRCLR5 3 BTB	BCLR5 2 BSC	BMI 2 REL							SEI 1 INH	ADD 2 IMM	ADD 2 DIR	ADD 3 EXT	ADD 3 IX2	ADD 2 IX1	ADD 1 IX	B
C	BRSET6 3 BTB	BSET6 2 BSC	BMC 2 REL	INC 2 DIR	INCA 1 INH	INCX 1 INH	INC 2 IX1	INC 1 IX		RSP 1 INH		JMP 2 DIR	JMP 3 EXT	JMP 3 IX2	JMP 2 IX1	JMP 1 IX	C
D	BRCLR6 3 BTB	BCLR6 2 BSC	BMS 2 REL	TST 2 DIR	TSTA 1 INH	TSTX 1 INH	TST 2 IX1	TST 1 IX		NOP 1 INH	BSR 2 REL	JSR 2 DIR	JSR 3 EXT	JSR 3 IX2	JSR 2 IX1	JSR 1 IX	D
E	BRSET7 3 BTB	BSET7 2 BSC	BIL 2 REL						STOP 1 INH		LDX 2 IMM	LDX 2 DIR	LDX 3 EXT	LDX 3 IX2	LDX 2 IX1	LDX 1 IX	E
F	BRCLR7 3 BTB	BCLR7 2 BSC	BIH 2 REL	CLR 2 DIR	CLRA 1 INH	CLRX 1 INH	CLR 2 IX1	CLR 1 IX	WAIT 1 INH	TXA 1 INH		STX 2 DIR	STX 3 EXT	STX 3 IX2	STX 2 IX1	STX 1 IX	F

INH = Inherent
IMM = Immediate
DIR = Direct
EXT = Extended

REL = Relative
BSC = Bit Set/Clear
BTB = Bit Test and Branch

IX = Indexed, No Offset
IX1 = Indexed, 8-Bit Offset
IX2 = Indexed, 16-Bit Offset

HI / LOW	0
0	5 BRSET0 3 BTB

LSB of Opcode

MSB of Opcode
Number of Cycles
Instruction Mnemonic
Number of Bytes/Addressing Mode

TABLE 5. I/O, CONTROL, STATUS, AND DATA REGISTER DEFINITIONS

	Bit 7	6	5	4	3	2	1	0	
$0000	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	PORT A
	3	4	5	6	7	8	9	10	Pin Numbers
	PA7	PA6	PA5	PA4	PA3	PA2	PA1	PA0	Pin Name
$0001	I/O	I/O	I/O	0	0	0	0	0	PORT B
	13	12	11						Pin Numbers
	PB7	PB6	PB5						Pin Name
$0002	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	PORT C
	15	16	17	18	19	20	21	22	Pin Numbers
	PC7	PC6	PC5	PC4	PC3	PC2	PC1	PC0	Pin Name
$0003	I	0	I/O	1	0	0	0	0	PORT D
	25		23						Pin Numbers
	PD7/TCAP		PD5						Pin Name
$0004	DDRA7	DDRA6	DDRA5	DDRA4	DDRA3	DDRA2	DDRA1	DDRA0	DDRA
$0005	DDRB7	DDRB6	DDRB5	1	1	1	1	1	DDRB
$0006	DDRC7	DDRC6	DDRC5	DDRC4	DDRC3	DDRC2	DDRC1	DDRC0	DDRC
$0007	0	0	DDRD5	0	0	0	0	0	DDRA
$0008	**UNUSED**								
$0009	**UNUSED**								
$000A	**UNUSED**								
$000B	**UNUSED**								
$000C	**UNUSED**								
$000D	**UNUSED**								
$000E	**UNUSED**								
$000F	**UNUSED**								
$0010	**UNUSED**								
$0011	**UNUSED**								
$0012	ICIE	OCIE	TOIE	0	0	0	IEDG	OLVL	TCR
$0013	ICF	OCF	TOF	0	0	0	0	0	TSR
$0014	Bit 15							Bit 8	CAPHI
$0015	Bit 7							Bit 0	CAPLO
$0016	Bit 15							Bit 8	CMPHI
$0017	Bit 7							Bit 0	CMPLO
$0018	Bit 15							Bit 8	CNTHI
$0019	Bit 7							Bit 0	CNTLO
$001A	Bit 15							Bit 8	ALTHI
$001B	Bit 7							Bit 0	ALTLO
$001C	0	0	0	0	0	0	WUTF	WUTE	WUTCR
$001D	**UNUSED**								
$001E	**UNUSED**								
$001F	**RESERVED**								RESERVED

A. **Package Type (select one):**

☐ 28 Pin Dual-In-Line Plastic (E28) ☐ 28 Pin SOIC (M28) ☐ 20 Pin SOIC (M20)

Production Packaging

☐ Bulk (Tubes, sticks, or trays) ☐ Tape and reel

B. Select the following microcomputer options. A manufacturing mask will be generated from this information. Refer to data sheet or data book instructions for submitting data for ROM patterns.

Internal Oscillator (select one)

☐ Crystal/Ceramic Resonator

☐ Resistor

Input Interrupt Trigger (select one)

☐ Edge Sensitive Only

☐ Level and Edge Sensitive

Port A Interrupt/Pullup Options (select all that apply - unselected indicates no interrupt and no pullup)

☐ PA7 Interrupt and Pullup ☐ PA6 Interrupt and Pullup

☐ PA5 Interrupt and Pullup ☐ PA2 Interrupt and Pullup

☐ PA4 Interrupt and Pullup ☐ PA1 Interrupt and Pullup

☐ PA3 Interrupt and Pullup ☐ PA0 Interrupt and Pullup

Wake Up Timer (select one)

☐ Enabled

☐ Disabled

Pinout (select one)

☐ Standard

☐ Low EMI

Operating Frequency (select one)

☐ Normal

☐ High (premium cost)

Operating Power (select one)

☐ Normal

☐ Low (premium cost)

Watchdog (select one)

☐ Enabled

☐ Disabled

STOP Instruction (select one)

☐ Enabled

☐ Disabled

C. Customer Company _____

Address _____

City _____

Phone (____) _____ Extension _____

Contact Person _____

Customer Part Number _____

D. Pattern Media (S-Record Formatted File Should Be Used - Unspecified locations are filled with 0's)

Floppy Disk: ☐ $3^1/_2$" ☐ $5^1/_4$" MODEM Upload: ☐ S-Record Filename _____

Medium if other than above † _____

Signature _____ Title _____

Date _____

† The P1B requires 8K of data